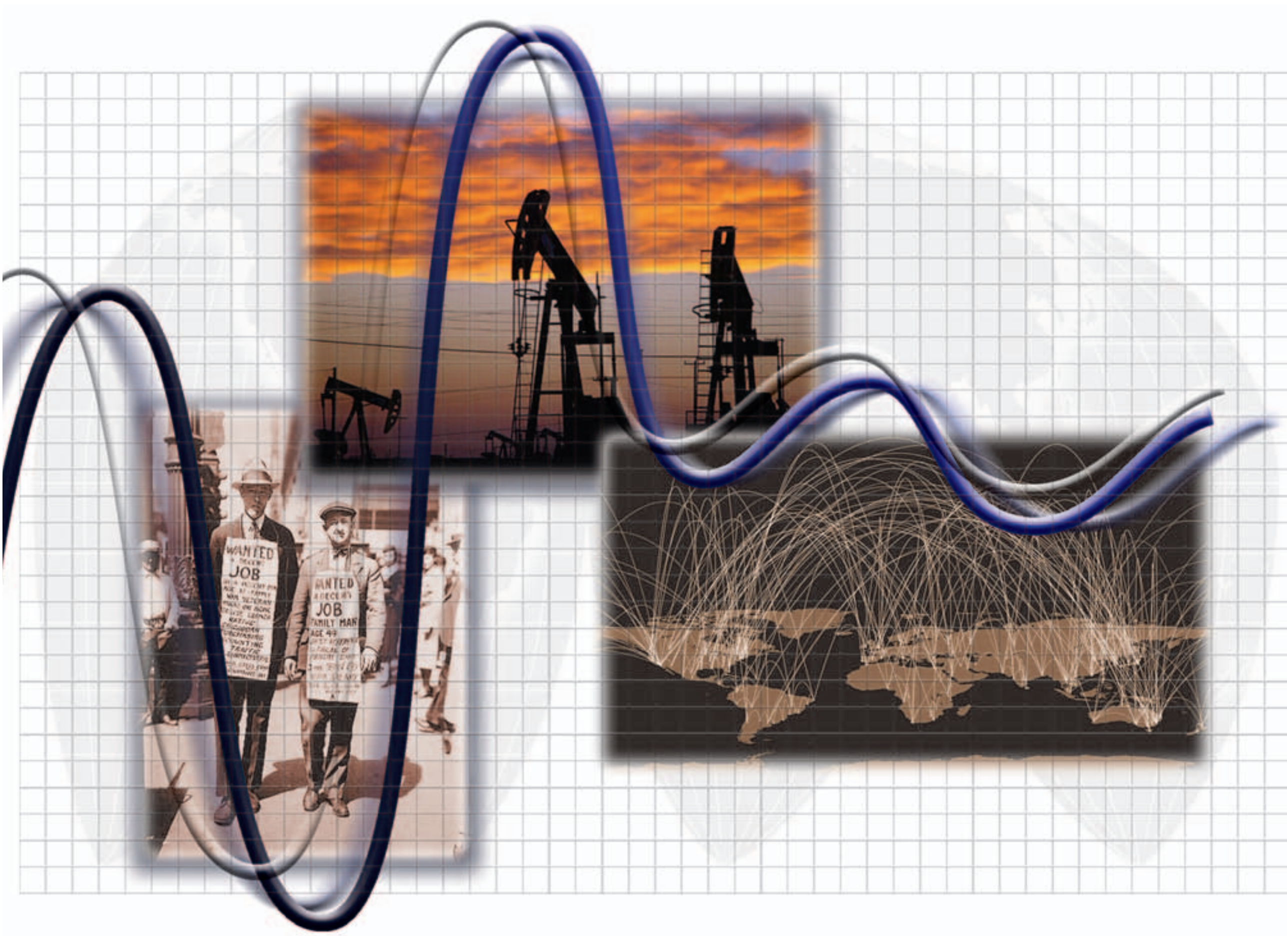
THE CHANGING NATURE OF THE BUSINESS CYCLE



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Introduction

Christopher Kent and David Norman

Fluctuations in economic activity over the course of the business cycle imply significant welfare costs. Most obvious are the costs associated with periods of relatively weak activity, when productive resources are under-utilised, and consumption is below par.[1] Periods of relatively strong activity can also be costly since they imply an inefficient bunching of activity, consumption and investment at particular points in time, and are often associated with inflationary pressures. It is not surprising, therefore, that the nature of the business cycle, including the magnitude of fluctuations and the degree of synchronisation of cycles across countries is closely studied by academic economists and policy-makers alike.

The widespread decline in the magnitude of business cycle fluctuations across developed economies over the past two decades or so has received much attention, but remains the subject of considerable debate. On the one hand, there are studies which suggest that most of the decline in volatility is due to good fortune (that is, smaller and less frequent global shocks); for example, Stock and Watson (2002) and Ahmed, Levin and Wilson (2004). On the other hand, there are studies that imply a more persistent decline in volatility, attributing much of it to structural changes and economic reforms, particularly with regards to monetary policy regimes (for example, Clarida, Galí and Gertler 2000). Others have emphasised the role of deeper financial markets in allowing households and firms to better smooth expenditures in the face of fluctuating incomes (for example, Dynan, Elmendorf and Sichel 2005). Of course, it is also possible that deeper financial markets will increase the role played by financial sector imbalances in generating and/or amplifying business cycle fluctuations in the future.

The degree of synchronisation across countries is of interest because it summarises the extent to which business cycles are jointly determined. Ultimately this depends on the relative size of common shocks versus country-specific or idiosyncratic shocks, and the way in which these shocks are transmitted within countries. For example, the trend towards liberalisation of international trade flows suggests that there is greater potential for the transmission of business cycle fluctuations across borders, thereby increasing the relative importance of common shocks and driving up synchronisation. At the same time, however, trade liberalisation might lead economies to become more specialised in production, increasing the importance of idiosyncratic shocks and resulting in less synchronised cycles. Similarly, the opening of capital markets globally might increase the potential for financial disturbances to be transmitted across borders, thereby raising synchronisation. Offsetting this, more open capital

1. There is a strand of literature which acknowledges the possibility that recessions are periods of 'creative destruction', whereby some older and less efficient enterprises fail, freeing up resources to be used by newer, more dynamic enterprises (see, for example, Schumpeter 1942 and Caballero and Hammour 1994).

markets would encourage diversification, allowing domestic incomes to become less dependent on the strength of domestic economic activity.

These issues were addressed at this year's Reserve Bank of Australia conference on the changing nature of the business cycle. This introduction presents a brief overview of the main results to emerge from the papers presented at the conference.

Some Stylised Facts

The first paper, by Jean-Philippe Cotis and Jonathan Coppel, provides a useful introduction to the themes of the conference by highlighting a range of ways in which the business cycles of OECD countries have, and have not, changed over the past two decades. They begin by noting that the amplitude of business cycle fluctuations has declined across almost all OECD countries over the past 30 years, with the standard deviation of the output gap falling on average by around 30 per cent. Looking at a number of different measures, they also document the high degree of synchronicity across OECD economies, and the fact that the euro-area economies are more closely correlated with each other, with the English-speaking OECD economies more closely correlated with the United States. However, they suggest that once account has been taken of the decline in output volatility, the extent of synchronisation has not changed very much over the past 35 years.

Cotis and Coppel provide some accounting for the sources of the general reduction in output volatility, finding that it stems mainly from more stable domestic demand, with only a modest contribution due to decreased volatility in external trade. It appears that the reduction in volatility is more evident in a group of 'successful' countries – including Australia, Canada, Ireland, New Zealand, the Nordic countries and the United Kingdom – than in the large continental European economies. These 'successful' countries experienced a relatively muted cycle earlier this decade, particularly when compared with their weaker performance in the early 1990s. Importantly, Cotis and Coppel find that this difference in performance during the recent cycle cannot be explained by more stimulatory policy settings, which were broadly consistent across both groups of countries. Instead, they present evidence which suggests that this difference is due in part to more flexible product and labour markets in the 'successful' countries, which has helped to reduce the 'sacrifice ratio' (the cost, in terms of reduced output, typically associated with disinflation). In addition, they argue that more highly developed mortgage markets have had a role in increasing the effectiveness of monetary policy. These findings are consistent with ongoing work at the OECD, which finds that economies that respond more rapidly to shocks – due to more flexible product and labour markets, and more developed mortgage markets – experience smaller reductions in output following adverse shocks. In this way, greater responsiveness ultimately leads to a reduction in output volatility. Cotis and Coppel conclude with a few remarks about the potential for the expansion of financial markets to increase the potency and speed with which monetary policy can affect economic activity, and the risk of macroeconomic instability arising from asset price misalignments.

Changes in the Volatility of the Business Cycle

Robert Gordon's paper takes a close look at the decline in the volatility of US output. He provides a detailed accounting of the behaviour of GDP by its component parts, showing that the reduction in domestic demand volatility highlighted by Cotis and Coppel can largely be explained by greater stability in residential investment and federal government spending – with some contribution to the decline in output volatility from reduced volatility of inventory investment. Gordon examines the reasons underlying the decline in macroeconomic volatility by means of a parsimonious structural model. His approach is similar to that of Stock and Watson (2002), but with explicit specification of supply shocks, rather than treating these as residuals in an inflation equation. He finds that the reduction in inflation volatility since the 1970s can primarily be attributed to smaller and generally 'beneficial' supply shocks. In contrast, he finds that the reduction in output volatility is primarily due to a reduction in the size of output errors in his model, reflecting greater stability of the 'IS' curve, with supply shocks playing only a relatively small role. Gordon appeals to his earlier finding to attribute this apparent increase in the stability of the 'IS' curve to reduced volatility in residential and inventory investment and federal government spending.

A second, and more contentious, finding of Gordon's paper relates to the role of monetary policy in accounting for the greater macroeconomic stability of the US. Gordon argues that previous estimates of Taylor rule reaction functions do not properly account for serial correlation in the residuals, and that applying such a correction makes a marked difference to results. In particular, Gordon argues that the (corrected) coefficients of the Taylor rule reaction function during the era of Chairman Greenspan suggest that he fails to abide by the 'Taylor Principle' – that increases in inflation above target should be met with a greater increase in nominal interest rates. Consequently, Gordon argues that the performance of the Federal Reserve under Greenspan – as judged by his model – is no better than that of the Federal Reserve under Arthur Burns.

Stephen Cecchetti, Alfonso Flores-Lagunes and Stefan Krause examine changes in the volatility of output across 25 countries in their paper. At a quarterly frequency, they find that more stable inventory investment can explain much of the decline in volatility across a range of countries. However, they note that this outcome may reflect deeper structural determinants; they focus primarily on the respective roles of improved monetary policy and financial innovation, and argue in favour of the latter being most important. With regards to monetary policy, they use a model to construct an 'output-inflation variability efficiency frontier', describing the optimal balance between output and inflation volatility, to examine the impact that improved monetary policy has had on output volatility. Their estimates suggest that monetary policy has contributed to a reduction in output volatility over recent decades in less than half the economies they study. Furthermore, in later panel regression models, they find that various measures of monetary policy are generally insignificant in explaining the reduction in output volatility from the first part of their sample period to the last. In contrast, Cecchetti *et al* observe that reduced volatility in consumption has been associated with an increase in debt-to-income ratios across the countries in their sample, and use this to argue (in support of Cotis and Coppel) that financial innovation over recent decades has allowed households to better smooth their consumption in the face of income shocks. They support this with evidence from their panel regressions, which attribute a prominent role to financial innovation in explaining reduced output volatility.

Christopher Kent, Kylie Smith and James Holloway take a somewhat similar approach to explaining the deeper determinants of reduced output volatility, using a panel regression across 20 OECD countries. However, their model differs from Cecchetti *et al* by controlling for trends in common (unexplained) innovations to output volatility, including a possible decline in the magnitude of global shocks. Kent *et al* argue in favour of two factors in explaining reduced output volatility. The first is less rigid regulation of markets, especially significant in the case of product market deregulation, but also true of labour market deregulation, in keeping with the earlier findings of Cotis and Coppel. The second factor is the role of improved monetary policy; they find that a dummy variable indicating a move to stricter monetary policy regimes is a statistically significant explanator for the reduction in output volatility across a number of alternative model specifications. In contrast to Cecchetti *et al*, they find that financial liberalisation is generally insignificant in explaining reduced output volatility.

Business Cycle Synchronisation

While Cotis and Coppel suggest that the synchronicity of business cycles has not changed much over time across OECD countries overall, Dan Andrews and Marion Kohler argue that this is not the case for Australia. They present evidence that the Australian business cycle has become increasingly synchronised with that of Canada, the UK and the US, but less synchronised with that of the euro area and Japan. Their paper examines the possible explanations for these changes over time, focusing on factors identified in the cross-section literature as being important for the level of business cycle correlations across countries. They find that the change in trade integration between two countries is the most robust explanator of changes in synchronicity over time, with a reduced share of trade between countries contributing, in general, to a decrease in synchronicity. Changes in the similarity of industrial structure are also found to be important in explaining changes in synchronicity over time, with increasingly similar economies tending to experience more correlated business cycles. However, Andrews and Kohler also emphasise that no single model is able to explain movements in bilateral correlations over time, and that idiosyncratic factors (proxied by divergences in fiscal and monetary policy) are often significant explanators. Finally, Andrews and Kohler discuss the possible role of international financial market integration in affecting synchronicity – noting that the theoretical sign of this is ambiguous – but cannot estimate this effect due to data constraints.

The paper by Mark Crosby and Philip Bodman provides an interesting counterpoint to the findings of both Cotis and Coppel and Andrews and Kohler. Crosby and Bodman use an historical dataset to look at business cycle synchronicity between Australia and the US over a sample extending as far back as 1870. They find that these countries' business cycles were essentially un-synchronised prior to World War I, despite very similar industrial structures and a reliance on the UK and a single commodity (wool for Australia and cotton for the US) for export earnings in the very early part of their sample. Crosby and Bodman argue that the high correlation between Australian and US cycles found in many papers (such as Otto, Voss and Willard 2001) is a much more recent phenomenon, only evident since the 1970s.

The second important thesis of Crosby and Bodman's paper is that business cycle correlations have historically tended to increase during recessions. Indeed, they argue that prior to WWII, business cycles were correlated across various economies only during the 1890s and 1930s downturns. Similarly, after WWII, the correlations between business cycles are much lower once recessionary periods are excluded from the sample. Furthermore, Crosby and Bodman assert that the global recessions of the early 1980s and 1990s can be largely attributed to monetary policy. Since policy-makers have learnt the lessons from these episodes, the implication is that there is unlikely to be much synchronicity between business cycles of these countries in the future.

Measuring the Business Cycle

The paper by Christian Gillitzer, Jonathan Kearns and Anthony Richards takes a close look at the Australian business cycle. Motivated by the possibility that GDP may not be the best measure of the state of the business cycle because of measurement error and the fact it may not adequately reflect developments in different parts of the economy, they construct coincident indicators using factor models. These measures attempt to extract the 'business cycle' from a wide range of economic indicators (using techniques pioneered by Stock and Watson 1999 and Forni *et al* 2000). They find that the resultant series are more persistent and less noisy than GDP, which they argue are features that make them better indicators of the business cycle.

The authors use these indices to examine several features of the Australian business cycle. In dating business cycle phases, they argue that there have only been three recessions since the early 1960s – in 1974–1975, 1982–1983, and 1990–1991 – in contrast to the six implied by the behaviour of GDP. They demonstrate that there has not been a clear decline in the volatility of their indices, in contrast to that which is evident in quarterly GDP, suggesting that a reduction in the extent of measurement error over time may have played some role in the decline in output volatility recorded in Australia. They also show that the increase in the correlation of their index with a comparable index for the US mirrors the correlation based on GDP, implying that the increase in the synchronicity of these two economies' business cycles is robust to alternative measurement.

Financial System Stability and the Business Cycle

The final paper, by Hyun Shin, stands in contrast to a number of others in this volume, by emphasising the potential for financial system developments to amplify business cycle fluctuations. He outlines a stylised, theoretical model linking asset prices (particularly house prices) to the health of bank balance sheets, which influences the availability of credit, and in turn can affect asset prices. A key feature of his model is the assumption that banks mark-to-market their mortgage portfolio, and will respond to any rise in their net worth by increasing lending. Shin argues that the circular relationship linking asset prices and credit can generate an amplified response to an easing of monetary policy. Furthermore, ultimately this response cannot be unwound without risking insolvency in the household and banking sectors and, therefore, a significant downturn in economic activity. With regards to the theme of the conference, Shin argues that the scope for this type of amplification of the business cycle is only likely to increase in the future. This follows from three trends. The first is greater accountability of management to shareholders, who will increasingly tend to focus on returns relative to the value of marked-to-market equity. The second is more sophisticated financial markets that make it increasingly easy to re-price banks' loan books on a regular basis. The third is an accounting framework that is encouraging the principle of marking-to-market to be applied across a greater part of banks' balance sheets. In combination, these trends imply that a rise in property prices will be more likely to push up the equity value of banks, encouraging them to lend more, thereby supporting further property price gains, and so on. In conclusion, Shin suggests that policy-makers need to play close attention to the possible links between monetary policy and balance-sheet effects, echoing a point made in the first paper by Cotis and Coppel.

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Business Cycle Dynamics in OECD Countries: Evidence, Causes and Policy Implications

Jean-Philippe Cotis and Jonathan Coppel[1]

Introduction

This paper deals with the interaction between economic policies and the business cycle. It focuses more specifically on the role that improved economic policies may have played in the continuous reduction of price and output fluctuations observed across OECD countries over the past two decades.

As suggested by the recent empirical literature, this issue remains largely unsettled. Some studies document progress achieved over the years in the conduct of monetary policy and conclude, on an *ex-ante* basis, that it must have contributed to increased price and output stability.[2] Others use econometric analysis to disentangle the respective roles played by improved monetary policies and luck – in the form of smaller and less frequent exogenous shocks – in explaining better outcomes.[3] Overall, they do not support the view that monetary policy had a decisive role to play in reducing price and output instability.

The present work tries to shed some additional and tentative light on these issues by examining recent cross-country stylised facts and adopting a broader policy perspective, extending beyond monetary policy. Focusing on the past five years, and taking a wide cross-country perspective, it suggests that the link between 'good' policies and conjunctural stability could be rather strong.

More concretely, a group of countries seems to have nearly 'extinguished' the business cycle while enjoying above-average trend growth. This successful group, which includes Australia, Canada, Sweden, the UK and some others, is characterised by monetary policy frameworks of the inflation-targeting type, as well as flexible regulatory frameworks in labour, product and financial markets. These countries are also those that undertook ambitious and comprehensive economic policy reforms over the past couple of decades to break away from a long-standing record of weak growth trends and substantial price and output instability. Therefore, it may not be

1. Jean-Philippe Cotis is the OECD Chief Economist and Jonathan Coppel is a Senior Economist working in Mr Cotis' office. The authors would like to thank conference participants for their very valuable comments and questions. They also greatly benefited from Adrian Pagan's very insightful remarks. The authors would also like to thank Debbie Bloch for her expert statistical assistance, Christophe André for programming the classical cycle dating algorithm and for useful comments and suggestions on an earlier version of this paper together with Jorgen Elmeskov, Vincent Koen and Alain de Serres. The views expressed in this paper are those of the authors and do not necessarily reflect those of the OECD Secretariat or the Organisation's member countries.

2. See Romer and Romer (2003).

3. See Stock and Watson (2004).

pure coincidence that indicators for English-speaking and Nordic countries point to a marked reduction in the amplitude of the business cycle.

This spectacular improvement in short- and long-run performance also stands in stark contrast to the more modest changes observed in large continental European countries, both in terms of policy reforms and economic performance. It is indeed striking that, faced with the same sort of negative outside shocks as continental European countries in terms of lost exports and investment, the successful group managed to do a much better job of smoothing consumption and output over the 2001–05 period, while the stance of fiscal and monetary policies was not particularly loose compared to the average in the large euro-area economies. In such a context, the sense of disappointment experienced in continental Europe may stem as much from the persistence of long-standing difficulties as from the realisation that other countries have really succeeded in improving economic performance over the years.

This combination of short-run resilience and, on average, parsimonious use of stabilisation policies strongly suggests that structural flexibility may have been instrumental in offsetting external turbulences. An important source of resilience seems to lie in highly flexible financial markets, in particular in the areas of consumer and mortgage financing that have endowed monetary policy with very strong transmission channels. The flip side of the coin may be, however, that in those resilient countries, neo-Wicksellian monetary policies may be prone to underrating the risks for future price and output stability from asset prices which are out of kilter.

Although this apparently outstanding performance of 'successful' countries may be one more streak of luck, it could also be noted that over recent years the international environment has become distinctly less placid. Geopolitical, oil market, as well as trade and exchange rate turbulence may have indeed provided a more stringent and therefore convincing test of the self-stabilising propensities of economies.

Looking at recent comparative evidence there thus seems to be a very strong *prima facie* case for viewing stabilisation and structural policies as jointly determining long-term growth performance and short-run stability of prices and output. Previous empirical OECD work already provides evidence that good stabilisation policies brought a very significant contribution to long-term growth.[4] And there is an increasing presumption that flexible regulatory frameworks that stimulate potential growth can interact positively with macroeconomic policies to ensure price and output stability.

Moving from descriptive statistics, comparative stylised facts and intuition to harder evidence remains very much of a challenge, however, and motivates work in progress at the OECD. Taking the perspective of *ex-ante* analysis, it is relatively easy to replicate observed stylised facts and cross-country variations through a calibrated macroeconomic maquette featuring variable degrees of price flexibility in labour, product and financial markets as well as rule-based monetary policies (Section 3.2.1). In terms of *ex-post* analysis, it has been possible to document, through

4. See OECD (2003b).

panel data and comparative analysis, how overly stringent regulatory frameworks are impeding price flexibility in labour, product and financial markets and thus the effectiveness of monetary policy (Section 3.2.2). Finally, *ex-post* analysis, in the form of SVAR modelling, is currently under way to verify that diverging output trajectories between large continental European countries and members of the 'successful group' cannot be explained by differences in shocks or macro-policy stances (Section 3.2.3).

These themes of interaction between economic policy and the business cycle and the role that improved economic policy may have played in the reduction of price and output fluctuations are addressed in the second half of this paper. In the first half, we examine the features of business cycles within countries and the changing degree of business cycle volatility and synchronisation across countries, along with the possible driving forces. The paper is organised as follows. The first section offers a brief overview of the different approaches to the measurement of business cycles. The second section then examines some statistics and stylised facts concerning business cycles in 12 OECD countries over the past 35 years, their degree of volatility and international synchronisation and how it is evolving over time. Such statistics show international convergence towards low output instability, with most spectacular progress achieved by the English-speaking and Nordic countries. A potential trend towards increased synchronisation, *stricto sensu*, is harder to identify. Section 3 analyses the latest developments in business cycle dynamics, using recent OECD work to examine the interaction with economic policy. Section 4 looks at policy implications.

1. Measuring Business Cycles in OECD Countries

1.1 Defining the business cycle

The business cycle is usually defined as a regular and oscillatory movement in economic output within a specified range of periodicities. The way in which this definition is made operational has evolved over the past half century. In the post-war period, following the seminal work of Burns and Mitchell (1946), cyclical instability was analysed in terms of expansions and contractions in the level of economic activity, typically measured by GDP. These cycles are known as classical business cycles.

This paper focuses only briefly on the classical cycle, because for many OECD economies declines in the level of economic activity are rare events. There are therefore relatively few classical cycles over a 35-year period, making it impossible to make firm inferences regarding the evolution of the size and length of business cycles. An alternative and generally favoured approach to analysing the business cycle is to focus on periods of deviations of output from trend. These episodes, which are more frequent in OECD economies, are known as growth cycles (or deviation cycles). The analysis is concerned with phases of above- and below-trend rates of growth, or movements in the output gap. Even with growth cycles, their frequency is limited over a 35-year period, since each cycle lasts about five years on average.

Moving from classical to growth cycles modifies the meaning of a turning point and phase, both concepts used to describe the morphology of a business cycle. For classical cycles, turning points are reached when output is at a local extremum. Whereas for growth cycles, extrema are defined in terms of output gaps.

Once the turning points are known, the length of each cycle can be identified. In classical cycles, the period between the trough and the peak is the expansion phase and the period between the peak and the trough is the contraction phase. For a growth cycle, the upturn phase is defined as a period when the growth rate is above the long-term trend rate of growth and conversely for the downturn phase. Table 1 provides a taxonomy of the concepts used and their relationship to each other. In practice, applying these definitions literally is difficult, since they imply overly frequent cycles, and thus more sophisticated rules (though still broadly consistent with these stricter definitions) are needed to date the cycle (see Section 2.1).[5]

Table 1: A Taxonomy of Business Cycle Definitions

Cycle type	Turning points	Phases
Classical (level of GDP)	Peaks (P) Troughs (T)	P–T contraction T–P expansion
Growth (filtered GDP)	Downturn (D) Upturn (U)	D–U low growth rate U–D high growth rate

Before moving to measurement issues, it is important to remember that the classical and growth approaches to the business cycle rely on very different conceptual foundations. While classical cycle analysis is purely descriptive, growth cycle analysis involves a separation between the trend and cyclical components of output that is fraught with statistical and conceptual difficulties (see below).

In this paper, trend output is assumed to be a stochastic unobservable variable, implicitly incorporating technology and other types of supply shocks, while the cyclical component of activity is supposed to be captured by the residual, transitory, component of output. Although this residual component could include, in theory, transitory technology shocks, it is supposed to mainly capture demand-driven fluctuations in output.[6]

5. From these definitions of classical and growth cycles it follows that classical recessions are always a subset of growth cycle recessions, and there may be multiple classical contraction episodes within a growth cycle recession. While growth cycle downturns tend to lead classical cycle peaks, growth cycle upturns tend to coincide or lag classical cycle troughs. Accordingly, we should expect that high growth rate phases will tend to be shorter-lived than expansion phases and that low growth rate phases will tend to be longer-lived than contraction phases. For more details on the relationship between classical and growth cycles, see Boehm and Liew (1994).

6. This assumption would not be accepted by proponents of the 'real business cycle' school, who tend to interpret the residual component as reflecting short-run supply fluctuations rather than demand-driven ones.

A more 'descriptive' approach, where trend output is approximated by a set of deterministic trends, may have possibly allowed a more encompassing examination of 'cyclical' fluctuations, including those arising from the supply side. However, emphasising the demand side of the business cycle is not without justification, given its centrality in the conduct of stabilisation policies. In short, using 'real business cycle' terminology, the paper leaves aside efficient supply-side fluctuations and focuses rather on inefficient demand-driven cyclical fluctuations.

1.2 Measuring the growth cycle in OECD economies

Growth cycles are defined in terms of deviations from trend. The problem, however, is that trend output growth cannot be directly measured. The rate of trend or potential growth is unobservable and has to be inferred from the data. There are many possible approaches to decomposing a series into its trend and cycle components and no single approach can claim to be unequivocally superior (see Box A). Indeed, most of the feasible approaches are ad hoc in the sense that the researcher requires only that the detrending procedure produces a stationary business cycle component, but does not otherwise explicitly specify the statistical characteristics of the business cycle. Hence, the choice of one methodology over another largely hinges on the specific characteristics of the time series and the purpose of the analysis.

In this paper we adopt a band-pass filter to assess the main features of business cycles in OECD countries. This filter is based on the idea that business cycles can be defined as fluctuations of a certain frequency. It eliminates very slow-moving (trend) components and very high-frequency (irregular) components while retaining intermediate (business cycle) components. When applying the filter, the critical frequency band to be allocated to the cycle has to be exogenously determined. Here, we follow Baxter and King (1999) and define the cycle using a uniform low-pass filter to eliminate low-frequency components of more than 32 quarters and a high-pass filter to eliminate high-frequency components of less than 6 quarters. A shortcoming with the filter is that it produces no values for the first and last 12 quarters since it is calculated by a moving average.[7] To compute the output gap for the period 1970 to 2003 we thus first extend our series to 2006 using the OECD's latest short-term economic projections. The data used are quarterly and cover 12 major OECD countries, including Australia.[8]

7. There are critics of the band-pass filter. Harvey and Trimbur (2003) argue that the filter may be inconsistent with some models of trends and cycles.

8. The resulting output gaps display a broadly similar profile to the OECD output gaps derived from a production function approach and published in the OECD's Analytical Database. Indeed, the impact of differences in detrending methods seems to be felt more strongly on the average level of trend output than on the slope of the trend output series (Claus, Conway and Scott 2000). Since this paper is more concerned with business cycle behaviour over time and across countries, that is, with changes in output gaps rather than output gap levels, the bias implied by a certain filter may not be a significant issue, provided the bias does not vary too much over time or across countries.

Box A: Trend-cycle Decomposition Techniques[1]

There is a large literature concerned with the best method of extracting a trend from the data. Within this literature there are three general approaches, based respectively on estimating a structural model of the supply side, using statistical techniques and using survey data.

The first approach derives potential output as the combination of various economic factors. Accordingly, an estimated production function can be used to determine the level of output that would be produced if factor inputs – labour and capital – were fully employed. While widely used by policy-makers for its capacity to reflect the consequences of economic policies on potential output, this approach nonetheless has its limitations: it is not obvious what functional form should be used; taking account of varying qualities of labour and capital may be tricky; and the notion of fully employed labour and capital is not easy to capture, as it depends on the level and intensity of use, which are unobservable and likely to change through time as relative prices evolve. Finally, the production function approach means that technical progress is explicitly modelled, despite not being directly observed, and different estimates of technical progress are likely to lead to somewhat different estimates of the level of potential output.

An alternative, but somewhat related, approach is semi-structural, such as Kalman filters or structural VAR models as developed by Blanchard and Quah (1989). The SVAR approach uses information from the labour market and capacity utilisation to aid in the decomposition of actual output into a permanent trend component (supply) and a temporary cyclical component (demand). The trend is interpreted as a measure of potential output and the cycle as a measure of the output gap. A shortcoming of SVAR techniques is the sensitivity of the results to the identifying assumptions.

The second approach, which does not rely on economic information, is based on statistical or time-series methods. Rather than directly building up an estimate of trend output, they take the data and indirectly identify the trend by decomposing the series into various components. They thus implicitly assume that GDP embodies a long-run equilibrium component and some short-run temporary disturbances along this trend. The problem is that there are a vast number of methods to make this split, each potentially yielding a different dating of the turning points and growth cycle chronologies (Canova 1998 and Quah 1992). The simplest is to fit a linear time trend and assume all deviations from the trend are cyclical. But this is likely to be unreliable during periods of structural change since trend growth itself changes over time.

1. For a more detailed discussion, see the Appendix in Cotis, Elmeskov and Mourougane (2005), on which this box is largely based.

An equally simple method that avoids a constant trend growth rate is to extrapolate a trend between cyclical peaks, but in practice it can be complicated to implement because it requires a method to identify turning points.

The most frequently used approach is to apply time-series techniques to extract the stochastic trend from GDP data. This allows shocks to aggregate supply to have a permanent effect on output. These techniques use various statistical criteria to identify a trend. Examples include the Hodrick-Prescott filter (HP filter), which is perhaps most common, the band-pass filter (BP filter), or the Beveridge-Nelson decomposition. Each method requires some identifying assumptions, which are often criticised for their arbitrariness and their lack of economic foundations. In practice, the differences across methods are typically small.

The third approach is to construct a measure of capacity utilisation based on business and household survey responses. These responses can then be used to compile a measure of full capacity, with deviations representing cyclical fluctuations. Though this approach is intuitively appealing, experience demonstrates that survey responses do not necessarily reflect aggregate demand pressures, with respondents themselves seemingly finding it hard to disentangle trend from cyclical developments.

All in all, estimating trend output remains an art more than a science and no single approach can be said to be universally superior. The preferred choice remains therefore highly judgemental and dependent on the context and the objective of the work.

2. Features of Business Cycles

2.1 The chronology of classical and growth cycles

Before the characteristics of business cycles can be examined, the first step is to identify the timing of turning points. For that, there is no ideal method, and in practice *ad hoc* rules of thumb are used, with the results possibly driven by the dating algorithm. This section of the paper follows Harding (2003), by using a more transparent version of the Bry and Boschan (1971) algorithm for dating classical business cycles. The algorithm inevitably involves an element of judgement in terms of the restrictions imposed. These relate to the minimum duration of a cycle to avoid spurious turning points, ensure phases alternate and prevent minor movements in GDP being classified as a cycle.[9] A similar algorithm is also applied to date the upturns and downturns of growth cycles. Appendices A and B show the dates, duration and amplitude of each cycle for the 12 OECD countries included in this study.

9. When output growth for a single quarter in isolation is negative and large (that is, more than 3 per cent) it is classified as a turning point.

2.2 Characteristics of cycles in OECD countries

Based on this method for dating business cycles, Table 2 summarises the main features of classical cycles over the past 34 years. Three points emerge. First, the depth and steepness of contractions appears smaller in the continental European economies than elsewhere, but similarly the vigour of expansion phases is less pronounced. This broadly corresponds to the characterisation of cycles in Europe as 'U-shaped' rather than 'V-shaped'. Second, there is no apparent pattern in the frequency of contraction and expansion phases across countries, although Italy stands out with a higher number of cycles over the period and Canada with relatively few. Third, the average duration of the contraction phase is closely centered on 3½ quarters, while the expansion phase ranges from 12 quarters (Italy) to beyond 30 quarters (France, Japan and the Netherlands).

The 'U-shaped' path of European business cycles may reflect the presence of stronger automatic fiscal stabiliser mechanisms linked to generous social expenditure systems which cushion the abruptness of a contraction for a given shock. An explanation for the softer recovery paths in Europe that has sometimes been suggested is that trend growth in continental European economies is slower than in the English-speaking economies, especially over the second half of the sample. This, however, does not appear to be supported by Table 3, which shows the main features of growth cycles, abstracting from trend growth. Indeed, all of the 4 countries where the average amplitude of upturns is below the 12-country average are also euro-area economies.

While the notion of cycles may implicitly convey a sense of regularity and repetition, the features of growth cycles in OECD economies suggest anything but regularity. The length of upturn and downturn phases ranges between 1½ and 3½ years and the steepness, or amplitude, of cycles on average spans a wide range. However, the cumulative movement of cycles, both during upturns and downturns, is relatively similar among countries.

Besides trying to identify country-specific cycles in OECD economies, we examine how the output gap has evolved over time within and across countries. This approach shifts the focus away from narrowly defined cycle analysis and takes a broader view of output fluctuations. On this basis, one feature clearly evident in OECD economies over the past three decades is the drop in the amplitude of output fluctuations, as proxied by the standard deviation of output gaps over approximately nine-year periods since 1970. The fall has been especially marked in Australia, the UK, the US, as well as in Italy, Spain and Sweden and was heavily concentrated over the past decade. Also evident from Table 4 is a tendency for the standard deviation of the output gap among the sampled countries to converge to a lower level. On average over the last nine years, the standard deviation of the output gap is about half what it was during the 1970s.

The tendency for the amplitude of the output gap to decline has been associated *ex post* with reduced volatility of domestic demand as well as a smaller dampening influence from external trade (Table 5). Taken in isolation, the declining contribution of trade to more stable GDP may look paradoxical, in a context where trade openness

Table 2: Summary Statistics Concerning Classical Cycles in Selected OECD Countries
Real GDP – 1970–2003

	Average of contraction phases (peak to trough)					Average of expansion phases (trough to peak)				
	Number of contractions	Duration (quarters)	Proportion of time in contraction (%)	Amplitude (% points)	Quarterly amplitude (% points)	Number of expansions	Duration (quarters)	Proportion of time in expansion (%)	Amplitude (% points)	Quarterly amplitude (% points)
Australia[(a)]	6	2.8	13.2	–2.00	–0.71	6	18.7	86.8	20.41	1.09
Belgium	7	2.9	18.3	–1.64	–0.58	6	14.8	81.7	11.94	0.81
Canada[(a)]	3	4.0	12.6	–3.21	–0.80	3	27.7	87.4	29.01	1.05
France	4	2.8	9.6	–1.16	–0.42	3	34.7	90.4	23.69	0.68
Germany	7	3.6	21.4	–1.62	–0.45	6	15.3	78.6	12.55	0.82
Italy	8	3.1	22.5	–1.36	–0.44	7	12.3	77.5	10.39	0.85
Japan	4	3.3	11.5	–2.51	–0.77	3	33.3	88.5	38.55	1.16
Netherlands	4	4.0	13.9	–2.09	–0.52	3	33.0	86.1	16.28	0.49
Spain[(a)]	4	3.0	10.3	–1.12	–0.37	4	26.0	89.7	16.87	0.65
Sweden[(a)]	4	4.5	13.6	–3.96	–0.88	4	28.5	86.4	18.32	0.64
UK[(a)]	4	4.8	15.6	–3.69	–0.78	4	25.8	84.4	17.17	0.67
US	5	3.4	15.3	–1.88	–0.55	4	23.5	84.7	26.38	1.12
Average	5	3.5	14.8	–2.19	–0.61	4	24.5	85.2	20.13	0.84

(a) Data thus far – the expansion continued beyond 2003.

Sources: OECD *Economic Outlook* No 77 database; authors' calculations

Table 3: Summary Statistics Concerning Growth Cycles in Selected OECD Countries
Band-pass filtered real GDP – 1970–2003

	Average downturns (downturn to upturn)					**Average upturns (upturn to downturn)**				
	Number of downturns	Duration (quarters)	Proportion of time in downturn (%)	Amplitude (% points)	Quarterly amplitude (% points)	Number of upturns	Duration (quarters)	Proportion of time in upturn (%)	Amplitude (% points)	Quarterly amplitude (% points)
Australia	7	6.3	37.0	3.51	0.56	7	10.7	63.0	3.34	0.31
Belgium	10	5.9	48.4	2.55	0.43	10	6.3	51.6	2.61	0.41
Canada	8	6.3	43.1	3.09	0.49	8	8.3	56.9	2.95	0.36
France	6	8.3	46.7	2.35	0.28	6	9.5	53.3	2.23	0.23
Germany	6	9.2	46.2	3.14	0.34	6	10.7	53.8	3.14	0.29
Italy	9	6.1	45.1	3.09	0.51	9	7.4	54.9	3.04	0.41
Japan	6	6.5	32.0	3.88	0.60	6	13.8	68.0	3.57	0.26
Netherlands	7	6.4	37.2	2.58	0.40	7	10.9	62.8	2.66	0.25
Spain	5	7.2	34.6	2.49	0.35	5	13.6	65.4	2.05	0.15
Sweden	7	9.0	52.9	3.34	0.37	7	8.0	47.1	3.19	0.40
UK	5	11.0	46.6	3.76	0.34	5	12.6	53.4	3.11	0.25
US	6	7.8	41.2	3.66	0.47	6	11.2	58.8	3.41	0.31
Average	7	7.5	42.6	3.12	0.43	7	10.2	57.4	2.94	0.30

Sources: OECD *Economic Outlook* No 77 database; authors' calculations

Table 4: The Amplitude of the Business Cycle has Declined
Standard deviation of the output gap, with trend GDP based on BP filter

	Period 1	Period 2	Period 3	Period 4
Australia	1.01	1.77	1.42	0.62
Belgium	1.39	1.05	1.01	0.88
Canada	1.03	1.81	1.71	0.92
France	1.01	0.75	0.91	0.89
Germany	1.41	1.17	1.26	0.71
Italy	1.92	1.14	1.00	0.62
Japan	1.97	0.95	1.19	1.13
Netherlands	0.93	1.33	0.93	0.89
Spain	1.51	0.59	1.26	0.63
Sweden	1.61	0.98	1.79	0.88
UK	1.62	1.55	1.51	0.41
US	1.91	1.89	1.02	0.96
Euro area	1.20	0.85	0.94	0.68

Note: Each period covers 35 quarters – Period 1: 1970:Q1–1978:Q3; Period 2: 1978:Q4–1987:Q2; Period 3: 1987:Q3–1996:Q1; Period 4: 1996:Q2–2004:Q4

Sources: OECD *Economic Outlook* No 77 database; authors' calculations

Table 5: Less Volatile Domestic Demand has Reduced the Amplitude of Business Cycles *(continued next page)*

		Total output gap variance	Contribution from total domestic demand	Contribution from trade	Residual
Australia	Period 1	na	na	na	na
	Period 2	3.14	3.70	–1.52	0.96
	Period 3	1.82	4.39	–3.40	0.83
	Period 4	0.38	2.64	–1.96	–0.31
Belgium	Period 1	1.94	3.02	–0.38	–0.70
	Period 2	1.11	3.04	–1.96	0.03
	Period 3	0.98	1.14	–0.11	–0.04
	Period 4	0.78	0.91	–0.11	–0.01
Canada	Period 1	1.05	2.55	–1.64	0.14
	Period 2	3.27	6.96	–4.05	0.37
	Period 3	2.77	2.99	–0.84	0.63
	Period 4	0.85	1.11	–0.43	0.17
France	Period 1	1.03	1.90	–0.90	0.03
	Period 2	0.56	0.94	–0.33	–0.04
	Period 3	0.84	1.03	–0.26	0.07
	Period 4	0.79	1.09	–0.43	0.13
Germany	Period 1	2.09	2.91	–0.62	–0.20
	Period 2	1.37	3.11	–1.57	–0.17
	Period 3	1.64	1.04	0.26	0.34
	Period 4	0.50	1.02	–0.56	0.04

Table 5: Less Volatile Domestic Demand has Reduced the Amplitude of Business Cycles *(continued)*

		Total output gap variance	Contribution from total domestic demand	Contribution from trade	Residual
Italy	Period 1	3.70	5.86	–2.66	0.51
	Period 2	1.30	2.66	–1.52	0.15
	Period 3	0.90	2.67	–2.10	0.33
	Period 4	0.39	0.52	–0.18	0.04
Japan	Period 1	3.88	22.41	–3.09	–15.44
	Period 2	0.91	4.65	–0.84	–2.90
	Period 3	1.43	4.57	–0.59	–2.56
	Period 4	1.27	1.31	–0.36	0.32
Netherlands	Period 1	0.86	2.83	4.02	–6.00
	Period 2	1.77	3.65	3.99	–5.87
	Period 3	0.82	1.73	3.03	–3.94
	Period 4	0.79	0.66	2.84	–2.71
Spain	Period 1	2.27	3.24	–1.38	0.41
	Period 2	0.35	1.51	–1.14	–0.02
	Period 3	1.42	3.33	–2.32	0.41
	Period 4	0.39	1.10	–0.59	–0.11
Sweden	Period 1	2.58	5.27	–2.01	–0.67
	Period 2	0.96	1.78	–1.15	0.33
	Period 3	2.86	3.55	–1.35	0.66
	Period 4	0.78	1.18	–0.61	0.21
UK	Period 1	2.62	2.82	–1.13	0.92
	Period 2	2.39	2.51	–0.97	0.84
	Period 3	2.24	3.54	–1.66	0.36
	Period 4	0.17	0.34	–0.11	–0.06
US	Period 1	3.66	5.28	–0.94	–0.68
	Period 2	3.56	5.14	–0.92	–0.65
	Period 3	0.95	1.31	–0.23	–0.13
	Period 4	0.92	1.25	0.18	–0.52

Notes: Each period covers 35 quarters – Period 1: 1970:Q1–1978:Q3; Period 2: 1978:Q4–1987:Q2; Period 3: 1987:Q3–1996:Q1; Period 4: 1996:Q2–2004:Q4. For Germany, Period 1 begins with 1971:Q1.

The variance of the output gaps is a proxy for the average size of the gap (since it measures the squared average distance from the gap mean, which is close to zero). The contributions to total output gap variance from the total domestic demand gap and the trade gap are calculated as a weighted average of their individual variances and their covariance. The residual is the discrepancy between the total output variance and the sum of its components, which is due to statistical discrepancies, averaging effects as well as the non-additivity of real expenditure components for countries using chain-weighted accounts. The gross contribution from trade denotes the isolated impact on output gap variance from the variance of export and import gaps. The covariance effect is mainly related to the strong positive covariance between the total domestic demand gap and the import gap, but includes also the covariance between the total domestic demand gap and the export gap as well as between the export gap and the import gap. See Dalsgaard, Elmeskov and Park (2002) for a fuller decomposition of the variance of output gaps.

Sources: OECD *Economic Outlook* No 77 database; authors' calculations

has continuously increased over the past 35 years. This modest contribution to economic stabilisation may signal, however, that in many countries domestic demand proved less volatile and less likely to trigger equilibrating trade flows. Increased domestic demand stability may partly reflect, in turn, improvements in the conduct of stabilisation policies, with monetary policy in particular putting a stronger emphasis on low and stable inflation. Moreover, as the relative size of the service sector has increased, and with technological innovations improving inventory management, the importance of stock-building to the cycle is less than it used to be.

2.3 Cross-country business cycle relationships in selected OECD countries

OECD economies have become increasingly integrated over the past half century, as trade and investment agreements reduced barriers and improved the climate for cross-border commerce. Today, trade openness in the OECD area is more than double the level in 1960 and foreign direct investment flows have soared. Altogether, this might be expected to result in more similar cycles across countries in terms of their intensity, duration and timing.

However, economic theory is not conclusive about the impact of increased trade on the degree of business cycle synchronisation. Very often, international trade linkages generate both demand- and supply-side spillovers across countries. For example, on the demand side an investment or consumption boom in one country can generate increased demand for imports, boosting other economies. Through these spillovers increased trade linkages result in more highly correlated business cycles. But business cycle co-movement could weaken in cases where increased trade is associated with increased inter-industry specialisation across countries and when industry-specific shocks are important in driving business cycles.[10]

Of course, there are reasons why business cycles do not move in tandem despite increased global integration. Some economies are more susceptible to shocks than others. For instance, economies that are well endowed with commodities, such as Australia, tend to experience greater variation in prices than economies specialised in services, and are therefore more susceptible to wider cyclical movements. Moreover, even if a shock is transmitted internationally, differences in the domestic structure of economies matter. How quickly and at what cost an economy is able to absorb the shock varies, depending on the structure and policy environment (see Section 3). Put succinctly, the degree to which the business cycle has become synchronised across OECD economies is intrinsically an empirical issue.

In this section of the paper, we therefore examine the statistical evidence for growth cycle synchronisation, looking at three aspects: the timing of growth cycle turning points across countries; the length of time cycles are in a similar phase with the cycle in the US; and the similarity of cycles with respect to the intensity of output co-movement across countries.

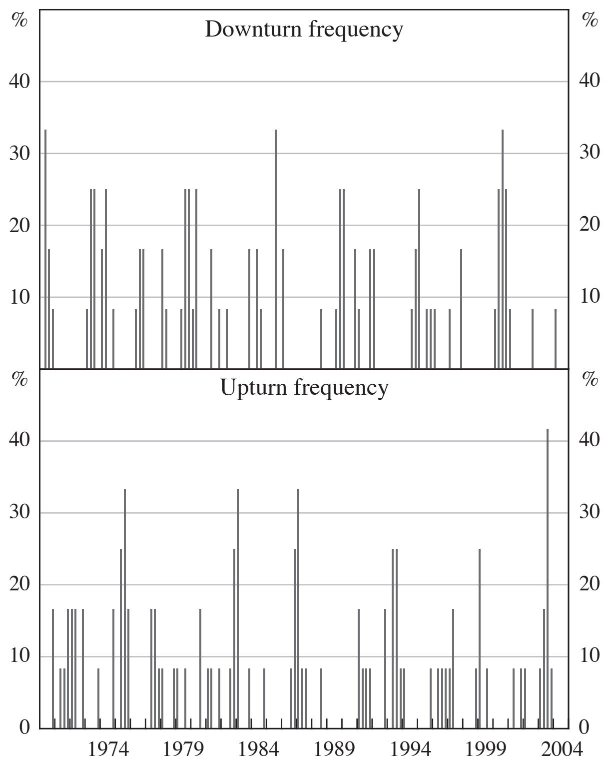
10. See Kose and Yi (2005) for a discussion on trade linkages and co-movement.

2.3.1 The timing of the most recent cycle was closely synchronised

The simplest way to approach business cycle synchronisation is to compare turning point dates across OECD countries. This can be achieved, based on the chronology of growth cycles, by examining the density of national turning points at each point in time (Figure 1). A series of closely grouped turning points is indicative of synchronisation. On this basis, there is no clear pattern toward greater or less synchronisation in the timing of turning points. The one possible exception is the most recent downturn in 2001, which was prompted by a global shock. The recovery phase was also tightly grouped, though not all countries in the sample participated in the recovery. Section 3.1 examines the nature of the most recent cycle compared with earlier ones and the differences in the forces driving recoveries across countries.

Figure 1: The Timing of Growth Cycle Turning Points is Disperse

Per cent of countries



Sources: OECD *Economic Outlook* No 77 database; authors' calculations

2.3.2 The duration of phase synchronisation with the US varies widely

Another aspect of business cycle synchronisation is the proportion of time two cycles are in the same phase. Figure 2 plots the output gap in each country as well as for the US. The bar at the bottom of each panel indicates periods when the two output gaps move in the same direction. What is evident from the graphs is the higher proportion of time that Australia (62 per cent), Canada (75 per cent) and the UK (76 per cent) are in the same phase over the period 1970 to 2004, compared with the euro-area countries (56 per cent). The same calculations show that individual euro-area countries are much more often in phase with the euro area than the US (not shown). In both cases, there is no clear-cut trend towards increased synchronisation of phases over time.

We also examine whether the above stylised facts are corroborated using the statistical framework suggested by Harding and Pagan (2002). They propose examining the degree of concordance between two cycles using the measure:

$$C_{ij} = T^{-1} \sum_{t=1}^{T} \left\{ S_{i,t} \bullet S_{j,t} + \left(1 - S_{i,t}\right) \bullet \left(1 - S_{j,t}\right) \right\} \qquad (1)$$

where $S_{i,t}$ represents the business cycle phase of country i at time t (1 represents expansion, 0 contraction), $S_{j,t}$ is defined similarly for country j and T is the sample size. The measure thus ranges between 0 (business cycles are mirror-images of each other) and 1 (perfect synchronisation). The values in Table 6 in general closely mirror the degree of phase synchronisation shown in Figure 2 and in most cases the concordance statistic is significant.[11] The average degree of concordance suggests the output gaps in these countries move in the same phase 64 per cent of the time, a result which is robust to different sample periods.

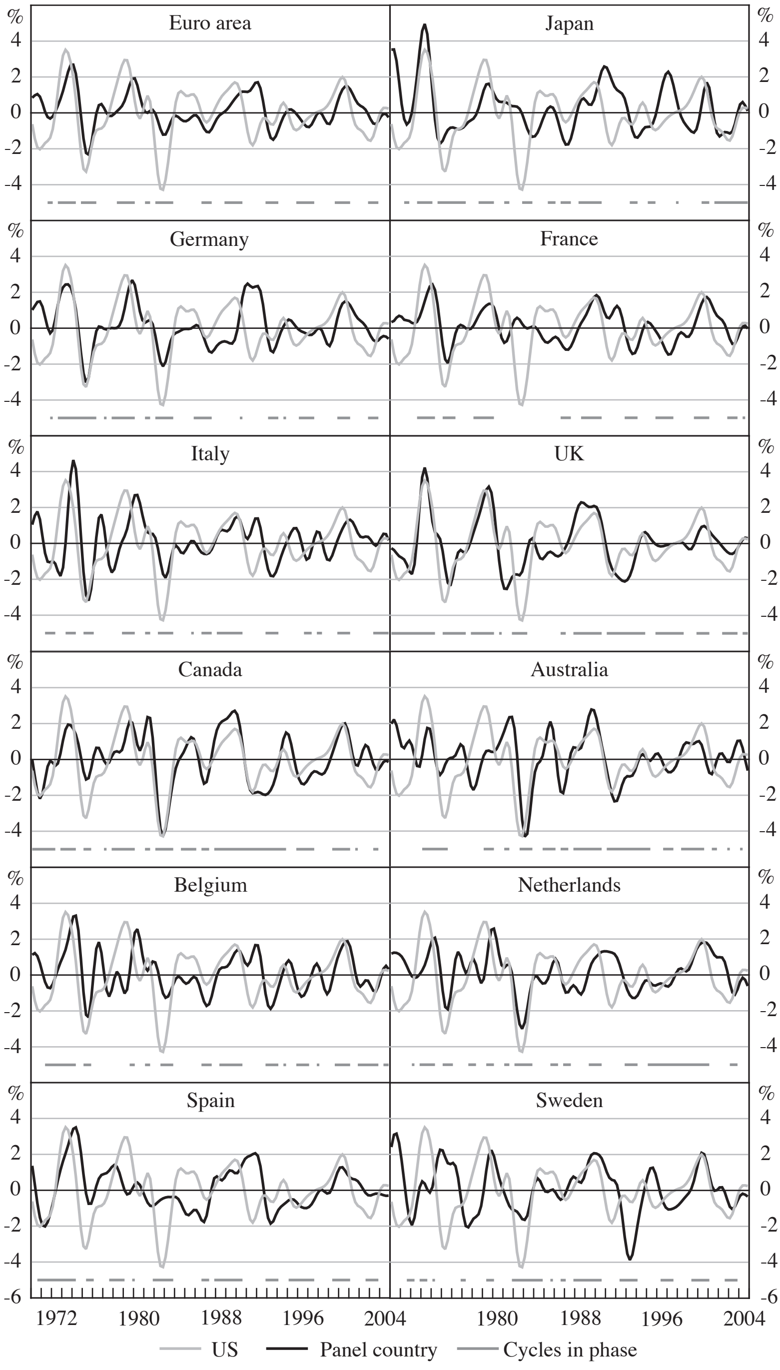
2.3.3 The intensity of cycle synchronisation

In addition to the timing and direction of bilateral movements in output gaps, the intensity of cycle co-movement matters, especially for policy-makers within a common currency area. In this respect, the size of the bilateral correlation coefficient between the output gap in one country and in another is a crude measure of the intensity of cyclical co-movement across countries. In our calculations, the average bilateral correlation among the countries in this study between 1970 and 2004 is 0.5. This likely understates the extent of cross-border business cycle linkages since the transmission of shocks from one country to another involves lags that are not captured, even for filtered series based on a moving average technique, with contemporaneous bilateral correlations.

11. The critical values for the concordance statistic are computed from a formula based on Monte Carlo simulations and reported in McDermott and Scott (2000). To compute the significance levels requires the assumption that the change in the output gap series is normally distributed and the underlying process is a pure random walk, which is not always the case.

Figure 2: Synchronisation of Output Gap Movements with the US is High

Per cent deviation of actual GDP from trend GDP



Notes: Output gap measures are computed using a band-pass filter. The bar at the bottom of each panel indicates the period when US and panel country business cycles are in the same phase.

Sources: OECD *Economic Outlook* No 77 database; authors' calculations

Table 6: The Concordance of Growth Cycles Across Selected OECD Countries
1970–2004

	Australia	Belgium	Canada	Germany	Spain	France	UK	Italy	Japan	Nether-lands	Sweden	US	Euro area
Australia	1	0.53	0.65**	0.54	0.46	0.55	0.51	0.65**	0.57	0.54	0.61*	0.61**	0.57
Belgium		1	0.68***	0.71***	0.71***	0.75***	0.59*	0.82***	0.63**	0.73***	0.75***	0.65**	0.80***
Canada			1	0.69***	0.58	0.66***	0.64**	0.64**	0.62**	0.65**	0.69***	0.80***	0.66***
Germany				1	0.56	0.69***	0.71***	0.74***	0.75***	0.74***	0.69***	0.61**	0.85***
Spain					1	0.66***	0.54	0.59*	0.53	0.69***	0.61*	0.64**	0.63**
France						1	0.67***	0.73***	0.59	0.65**	0.70***	0.67***	0.74***
UK							1	0.59*	0.58*	0.52	0.64**	0.61**	0.61**
Italy								1	0.66**	0.72***	0.70***	0.57	0.88***
Japan									1	0.66**	0.58	0.61**	0.67**
Netherlands										1	0.66***	0.58	0.76***
Sweden											1	0.64**	0.69***
US												1	0.59*
Euro area													1

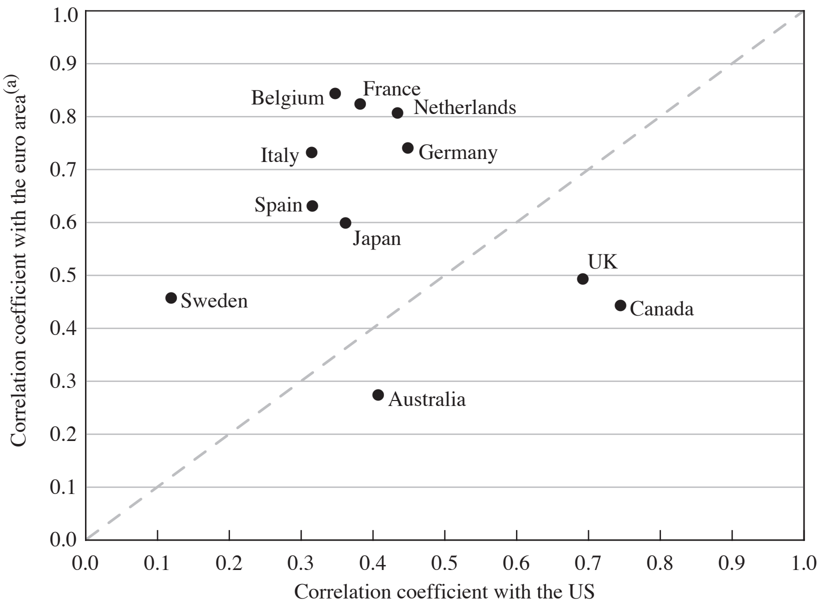
Notes: ***, ** and * denote concordance statistic significance at the 1, 5 and 10 per cent levels, respectively.
Gap based on trend GDP as calculated with BP filter (6,32), K=12.

Sources: OECD *Economic Outlook* No 77 database; authors' calculations

Generally, the euro-area countries are more highly correlated with the rest of the euro area than the US. In contrast, Australia and Canada's cycles are relatively more closely synchronised with the US (Figure 3). The UK's greater correlation with the US than the euro area appears puzzling, given the country's close economic ties with the euro area. However, the correlation coefficient mixes characteristics of duration and amplitude into one measure and common shifts in amplitude may be hard to interpret in terms of diffusion and propagation of output fluctuations. An example of such ambiguity may occur when for autonomous reasons – such as universally improved stabilisation policies – countries share a common trend of decreasing output volatility.

Figure 3: Correlation Coefficients of National Output Gaps with the Euro Area and the US

1970–2004



(a) For the calculation of the correlation coefficient, the euro-area aggregate excludes the euro-area country concerned.

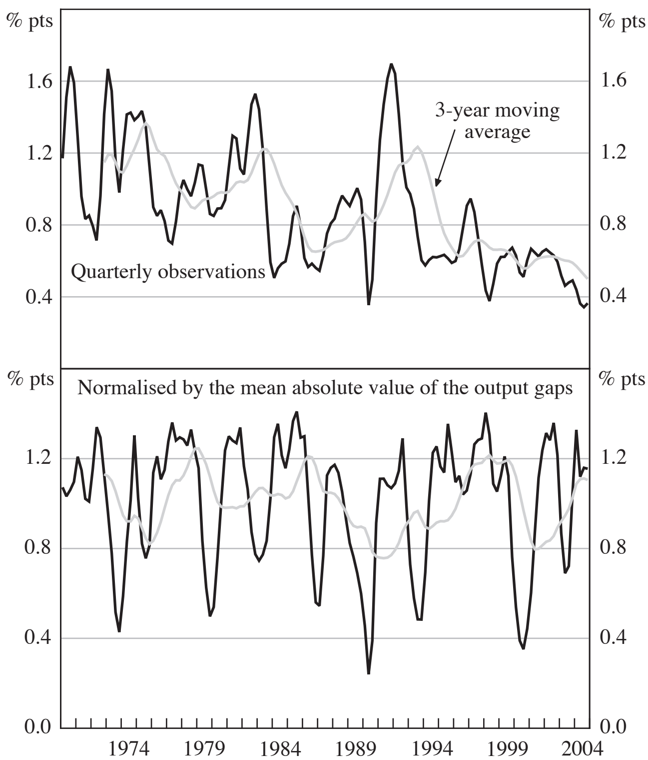
Sources: OECD *Economic Outlook* No 77 database; authors' calculations

The above measures provide a sense of business cycle convergence on average over the period. But they are not well suited to gauge whether synchronisation – in the sense of propagation – has risen over time. Stronger propagation seems likely, however, not least given the increased size of household and corporate balance sheets, with assets whose prices are determined in world markets. One proxy for measuring the changing degree of cycle synchronisation is to examine how the standard deviation of output gaps across countries has evolved. If this measure were consistently zero over time, it would indicate that business cycles in the 12 countries in this study have the same timing and amplitude. On this basis, there is certainly a clear trend towards less divergent cycles over time (Figure 4, top panel).

However, since other measures of cyclical convergence (timing of turning points, proportion of time in the same phase of the cycle) do not suggest a clear-cut trend toward increased synchronisation, the reduction in output gap dispersion is also likely to reflect the fact that output gaps on average have become smaller over time. Indeed, when the standard deviation of output gaps across countries is normalised by the average absolute value of the gap to control for the effect of smaller gaps there is no clear downward trend over time (Figure 4, bottom panel).

Figure 4: Business Cycle Divergence Across Countries

Standard deviation across countries of output gaps, calculated using a BP filter



Sources: OECD *Economic Outlook* No 77 database; authors' calculations

In summary, these statistics indicate that the amplitude of cycles has diminished over the past 35 years. There has perhaps also been a slight tendency towards fewer and longer growth cycles. Regarding the synchronicity of cycles among the countries examined in this paper, there is a high degree of co-movement in the cycle phase and in the average intensity of co-movement. However, cycle turning points display limited synchronicity and while overall there appears to be a trend towards increased convergence, this seems at least partially linked to the reduced amplitude of cycles in individual countries.

3. Forces Bearing on OECD Business Cycle Dynamics

3.1 Sources of divergence in the current cycle

What is striking with the volatility statistics discussed above is that they do not clearly suggest that the current characteristics of the cycle are notably different across OECD countries. This is despite the now widespread perception that a group of 'successful' countries (Australia, Canada, Ireland, New Zealand, the Nordic countries and the UK) did much better than average to weather the 2001 global slowdown, while large continental European countries seem mired in a low activity trap. Such a discrepancy may reflect the difficulty of using statistical filters to distinguish between persistently weak demand and lower trend output, especially at the end of samples. By contrast, volatility statistics computed with OECD traditional production function-based trend output yield a somewhat different picture, and are closer to intuition (Figure 5).

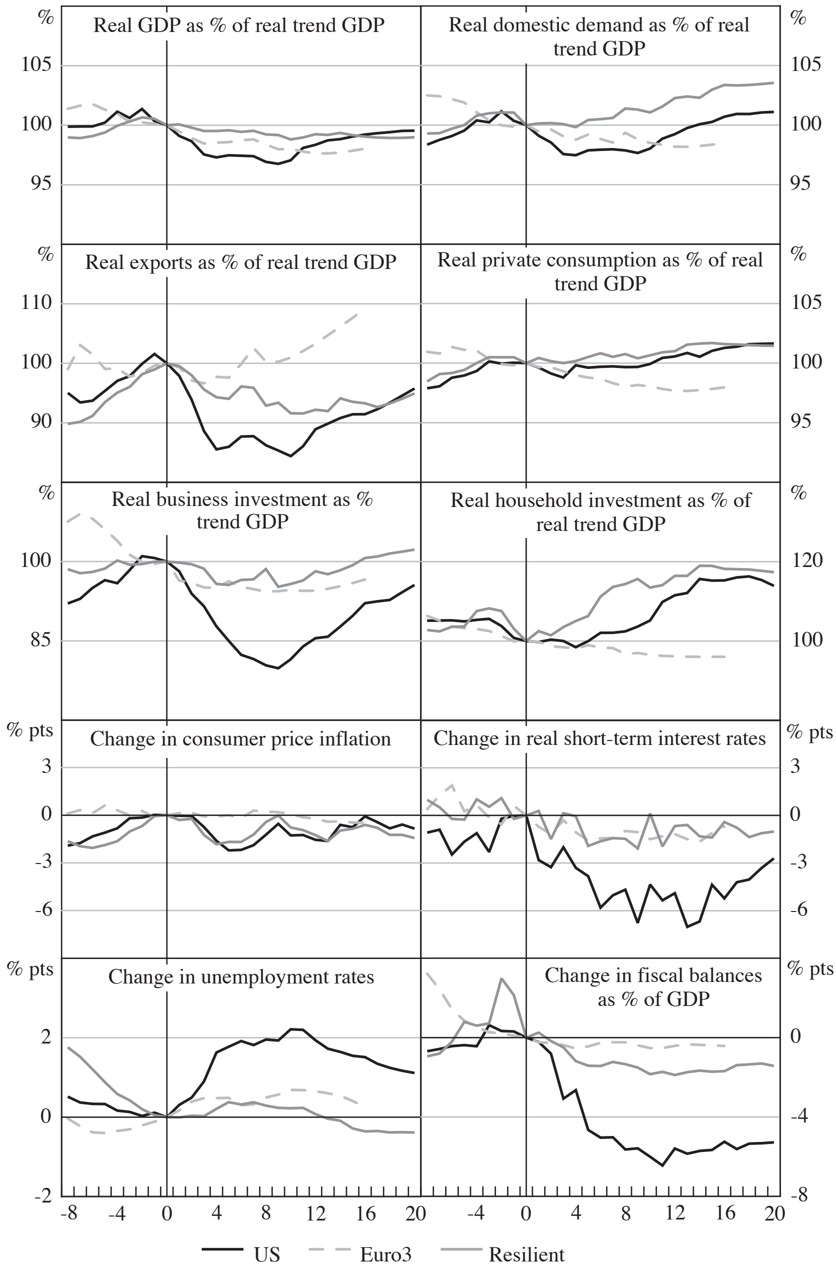
This picture is one of distinct resilience (that is, avoiding long periods away from equilibrium following negative shocks) in the successful group in reaction to the 2001 slowdown. Even though the downturn in all countries was to a large extent prompted by a worldwide demand shock, related to the bursting of bubbles in equity prices and over-investment in ITC equipment, growth relative to trend barely slowed in Australia, Canada, Spain, the UK and some others, whereas the large continental European economies, and hence the euro area as a whole, faced a protracted slowdown. Furthermore, the pace of recovery remains more subdued in the euro area, with the output gap projected to widen further, before starting to close very slowly over the next two years.

The current situation, with the English-speaking and Nordic countries faring well, stands in stark contrast with the experience of previous slowdowns when these same economies showed fragility during the slowdown and a lack of responsiveness in the upswing (Figure 6). On the contrary, developments in the euro area are similar to previous cycles, suggesting that its relatively lower degree of resilience does not represent an entirely new phenomenon.

A notable difference across country groups in the current cycle has been the behaviour of private consumption and residential investment. In stark contrast with previous episodes, these have shown strength both in the US and in the successful economies, offsetting weakness in the more externally exposed sectors. In contrast, household demand in the euro area failed to buffer the slowdown and support recovery, in line with past experience. Moreover, it appears that these differences can only be partly attributed to disparities in the stance of macroeconomic policy, since a similar aggregate response of monetary and, to a somewhat lesser degree, fiscal policies was observed in both groups of countries (see Figure 5, lower two right-hand panels).[12] This suggests that more fundamental or structural factors are

12. If exchange rate developments are taken into consideration, then euro-area monetary conditions hardly changed.

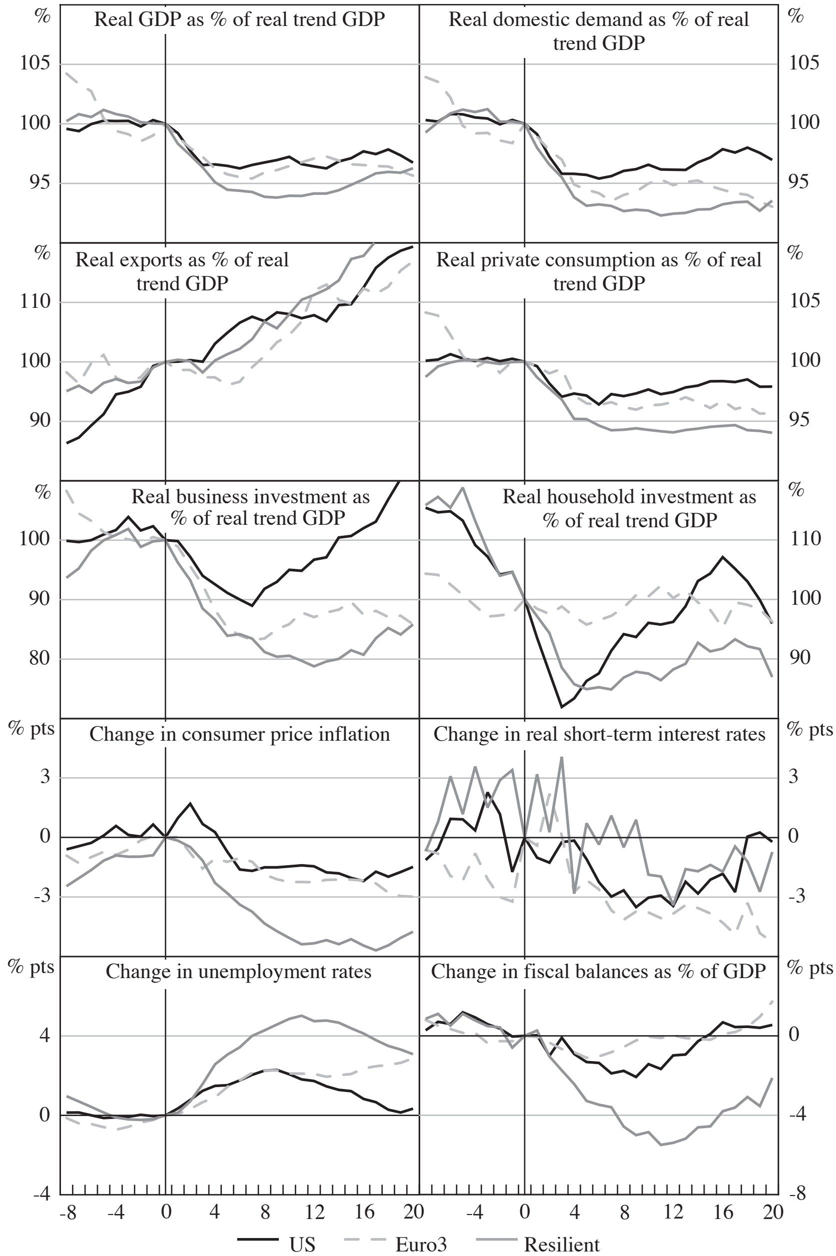
Figure 5: Sources of Divergence in the Most Recent Business Cycle



Notes: Euro3 = France, Germany and Italy. Resilient group = Australia, Canada, Spain and the UK. Most recent cycle peaks: 2000:Q4 for Australia, Canada, Spain, the UK and the US; 2002:Q3 for France and Germany; and 2002:Q4 for Italy. For Australia, Canada, Spain and the UK, the cycle turning points are based on changes in the output gap.

Sources: OECD *Economic Outlook* No 77 database; authors' calculations

Figure 6: Sources of Divergence in the Previous Business Cycle



Notes: Euro3 = France, Germany and Italy. Resilient group = Australia, Canada, Spain and the UK. Previous cycle peaks: 1990:Q2 for Australia, the UK and the US; 1990:Q1 for Canada; and 1992:Q2 for France, Germany, Italy and Spain.

Sources: OECD *Economic Outlook* No 77 database; authors' calculations

behind divergences in the capacity of the economies to absorb and recover from shocks, including differences in the effectiveness of macroeconomic policies, especially through their influence on domestic demand. The following section examines some of the underlying causes of those differences in the capacity to absorb adverse shocks and speedily recover in their aftermath.

3.2 Why did successful economies become more resilient?

3.2.1 A hypothesis that attributes strong resilience to good structural policies

There are a number of possible linkages between structural policies, growth and resilience that can be invoked to explain how strong long-term growth may also increase short-term adaptability to shocks. These include:

- structural regulatory settings could serve to accelerate the speed of real wage adjustment and to reduce the persistence of unemployment.[13] This will generally lead to shorter deviations of actual output and employment from equilibrium.[14] Also, faster reversals of unemployment to equilibrium reduce the risk that hysteretic effects set in and, therefore, that adverse shocks will permanently lower employment rates;
- regulatory settings, favourable to the development of financial markets, could also contribute to greater consumption smoothing by providing households with better access to credit markets, allowing them to borrow against the least liquid component of their wealth, namely housing.[15] As well, it is likely that flexible and diversified financial markets tend to strengthen the elasticity of domestic and household demand to interest rates (see Section 3.2.2 below);
- flexible product and labour market regulations could speed the recovery process following an adverse shock to the extent that factor reallocation is enhanced. Moreover, by facilitating the process of creative destruction, light regulation may enhance the expansion phase once it takes hold;[16] and
- labour market policies that lead to low structural unemployment and short unemployment duration spells tend to reduce precautionary saving.

13. Differences in structural policy and institutions, to the extent that they imply differences in the speed of real wage adjustment across countries, have been identified as one of the reasons why a number of large common shocks in the 1970s and 1980s led to diverse unemployment experiences across countries. See, for example, Bertola, Blau and Kahn (2002), Blanchard and Wolfers (2000), Fitoussi *et al* (2000) and OECD (1994).

14. It is equally possible that the deviations are shallower, depending on the source of the shocks.

15. See, for example, Catte *et al* (2004).

16. See, for instance, Bergoeing *et al* (2002), Caballero and Hammour (2001) and Davis, Haltiwanger and Schuh (1996).

To illustrate the effect of flexible labour, product and capital markets and strong monetary policy transmission mechanisms on the degree of resilience of economies, recent OECD work developed a small simulation model with alternative calibrations to replicate economic structures in the US and the euro area.[17] The US model is able to replicate the key properties of the Federal Reserve Board's FRB-US model of the US economy. However, for the euro-area model to display similar properties shown by the European Central Bank's (ECB) Area-Wide Model it was necessary to make adjustments to reflect rigidities in product and labour markets. This was done by lengthening lag structures in price and wage setting and by reducing the impact that any disequilibria have on behaviour. Once calibrated to capture the general workings of the US and euro-area economies, these maquettes can be used to simulate the economic consequences of various shocks. The results broadly suggest that an economy characterised by rigidities tends to be less resilient.

3.2.2 OECD empirical work tentatively supports a relationship between price rigidities and regulatory settings

There is empirical support for the notion that structural policies and institutions in the euro area prolong adjustment and bear adversely on the effectiveness of monetary policy. Concerning, for example, the length of time to adjust to a shock, OECD work has examined why consumer price inflation in the euro area has remained persistently above the ECB's 2 per cent objective even through periods when the output gap was clearly negative.[18] In contrast, prices seem to adjust upwards in a normal manner when capacity constraints are evident.

The responsiveness of prices to output developments was thus explored by estimating an asymmetric Philips curve for a panel of 17 OECD countries, including various non-euro-area economies. Apart from linking inflation to a measure of inflation expectations and the output gap,[19] the model included an interaction term with the output gap to capture the effects of structural rigidities on the cycle. The rigidity indicators used in the regressions were the strength of employment protection legislation and the tightness of product market regulations.[20] The model was estimated with quarterly data over the period 1985 to 2004 using Panel Ordinary Least Squares.

The main result from the analysis is a statistically significant link between more rigid regulatory settings and a weaker response of prices to a negative output gap. Since the euro-area countries score higher on these measures of structural rigidity than

17. See Drew, Kennedy and Sløk (2004).
18. See Cournède, Janovskaia and Van den Noord (2005).
19. The output gap series is from the OECD's Analytical Database. Robustness of the regression results was examined, *inter alia*, using a univariate estimate of the output gap.
20. The structural policy variables are defined on a 0–5 scale, with higher values corresponding to more centralised wage coordination or stricter regulation. The degree of concentration in wage bargaining was also examined, but the estimation results are less convincing.

the English-speaking countries in the sample, the simulated response of inflation to a widening negative output gap is much weaker in most of the euro area (Table 7).

This result implies that the sacrifice ratio in the 'rigid' euro area is larger than in the 'flexible' English-speaking countries. Another dimension to resilience, also influencing the size of the sacrifice ratio, is the speed and magnitude with which monetary policy responses to shocks are transmitted through economies. In this regard, other recent OECD work has examined whether the structure of housing and mortgage markets influences the effectiveness of monetary policy.[21] The focus on the housing market is not accidental. It is motivated by the stylised fact, observed

Table 7: The Impact of Weak Economic Activity on Inflation
Simulated inflation fall induced by a 1 percentage point wider negative output gap[(a)]

	Structural indicator used in the regression	
	Employment protection legislation	Product market regulation
Euro-area countries		
Austria	0.1	0.2
Belgium	0.4	0.2
Finland	0.2	0.3
France	0.2	0.1
Germany	0.1	0.3
Italy	0.4	0.1
Netherlands	0.0	0.2
Spain	0.0	0.2
Other countries		
Australia	0.5	0.3
Canada	0.5	0.4
Denmark	0.4	0.2
Japan	0.2	0.3
New Zealand	0.5	0.3
Norway	0.0	0.2
Sweden	0.1	0.3
UK	0.6	0.4
US	0.8	0.4

(a) Inflation is measured as the annualised quarterly change in the consumer price index. The results shown here are based on the coefficients drawn from regressing inflation on the previous period output gap, on its interaction with the corresponding rigidity index, on expected inflation and on other variables.

Sources: The sources for the data and indicators underlying the calculations are described in Cournède *et al* (2005).

21. See Catte *et al* (2004).

above, that a source of divergence across countries in the current cycle relates to the behaviour of residential investment.

The study finds a strong linkage from house prices to activity through wealth channels affecting personal consumption, in line with other research.[22] Housing markets are also important in the transmission of monetary policy. A high interest rate sensitivity is beneficial as it implies that monetary policy is more powerful in boosting or damping cyclical fluctuations. But the effects of monetary policy on activity, as measured by the impact of policy-determined interest rate changes on housing market interest rates and then on house prices and wealth, differ considerably across OECD economies. These differences in the size and speed of interaction between housing and the business cycle can be partly traced back to differences in institutional features of housing and mortgage markets, such as the type of mortgage interest rate regime that predominates (that is, floating or fixed) and the costs of refinancing (Table 8). Those countries where the degree of mortgage market 'completeness' is high[23] are associated with a larger estimated long-term marginal propensity to consume out of housing wealth. This suggests that the mortgage market is pivotal in translating house price shocks into spending responses. Indeed, the close relationship of mortgage market 'completeness' with real house price–consumption correlations and housing equity withdrawal (HEW) illustrates the crucial role played by the provision of liquidity in connection with housing assets (Figure 7).[24]

Overall, these studies suggest that structural policies do not only bear on long-term growth, but also on cyclical developments, through two broad channels. The first is by inhibiting or slowing the pace of adjustment to shocks and the second is via weakening the effectiveness of stabilisation policies. However, it could reasonably be argued that the differences across countries in the recent cycle simply reflect more frequent and larger idiosyncratic shocks in the euro area or different policy responses. The next section evaluates this possibility using a methodology that explicitly takes into consideration differences in the source and size of shocks as well as the contribution of macroeconomic policies.

22. See, for example, Pichette and Tremblay (2003) for Canada; Case, Quigley and Shiller (2001) and Benjamin, Chinloy and Jud (2004) for the US; Deutsche Bundesbank (2003) for Germany; OECD (2003a) for the UK; Dvornak and Kohler (2003) for Australia; and Ludwig and Sløk (2004) for a panel of seven countries.

23. See Mercer Oliver Wyman (2003) for details on the compilation of the index. The index is calculated for the eight countries shown in Table 8.

24. More generally, ongoing work at the OECD is examining the linkages between financial market development and output growth.

Table 8: Mortgage Market Completeness – Range of Mortgage Products Available and Borrowers Served in Eight European Countries *(continued next page)*

	Denmark	France	Germany	Italy	Netherlands	Portugal	Spain	UK
LTV ratios								
Typical	80	67	67	55	90	83	70	69
Maximum	80	100	80	80	115	90	100	110
Variety of mortgage products								
Rate structure								
Variable	**	**	**	**	**	**	**	**
Variable (referenced)	**	**	–	**	**	**	**	**
Discounted	–	**	–	*	–	–	**	**
Capped	**	**	*	*	**	–	*	**
Range of fixed terms								
2–5	**	**	**	**	**	*	*	**
5–10	**	**	**	**	**	*	*	*
10–20	**	**	**	*	**	–	*	*
20+	**	*	*	*	*	–	*	–
Repayment structures								
Amortising	**	**	**	**	**	**	**	**
Interest only	*	**	**	*	**	–	–	**
Flexible	*	**	–	*	**	–	*	**
Fee-free redemption[(a)]	**	–	–	–	–	–	–	*
Full-yield maintenance fee	**	*	**	*	**	*	*	*

Table 8: Mortgage Market Completeness – Range of Mortgage Products Available and Borrowers Served in Eight European Countries *(continued)*

	Denmark	France	Germany	Italy	Netherlands	Portugal	Spain	UK
Range of borrower types and mortgage purposes								
Borrower type								
Young household (<30)	**	*	**	*	*	**	**	**
Older household (>50)	**	*	*	*	**	*	*	**
Low equity	–	**	*	–	*	*	*	**
Self-certify income	–	–	–	–	*	–	*	*
Previously bankrupt	*	–	–	–	–	–	–	*
Credit impaired	*	*	–	*	*	–	*	**
Self-employed	**	*	**	**	*	**	**	**
Government-sponsored	*	**	*	*	*	**	*	*
Purpose of loan								
Second mortgage	**	*	**	**	**	**	**	**
Overseas holiday homes	**	**	*	**	*	–	–	**
Rental	**	**	**	**	**	**	**	**
Equity release	**	–	*	**	**	–	*	**
Shared ownership	**	*	*	*	*	**	–	**
Mortgage market completeness index[(b)]	75	72	58	57	79	47	66	86

Notes: ** readily available; * limited availability; – no availability

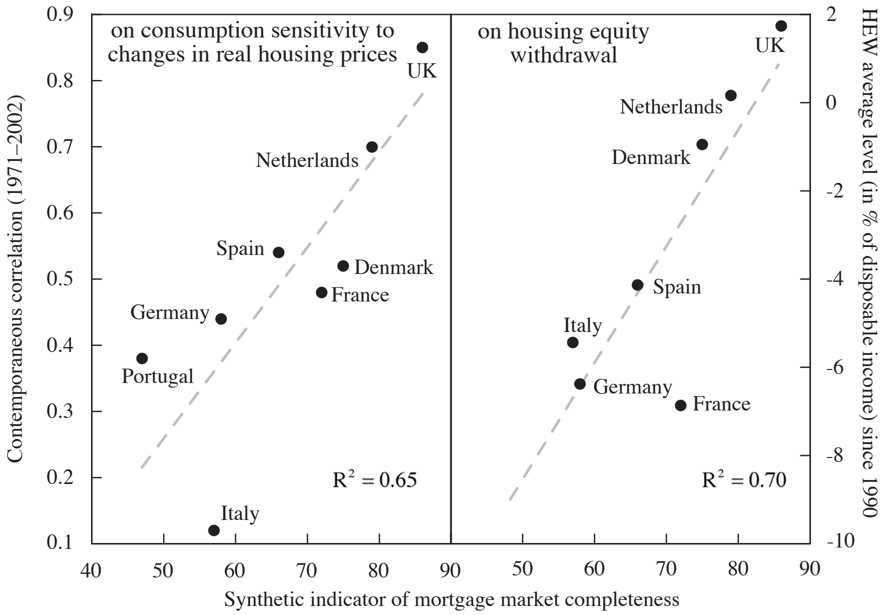
'Readily available' means that products are actively marketed with high public awareness. 'Limited availability' means that only a small subset of lenders provide this product, often with additional conditions. 'No availability' means that no lenders surveyed offered the product. See Mercer Oliver Wyman (2003) for further details on the sample and criteria of the survey.

(a) On fixed-rate products only

(b) Higher scores indicate more complete markets. See Mercer Oliver Wyman (2003) for details on the calculation of the index.

Source: Mercer Oliver Wyman (2003)

Figure 7: Effects of Mortgage Market Completeness



Notes: HEW is for housing equity withdrawal.
The synthetic indicator of mortgage market completeness is presented in Table 8 (for additional information see Mercer Oliver Wyman 2003). For Portugal, the contemporaneous correlation between consumption and real house price change is calculated over the period 1989–2001, due to limited data availability.

Sources: Banco de España; Bank of Canada; Banque de France; Board of Governors of the Federal Reserve System; De Nederlandsche Bank; European Central Bank; Japan Statistics; Mercer Oliver Wyman (2003); OECD; Office for National Statistics; Statistics Canada

3.2.3 Towards a better understanding of the output costs of differences in resilience

More sophisticated empirical techniques are required to move towards a better understanding of the cost of slow adjustment to shocks, in terms of cumulative output losses, and the role played by structural policies. Initial and ongoing OECD work on this issue is based on the estimation of structural vector-autoregression (SVAR) models for the G7 countries and Spain (because it is a large euro-area country and is also one of the few that appeared resilient to the recent downturn), similar to those recently developed in Buckle *et al* (2002) and Dungey and Pagan (2000).

The SVAR system allows an analysis of different country responses to standardised shocks. And a cross-country comparison of the responses provides a better indication of the degree of resilience than merely looking at the data since it corrects for the possibility that countries have faced shocks of uneven magnitude and/or different types of shocks. Moreover, the inclusion of equations representing monetary and fiscal policy makes it possible to isolate the impact of automatic and discretionary macroeconomic policy actions on cyclical movements, thereby giving an indication of cross-country differences in resilience that are related to the structural characteristics of countries.

The SVAR approach is equally subject to weakness and limitations. First, the economic interpretation of the estimated shocks is largely dependent on the identifying power of the restrictions imposed on the system; second, the estimation assumes that the underlying structural relationships have been stable over the estimation period; and third, the omission of shocks may affect the results. The specific application of the SVAR models also involves a number of caveats. For instance, it has not been possible to estimate the models taking into consideration possible asymmetric effects between positive and negative gaps in output and other data. Moreover, the gap series have been calculated using a HP filter with a common smoothing parameter across all countries and all series.[25]

Bearing in mind these caveats, the early results from this work tend to confirm the apparent differences in the degree of resilience based on the behaviour of output in the recent cycle. Canada, the UK and the US appear to respond relatively rapidly to all, or most, of the seven shocks analysed, and the cost of shocks in terms of output displacement during the adjustment period is relatively small (Tables 9 and 10).[26] This corroborates *prima facie* evidence that these economies are more resilient and may in part explain the different pattern of recoveries from the recent cycle.

In contrast, Germany is found to be a slow adjuster and to incur costly adjustments to most of the shocks, especially in the case of shocks to the globalised parts of the economy. Compared with the US, the adjustment time in Germany is over a year longer on average across shocks. For the other countries included in the study, the speed of output adjustment and the overall cost in terms of cumulative output losses varies significantly across shocks. The shock to inflation (that is, a temporary supply shock) consistently causes the largest negative displacement. The higher relative cumulative output costs seen in the European countries under this shock are consistent with estimates of higher output sacrifice ratios for the euro area, and provide indirect evidence of structural policy settings that hamper adjustment.

The SVAR models were also utilised to decompose past movements in output gaps into their main driving forces.[27] The rationale for doing this is to assess whether relative lack of resilience in the larger euro-area economies, particularly Germany,

25. Ongoing work is examining the sensitivity of the results to different detrending approaches for output and other economic series. The preliminary findings presented in this paper, although interesting, should nonetheless be treated with some caution.

26. The shocks applied are one standard deviation of the estimated structural errors and the reported adjustment times in Table 9 are taken directly from the impulse response profiles. However, because volatility is often exhibited in these profiles during the first year, calculating the initial cycle response times ignores the response profile in the first year.

27. See OECD (2004) for details on the methodology. While such decompositions can provide valuable information about business cycle dynamics, they are dependent on the underlying, highly simplified model. In practice, economies are subject to a myriad of economic forces, some of which may be idiosyncratic to a country or a specific time period.

Table 9: Adjustment Times for Impulse Response Profiles
Quarter in which variable completes initial cycle

Shock to:	World output	Oil prices	Externally focused demand	Domestically focused demand	Inflation	Fiscal policy	Interest rate	**Simple average**
				Output				
US	7	10	16	6	10	4	16	**9.9**
Japan	13	20	10	10	20	16	10	**14.1**
Germany	13	16	14	10	20	12	16	**14.4**
France	14	18	8	11	11	16	5	**11.9**
UK	10	15	10	9	13	9	12	**11.1**
Italy	13	16	12	7	19	10	10	**12.4**
Canada	10	13	10	13	10	5	18	**11.3**
Spain	20	13	11	9	9	9	13	**12.0**
Average adjustment	**13**	**15**	**11**	**9**	**14**	**10**	**13**	**12.1**
				Domestically focused demand				
US	12	10	13	6	12	6	10	**9.9**
Japan	16	22	13	8	22	12	10	**14.7**
Germany	14	14	16	12	22	12	16	**15.1**
France	14	19	10	13	9	16	6	**12.4**
UK	10	15	10	8	13	9	8	**10.4**
Italy	20	12	18	16	16	16	12	**15.7**
Canada	8	10	6	14	7	20	20	**12.1**
Spain	25	16	12	11	10	10	9	**13.3**
Average adjustment	**15**	**15**	**12**	**11**	**14**	**13**	**11**	**13.0**
				Inflation				
US	12	12	14	10	10	12	10	**11.4**
Japan	16	20	12	10	22	24	20	**17.7**
Germany	19	19	20	14	14	16	16	**16.9**
France	26	16	16	22	22	12	10	**17.7**
UK	16	10	18	14	13	16	13	**14.3**
Italy	22	19	13	19	19	18	18	**18.3**
Canada	10	10	16	15	12	12	18	**13.3**
Spain	28	18	16	12	11	8	10	**14.7**
Average adjustment	**19**	**16**	**16**	**15**	**15**	**15**	**14**	**15.5**

Source: OECD

Table 10: Adjustment Costs for Output

Ratio of cumulative gap of output responses to cumulative gap of variables shocked

	World output	Oil prices	Externally focused demand	Domestically focused demand	Inflation	Interest rate	Fiscal policy	**Simple average absolute value**	**Average excluding policy shocks**
US	0.25	–0.01	0.20	0.11	–0.09	–0.83	0.04	**0.22**	**0.13**
Japan	0.25	–0.02	0.28	0.99	–0.44	0.06	–0.55	**0.37**	**0.40**
Germany	0.59	–0.05	0.93	0.58	–0.48	–0.69	–1.29	**0.66**	**0.53**
France	0.62	–0.03	0.27	0.56	–0.35	–0.02	0.11	**0.28**	**0.37**
UK	0.12	–0.03	0.14	0.20	–0.38	–0.63	0.02	**0.22**	**0.17**
Italy	0.20	–0.01	0.16	0.25	–0.33	–0.22	–0.04	**0.17**	**0.19**
Canada	0.33	–0.04	0.43	0.36	–0.24	–0.25	0.06	**0.24**	**0.28**
Spain	0.54	–0.01	0.23	0.41	–0.27	–0.10	–0.12	**0.24**	**0.29**
Average values	**0.34**	**–0.02**	**0.34**	**0.44**	**–0.33**	**–0.37**	**–0.24**	**0.30**	**0.29**

Source: OECD

suggested by the SVAR results is structural in nature (including less favourable macroeconomic policy settings), or whether it can be explained by 'bad luck' (larger negative shocks to these economies). The model analysis confirms that the response of monetary and fiscal policies has played an important role in buffering the negative shock in the US in the most recent period. However, even after purging the impact of macroeconomic policy and shocks to the globalised parts of the economy, the growth profile in the big continental European countries over the recent business cycle still seems more sluggish, suggesting intrinsic differences in resilience.

4. Implications for Stabilisation Policies

The evolving nature of the business cycle bears on the capacity of stabilisation policy to smooth prices and output. Specifically, closer international integration limits the effectiveness of active fiscal policy, as a result of leakages through trade and other channels. In the context of a currency union, however, cycle convergence is necessary for effective monetary policy, and indeed is one of the criteria for evaluating the suitability of joining a single-currency zone.

Even though this study did not find strong support for closer synchronisation among the 12 OECD countries considered, it is plausible that ongoing globalisation trends will increase cycle convergence in the future. And it may do so through new channels, such as closer financial market linkages and asset markets whose prices tend to be determined in global, rather than national or local, markets. Accordingly, policy-makers need to remain abreast of new business cycle developments.

Forces acting to change international linkages may also bear on the nature of business cycle dynamics within a country. It is evident, for example, that asset markets now play a bigger role in national economies. This provides both a source of resilience and a risk to stability. A larger value of traditionally less liquid assets in balance sheets (such as housing), together with flexible and innovative financial markets, has arguably made housing markets more responsive to changes in monetary policy through wealth and balance sheet effects. This, of course, means that the magnitude of monetary policy responses needed to modify demand is now smaller than before, and it may also have changed the lags in policy transmission in uncertain ways. These effects need to be better understood.

There is also a danger that the credit and asset price channels of monetary policy transmission have created new potential sources of price and output instability, because asset prices are prone to substantial and prolonged periods of misalignments. Indeed, many of the deepest recessions experienced in OECD countries in the last two decades have been associated with asset price cycles. Obviously, therefore, misalignments in asset prices should be avoided, but it is less obvious how to do so. Here the conventional wisdom that monetary policy responds to the extent that asset price developments bear on demand pressures and thus broader price developments remains, in our view, appropriate. As well, stronger monitoring of systemic risks and flanking policies that bolster prudential regulation and supervision, without harming competition and innovation, have an expanded role to play. This is happening.

More generally, lack of resilience bears on the cost of output deviations from trend and increases the risk of hysteresis and the permanent output losses associated with it. Avoiding sharp and persistent falls in output is therefore of great importance in terms of welfare. Here broader economic policies can help. Removing market rigidities in product and labour markets raises the adaptability of economies to shocks and ultimately economies' potential rates of growth.

5. Conclusions

This paper examines two interrelated aspects of business cycles. The first focuses on the features of business cycles within 12 OECD countries, the degree of international synchronisation and how it is evolving over time. Overall, we find evidence that the severity of cycles has diminished over the past 35 years, reflecting in part improved inventory management techniques, the rising relative importance of services in overall output and more effective monetary policy frameworks for absorbing nominal shocks. Regarding the similarity of cyclical characteristics and the strength of their association across countries, the paper examines a number of aspects, including the timing of growth cycle turning points, the length of time cycles are in a similar phase with the US and the similarity of cycles with respect to the intensity of output co-movement. These measures suggest that business cycle synchronisation is high for the 12 OECD countries included in this study, but the paper is more agnostic concerning the evolution of cycle synchronisation through time. While there appears to be a trend towards increased convergence, this seems at least partially linked to the reduced severity of cycles in individual countries.

These findings are standard and generally supported in the literature. Yet, they do not clearly reveal the recent dichotomy in economic performance between the large euro-area economies, which have experienced a protracted period of excess capacity, and other OECD countries which were better able to absorb the global shock that prompted the slowdown in 2001. The second part of this paper focused more closely on this episode, paying particular attention to the interaction between economic policies and the business cycle. The paper tentatively argues that it is not merely coincidence that the strongly performing OECD economies over the past cycle were also those that undertook ambitious and comprehensive economic policy reforms over the past 20 years. Nor is it sheer 'good luck' in the sense of smaller negative shocks to these economies. Rather, recent and ongoing OECD studies based on panel data regressions and SVAR analysis discussed in this paper bolster the presumption that flexible product, labour and financial markets not only stimulate potential growth, but also interact positively with macroeconomic policies to ensure price and output stability. The sense of disappointment experienced in continental Europe may thus stem as much from the persistence of long-standing difficulties as from the realisation that other countries have succeeded in turning their economies around over the years.

Finally, the paper identifies a number of challenges to policy-makers that stem from the evolving features of business cycles within and across countries. Closer international synchronisation will reduce the effectiveness of active fiscal policy, while the expansion of financial markets increases the potency and possibly changes the speed of monetary policy transmission through wealth and balance sheet effects. Policy-makers need to better understand the magnitude of these effects. Through the same channels there is equally a risk of greater price and output instability if asset prices become misaligned. The conventional wisdom of how to respond to asset price misalignments remains in our opinion appropriate, though financial supervision institutions must continue to evolve to take account of financial innovation. Finally, economic policy more generally needs to tackle the lack of resilience to adverse shocks, particularly in the large euro-area countries, by removing micro rigidities in labour and product markets.

Appendix A: Chronology of Classical Cycles
1970–2003 *(continued next page)*

US

Contraction (peak to trough)				Expansion (trough to peak)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1973:Q4–1975:Q1	5	–3.10	–0.62	1975:Q1–1980:Q1	20	23.21	1.16
1980:Q1–1980:Q3	2	–2.18	–1.09	1980:Q3–1981:Q3	4	4.35	1.09
1981:Q3–1982:Q3	4	–2.71	–0.68	1982:Q3–1990:Q2	31	37.51	1.21
1990:Q2–1991:Q1	3	–1.26	–0.42	1991:Q1–2000:Q4	39	40.43	1.04
2000:Q4–2001:Q3	3	–0.17	–0.06				

Japan

Contraction (peak to trough)				Expansion (trough to peak)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1973:Q4–1974:Q1	1	–3.46	–3.46	1974:Q1–1993:Q1	76	101.37	1.33
1993:Q1–1993:Q4	3	–1.67	–0.56	1993:Q4–1997:Q1	13	9.83	0.76
1997:Q1–1998:Q2	5	–2.20	–0.44	1998:Q2–2001:Q1	11	4.43	0.40
2001:Q1–2002:Q1	4	–2.70	–0.68				

Appendix A: Chronology of Classical Cycles
1970–2003 *(continued next page)*

Germany

Contraction (peak to trough): Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Expansion (trough to peak): Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1974:Q1–1975:Q1	4	–3.30	–0.83	1975:Q1–1980:Q1	20	20.91	1.05
1980:Q1–1980:Q4	3	–1.81	–0.60	1980:Q4–1981:Q3	3	1.36	0.45
1981:Q3–1982:Q3	4	–1.85	–0.46	1982:Q3–1992:Q1	38	36.36	0.96
1992:Q1–1993:Q2	5	–2.66	–0.53	1993:Q2–1995:Q2	8	5.01	0.63
1995:Q2–1996:Q1	3	–0.76	–0.25	1996:Q1–2001:Q1	20	11.16	0.56
2001:Q1–2001:Q4	3	–0.37	–0.12	2001:Q4–2002:Q3	3	0.52	0.17
2002:Q3–2003:Q2	3	–0.60	–0.20				

France

Contraction (peak to trough): Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Expansion (trough to peak): Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1974:Q3–1975:Q1	2	–1.95	–0.98	1975:Q1–1980:Q1	20	17.76	0.89
1980:Q1–1980:Q3	2	–0.77	–0.38	1980:Q3–1992:Q1	46	29.95	0.65
1992:Q1–1993:Q1	4	–1.32	–0.33	1993:Q1–2002:Q3	38	23.35	0.61
2002:Q3–2003:Q2	3	–0.59	–0.20				

Appendix A: Chronology of Classical Cycles
1970–2003 *(continued next page)*

Italy

Contraction (peak to trough)				**Expansion (trough to peak)**			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1974:Q3–1975:Q2	3	–3.84	–1.28	1975:Q2–1977:Q1	7	10.88	1.55
1977:Q1–1977:Q3	2	–1.49	–0.74	1977:Q3–1980:Q4	13	15.13	1.16
1980:Q4–1981:Q3	3	–0.65	–0.22	1981:Q3–1982:Q1	2	1.84	0.92
1982:Q1–1982:Q4	3	–1.41	–0.47	1982:Q4–1991:Q1	33	25.40	0.77
1991:Q1–1993:Q3	6	–2.24	–0.37	1993:Q3–1996:Q1	10	7.42	0.74
1996:Q1–1996:Q4	3	–0.87	–0.29	1996:Q4–2001:Q1	17	11.13	0.65
2001:Q1–2001:Q4	3	–0.10	–0.03	2001:Q4–2002:Q4	4	0.92	0.23
2002:Q4–2003:Q2	2	–0.30	–0.15				

UK

Contraction (peak to trough)				**Expansion (trough to peak)**			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1973:Q2–1974:Q1	3	–3.60	–1.20	1974:Q1–1974:Q3	2	3.06	1.53
1974:Q3–1975:Q3	4	–2.59	–0.65	1975:Q3–1979:Q2	15	14.68	0.98
1979:Q2–1981:Q1	7	–6.03	–0.86	1981:Q1–1990:Q2	37	33.76	0.91
1990:Q2–1991:Q3	5	–2.52	–0.50	1991:Q3–2003:Q4[(a)]	49	39.18	0.80

Appendix A: Chronology of Classical Cycles

1970–2003 *(continued next page)*

Canada

Contraction (peak to trough)				Expansion (trough to peak)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1980:Q1–1980:Q3	2	–1.38	–0.69	1980:Q3–1981:Q2	3	4.71	1.57
1981:Q2–1982:Q4	6	–4.88	–0.81	1982:Q4–1990:Q1	29	34.22	1.18
1990:Q1–1991:Q1	4	–3.37	–0.84	1991:Q1–2003:Q4[(a)]	51	48.08	0.94

Australia

Contraction (peak to trough)				Expansion (trough to peak)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1971:Q3–1972:Q1	2	–1.00	–0.50	1972:Q1–1974:Q1	8	10.07	1.26
1974:Q1–1974:Q2	1	–3.24	–3.24	1974:Q2–1975:Q2	4	5.59	1.40
1975:Q2–1975:Q4	2	–1.96	–0.98	1975:Q4–1977:Q2	6	6.65	1.11
1977:Q2–1977:Q4	2	–0.61	–0.31	1977:Q4–1981:Q3	15	15.88	1.06
1981:Q3–1983:Q1	6	–3.96	–0.66	1983:Q1–1990:Q2	29	36.18	1.25
1990:Q2–1991:Q2	4	–1.22	–0.31	1991:Q2–2003:Q4[(a)]	50	59.43	1.19

Appendix A: Chronology of Classical Cycles
1970–2003 *(continued next page)*

Belgium

Contraction (peak to trough)				Expansion (trough to peak)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1974:Q3–1975:Q2	3	–2.53	–0.84	1975:Q2–1976:Q4	6	7.46	1.24
1976:Q4–1977:Q2	2	–0.67	–0.34	1977:Q2–1980:Q1	11	11.54	1.05
1980:Q1–1980:Q4	3	–1.84	–0.61	1980:Q4–1992:Q1	45	28.75	0.64
1992:Q1–1993:Q1	4	–2.88	–0.72	1993:Q1–1995:Q3	10	7.12	0.71
1995:Q3–1996:Q1	2	–0.67	–0.33	1996:Q1–1998:Q2	9	7.71	0.86
1998:Q2–1998:Q4	2	–0.78	–0.39	1998:Q4–2000:Q4	8	9.08	1.14
2000:Q4–2001:Q4	4	–2.13	–0.53				

Netherlands

Contraction (peak to trough)				Expansion (trough to peak)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1974:Q3–1975:Q2	3	–1.20	–0.40	1975:Q2–1979:Q4	18	16.31	0.91
1979:Q4–1981:Q3	7	–2.19	–0.31	1981:Q3–1982:Q1	2	1.02	0.51
1982:Q1–1982:Q4	3	–3.42	–1.14	1982:Q4–2002:Q3	79	31.51	0.40
2002:Q3–2003:Q2	3	–1.56	–0.52				

Appendix A: Chronology of Classical Cycles
1970–2003 *(continued)*

Spain

Contraction (peak to trough)				Expansion (trough to peak)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1974:Q4–1975:Q2	2	–0.58	–0.29	1975:Q2–1978:Q2	12	8.40	0.70
1978:Q2–1979:Q1	3	–0.43	–0.14	1979:Q1–1980:Q4	7	1.95	0.28
1980:Q4–1981:Q2	2	–0.68	–0.34	1981:Q2–1992:Q1	43	40.26	0.94
1992:Q1–1993:Q2	5	–2.81	–0.56	1993:Q2–2003:Q4[(a)]	42	39.44	0.94

Sweden

Contraction (peak to trough)				Expansion (trough to peak)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1970:Q4–1971:Q2	2	–2.25	–1.13	1971:Q2–1976:Q2	20	15.55	0.78
1976:Q2–1977:Q1	3	–3.01	–1.00	1977:Q1–1980:Q1	12	10.98	0.92
1980:Q1–1980:Q2	1	–4.90	–4.90	1980:Q2–1990:Q1	39	28.44	0.73
1990:Q1–1993:Q1	12	–5.65	–0.47	1993:Q1–2003:Q4[(a)]	43	36.12	0.84

(a) Data thus far – the expansion continued beyond 2003.

Sources: OECD *Economic Outlook* No 77 database; authors' calculations

Appendix B: Chronology of Growth Business Cycles
1970–2003 *(continued next page)*

US

Downturns (upturn to downturn)				Upturns (downturn to upturn)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1973:Q2–1975:Q2	8	–6.78	–0.85	1975:Q2–1979:Q2	16	6.20	0.39
1979:Q2–1980:Q3	5	–3.25	–0.65	1980:Q3–1981:Q2	3	1.28	0.43
1981:Q2–1982:Q3	13	–5.18	–0.40	1982:Q3–1984:Q3	5	5.43	1.09
1984:Q3–1987:Q1	9	–1.74	–0.19	1987:Q1–1989:Q4	13	2.23	0.17
1989:Q4–1991:Q3	7	–3.50	–0.50	1991:Q3–1994:Q3	12	2.36	0.20
1994:Q3–1995:Q4	5	–1.53	–0.31	1995:Q4–2000:Q2	18	2.96	0.16

Japan

Downturns (upturn to downturn)				Upturns (downturn to upturn)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1970:Q2–1971:Q3	3	–4.18	–1.39	1971:Q3–1973:Q2	10	5.60	0.56
1973:Q2–1974:Q4	9	–6.67	–0.74	1974:Q4–1979:Q3	16	3.34	0.21
1979:Q3–1983:Q4	6	–2.96	–0.49	1983:Q4–1985:Q3	18	1.69	0.09
1985:Q3–1987:Q1	4	–2.12	–0.53	1987:Q1–1990:Q4	17	4.35	0.26
1990:Q4–1994:Q1	11	–3.96	–0.36	1994:Q1–1997:Q1	14	3.67	0.26
1997:Q1–1999:Q3	6	–3.39	–0.56	1999:Q3–2000:Q4	8	2.80	0.35

Appendix B: Chronology of Growth Business Cycles
1970–2003 *(continued next page)*

Germany

Downturns (upturn to downturn)				Upturns (downturn to upturn)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1970:Q4–1971:Q4	4	–1.77	–0.44	1971:Q4–1973:Q3	7	2.72	0.39
1973:Q3–1975:Q2	7	–5.46	–0.78	1975:Q2–1979:Q4	18	5.70	0.32
1979:Q4–1982:Q4	12	–4.81	–0.40	1982:Q4–1986:Q1	13	2.30	0.18
1986:Q1–1987:Q3	6	–1.53	–0.26	1987:Q3–1991:Q1	14	3.83	0.27
1991:Q1–1993:Q3	10	–3.82	–0.38	1993:Q3–1995:Q1	6	1.82	0.30
1995:Q1–1999:Q1	16	–1.47	–0.09	1999:Q1–2000:Q3	6	2.48	0.41

France

Downturns (upturn to downturn)				Upturns (downturn to upturn)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1974:Q1–1975:Q3	6	–4.37	–0.73	1975:Q3–1979:Q4	17	3.30	0.19
1979:Q4–1981:Q1	5	–2.17	–0.43	1981:Q1–1982:Q2	5	1.39	0.28
1982:Q2–1987:Q2	20	–1.77	–0.09	1987:Q2–1990:Q1	11	3.04	0.28
1990:Q1–1991:Q2	5	–1.28	–0.26	1991:Q2–1992:Q1	3	0.68	0.23
1992:Q1–1993:Q3	6	–2.67	–0.44	1993:Q3–1995:Q1	6	1.78	0.30
1995:Q1–1997:Q1	8	–1.81	–0.23	1997:Q1–2000:Q4	15	3.20	0.21

Appendix B: Chronology of Growth Business Cycles

1970–2003 *(continued next page)*

Italy

Downturns (upturn to downturn)				Upturns (downturn to upturn)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1970:Q3–1972:Q4	9	–3.59	–0.40	1972:Q4–1974:Q1	5	6.46	1.29
1974:Q1–1975:Q3	6	–7.83	–1.31	1975:Q3–1976:Q4	5	4.80	0.96
1976:Q4–1977:Q4	4	–3.23	–0.81	1977:Q4–1980:Q2	10	4.32	0.43
1980:Q2–1983:Q1	11	–4.61	–0.42	1983:Q1–1985:Q3	10	2.04	0.20
1985:Q3–1987:Q1	6	–0.72	–0.12	1987:Q1–1990:Q1	12	2.11	0.18
1990:Q1–1991:Q1	4	–1.26	–0.31	1991:Q1–1992:Q1	4	1.13	0.28
1992:Q1–1993:Q3	6	–3.22	–0.54	1993:Q3–1995:Q4	9	2.68	0.30
1995:Q4–1996:Q4	4	–1.75	–0.44	1996:Q4–1997:Q4	4	1.55	0.39
1997:Q4–1999:Q1	5	–1.59	–0.32	1999:Q1–2001:Q1	8	2.26	0.28

UK

Downturns (upturn to downturn)				Upturns (downturn to upturn)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1973:Q2–1975:Q4	10	–6.59	–0.66	1975:Q4–1979:Q3	15	5.52	0.37
1979:Q3–1981:Q2	7	–5.70	–0.81	1981:Q2–1983:Q4	10	2.82	0.28
1983:Q4–1984:Q4	4	–1.15	–0.29	1984:Q4–1988:Q3	15	3.16	0.21
1988:Q3–1992:Q4	17	–4.41	–0.26	1992:Q4–1994:Q4	17	2.75	0.16
1994:Q4–1999:Q1	17	–0.95	–0.06	1999:Q1–2000:Q3	6	1.29	0.22

Appendix B: Chronology of Growth Business Cycles
1970–2003 *(continued next page)*

Canada

Downturns (upturn to downturn)				Upturns (downturn to upturn)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1973:Q3–1975:Q2	7	–3.05	–0.44	1975:Q2–1976:Q2	4	1.76	0.44
1976:Q2–1977:Q2	4	–0.93	–0.23	1977:Q2–1979:Q3	9	2.40	0.27
1979:Q3–1980:Q3	4	–1.64	–0.41	1980:Q3–1981:Q2	3	1.88	0.63
1981:Q2–1982:Q4	6	–6.63	–1.11	1982:Q4–1985:Q3	11	5.51	0.50
1985:Q3–1986:Q4	5	–2.58	–0.52	1986:Q4–1989:Q4	12	4.06	0.34
1989:Q4–1992:Q4	12	–4.68	–0.39	1992:Q4–1994:Q4	8	3.47	0.43
1994:Q4–1996:Q3	7	–2.88	–0.41	1996:Q3–2000:Q3	16	3.39	0.21
2000:Q3–2001:Q4	5	–2.35	–0.47	2001:Q4–2002:Q3	3	1.14	0.38

Australia

Downturns (upturn to downturn)				Upturns (downturn to upturn)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1970:Q2–1972:Q4	10	–2.62	–0.26	1972:Q4–1973:Q3	3	2.15	0.72
1973:Q3–1974:Q4	5	–2.61	–0.52	1974:Q4–1976:Q4	8	1.70	0.21
1976:Q4–1978:Q1	5	–2.54	–0.51	1978:Q1–1981:Q4	15	4.07	0.27
1981:Q4–1983:Q1	5	–6.67	–1.33	1983:Q1–1985:Q3	10	6.41	0.64
1985:Q3–1986:Q4	5	–3.98	–0.80	1986:Q4–1989:Q3	11	4.66	0.42
1989:Q3–1991:Q4	9	–5.12	–0.57	1991:Q4–1996:Q1	17	2.67	0.16
1996:Q1–1997:Q2	5	–1.04	–0.21	1997:Q2–2000:Q1	11	1.73	0.16

Appendix B: Chronology of Growth Business Cycles

1970–2003 *(continued next page)*

Belgium

Downturns (upturn to downturn)				Upturns (downturn to upturn)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1970:Q2–1971:Q4	6	–1.95	–0.33	1971:Q4–1974:Q2	10	4.04	0.40
1974:Q2–1975:Q3	5	–5.66	–1.13	1975:Q3–1976:Q3	4	4.19	1.05
1976:Q3–1977:Q3	4	–3.04	–0.76	1977:Q3–1978:Q2	3	1.39	0.46
1978:Q2–1979:Q1	3	–1.21	–0.40	1979:Q1–1980:Q2	5	3.58	0.72
1980:Q2–1983:Q1	11	–3.82	–0.35	1983:Q1–1984:Q2	5	1.19	0.24
1984:Q2–1987:Q1	11	–1.64	–0.15	1987:Q1–1990:Q1	12	3.11	0.26
1990:Q1–1991:Q1	5	–0.86	–0.17	1991:Q1–1991:Q4	3	1.13	0.38
1991:Q4–1993:Q2	5	–3.55	–0.71	1993:Q2–1995:Q1	7	2.70	0.39
1995:Q1–1996:Q2	5	–2.02	–0.40	1996:Q2–1997:Q4	6	1.84	0.31
1997:Q4–1998:Q4	4	–1.40	–0.35	1998:Q4–2000:Q4	8	2.95	0.37

Netherlands

Downturns (upturn to downturn)				Upturns (downturn to upturn)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1970:Q2–1972:Q2	8	–1.41	–0.18	1972:Q2–1974:Q2	8	2.24	0.28
1974:Q2–1975:Q3	5	–3.98	–0.80	1975:Q3–1976:Q3	4	3.20	0.80
1976:Q3–1977:Q2	3	–1.17	–0.39	1977:Q2–1978:Q1	3	0.76	0.25
1978:Q1–1978:Q4	3	–1.34	–0.45	1978:Q4–1980:Q1	5	3.04	0.61
1980:Q1–1982:Q4	3	–5.58	–1.86	1982:Q4–1986:Q1	21	3.90	0.19
1986:Q1–1988:Q3	11	–1.98	–0.18	1988:Q3–1990:Q4	8	2.40	0.30
1990:Q4–1993:Q4	12	–2.60	–0.22	1993:Q4–2000:Q3	27	3.11	0.12

Appendix B: Chronology of Growth Business Cycles
1970–2003 *(continued)*

Spain

Downturns (upturn to downturn)				Upturns (downturn to upturn)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1974:Q2–1975:Q4	6	–4.25	–0.71	1975:Q4–1978:Q1	9	2.15	0.24
1978:Q1–1979:Q3	6	–1.58	–0.26	1979:Q3–1980:Q2	3	0.61	0.20
1980:Q2–1981:Q4	6	–1.32	–0.22	1981:Q4–1983:Q4	8	0.52	0.06
1983:Q4–1986:Q4	12	–1.40	–0.12	1986:Q4–1991:Q4	20	3.83	0.19
1991:Q4–1993:Q2	6	–3.92	–0.65	1993:Q2–2000:Q2	28	3.14	0.11

Sweden

Downturns (upturn to downturn)				Upturns (downturn to upturn)			
Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)	Period	Duration (quarters)	Amplitude (% points)	Quarterly amplitude (% points)
1970:Q3–1972:Q1	6	–5.10	–0.85	1972:Q1–1973:Q1	4	2.44	0.61
1973:Q1–1973:Q4	3	–0.61	–0.20	1973:Q4–1974:Q4	4	2.38	0.59
1974:Q4–1977:Q3	11	–4.32	–0.39	1977:Q3–1979:Q4	9	4.30	0.48
1979:Q4–1983:Q1	13	–3.88	–0.30	1983:Q1–1984:Q2	5	2.31	0.46
1984:Q2–1986:Q3	9	–1.19	–0.13	1986:Q3–1989:Q4	13	2.59	0.20
1989:Q4–1993:Q2	14	–5.95	–0.42	1993:Q2–1995:Q3	9	5.14	0.57
1995:Q3–1997:Q2	7	–2.32	–0.33	1997:Q2–2000:Q2	12	3.14	0.26

Sources: OECD *Economic Outlook* No 77; authors' calculations

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Discussion

1. Eva Ortega

Introduction

This paper is a very careful study of business cycles in OECD countries and their latest changes. In particular, it studies the business cycles in the G7 and Australia, Belgium, the Netherlands, Spain and Sweden, for the period from 1970 to 2003.

The authors postulate that there is a linkage between 'good' policies and both macroeconomic stabilisation – in the business cycle frequency – and long-run growth. In discussing this hypothesis, several very important issues are raised. Some empirical evidence is also provided in support of the hypothesis.

The main findings of the paper are the following. First, confirming the results elsewhere in the literature, the paper reports different measures showing that business cycle volatility is less in recent years than it used to be. Why this is so is discussed in several papers in this conference, such as those by Robert Gordon, Steve Cecchetti and co-authors, and Christopher Kent and co-authors. Second, it is argued that it is difficult to identify an increase in business cycle synchronicity between these countries. Third, the paper argues that 'good' stabilisation and structural policies are linked to lower volatility in both prices and output, that is, short-run stability, and to better long-run performance, that is, higher output growth. Finally, the authors argue that the strong resilience shown during the recent cycle by countries like Australia, Canada, Spain and the UK can be linked to good structural policies – flexible regulation of labour, product and financial markets, put in place in those countries in previous years. In contrast, the paper shows that countries with more rigid regulations, such as the big continental European countries, showed less flexible prices and higher sacrifice ratios in the last cycle.

My discussion will evolve around two points. The first refers to the evolution of business cycle synchronicity. I discuss further evidence in the empirical debate on whether synchronicity has increased in the OECD or not. The second, more fundamental, point refers to the main hypothesis of the paper, that improved short- and long-run performance is linked to good policies, and in particular to flexible regulation of labour, product and financial markets. I essentially agree with the authors that this hypothesis is a reasonable one. In support of my position, I discuss the cases of Spain and Canada.

Business cycle synchronicity

The paper argues that, possibly due to generalised lower business cycle volatility, it is difficult to identify empirically an increase in business cycle synchronicity over time. The authors show this point by computing the standard deviation across countries of the output gap in Figure 4.

I would like to stress that it is important to note the asymmetry of the degree of synchronicity across business cycle phases; international business cycle synchronicity is higher in recession phases. This can be seen in that same Figure 4, as well as in the evidence shown in Cotis *et al*'s Figure 1 which is used to analyse the clustering of turning points across countries. Indeed, it is not by chance that academics and institutions intensified their research efforts on the issue of business cycle synchronicity in the last recession.

One such example is Canova, Ciccarelli and Ortega (2004), where a panel VAR is estimated – using Bayesian techniques – for quarterly growth rates of GDP, employment, retail sales and industrial production in the G7, allowing for both cross-country interdependencies and time variation. Each quarterly growth rate is decomposed into the sum of a world component, a country component, a variable-specific component and a residual. It is shown that both the world component and the country components are significantly more synchronised in recessions than in expansions. The following figure (Figure 1), borrowed from that paper, displays the posterior median and 67 per cent confidence interval for the world and seven country components. It can easily be seen that the confidence intervals narrow significantly around recessions.

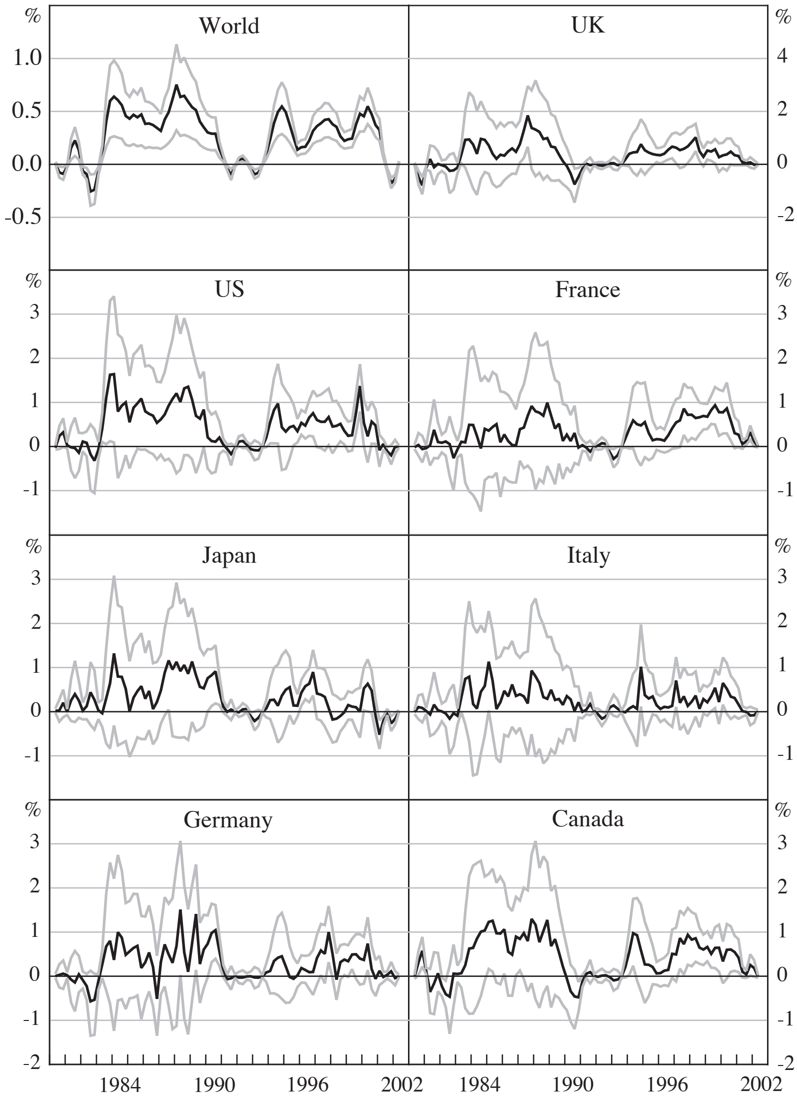
A second point I would like to discuss with respect to this paper's difficulty in finding increased business cycle synchronicity is the following. The recent empirical literature mentioned in the paper and elsewhere has found two apparently contradictory facts. On the one hand, country-specific factors are often found to be important and increasing contributors to volatility, but on the other hand, cross-country synchronicity is also found to be higher than in the past. Theoretically, the intensification of economic integration between industrialised economies is compatible with both facts: on the one hand increased integration means more cross-country trade, but on the other hand it can also mean increased industrial specialisation, and hence more scope for sector-specific shocks to cause different business cycle behaviour.

A recent example of a paper where these two facts are found is Cardarelli and Kose (2004). They estimate a dynamic factor model for the G3 and Canada and find that: (a) the explanatory power of the common cycle has increased in the 1980s and 1990s with respect to previous decades; but (b) idiosyncratic factors are still the biggest source of some countries' business cycle fluctuations (for example, Canada).

Both facts are not incompatible. Despite a common cycle being a consistent and significant explanatory factor of industrialised economies' business cycles in recent decades, the well-documented decrease in macroeconomic fluctuations in the 1990s has caused a reduction in the variability of, and hence the uncertainty around estimates of, common cycles and country-specific cycles. Country-specific cycles thus became a significant explanatory factor in the 1990s, together with the common cycle. In previous decades, however, estimates of country-specific cycles used to be insignificant due to their large variability. Figure 1 (taken from Canova *et al* 2004) illustrates this point.

The question, then, is why business cycle volatility dropped in the 1990s, an issue that is discussed at length elsewhere in this conference volume.

Figure 1: World and Country Indicators



Source: Canova *et al* (2004)

Good policies and macroeconomic performance

The authors show that after the last global recession, countries like Australia, Canada, Spain and the UK displayed a quicker recovery (essentially driven by private consumption and residential investment) while conducting similar monetary and fiscal policies to other, less resilient, countries. This observation leads them to postulate that this different behaviour was due to the more resilient countries having a higher degree of structural flexibility.

The paper goes on and summarises results from previous OECD studies, showing that countries with more flexible regulation of labour, product and financial markets also have more flexible price systems. Hence, they were more resilient after the last recession, and have stronger potential growth rates.

It is a very important contribution of this paper to document as much as is possible the extent to which this hypothesised linkage between flexible regulation schemes and stabilisation and growth is empirically valid.

I agree that there is evidence that justifies taking this hypothesis seriously. I will try to show that the cases of Spain and Canada confirm the role that this paper attributes to good policies. Both countries conducted a series of structural reforms in the 1990s and disciplined monetary and fiscal policies, that very likely gave their respective economies the structural flexibility referred to by Cotis and Coppel. These 'good' policies very likely mean that these two economies were better placed to face a recession.

It is easy to suspect that Spain has a higher degree of structural flexibility than the other big euro-area economies if one compares recent economic growth rates. GDP growth in Spain in 2004 was 3.1 per cent – substantially higher than in France, Germany or Italy, despite a common monetary policy.

In fact, Spain put in place a number of significant reforms in the 1990s. Very importantly, several measures led to substantially more flexible regulation of the labour market. The result was the creation of a mass of very flexible employment (more than 30 per cent of employment is temporary) that allowed the economy to create jobs and increase growth at the same time. The flows into and out of employment in Spain have reached the levels observed in the US economy.

Another important 'good policy' was the fiscal discipline imposed since the mid 1990s, the result of which has been the maintenance of a fiscal surplus.

Finally, it is also important to stress the fact that financial intermediaries are reasonably flexible and competitive, and much more so than in other big euro-area economies. In particular, low margins on mortgage loans in Spain ensure it has the lowest mortgage rates in Europe.

In the case of Canadian resilience after the 2001 recession, it has to be said that this recession affected the Canadian economy less than, for example, the US, partly because of a smaller presence of the high-tech sector in Canada.

But it is also true that the Canadian economy conducted a number of substantial reforms in the mid 1990s. In the labour market, some benefits (including unemployment insurance) were made less generous. On the fiscal side, a big shift was made from very large Federal deficits to a tighter fiscal policy. Since the mid 1990s, the Federal budget has shown a surplus and there has been a downward trend in the public debt-to-GDP ratio.

Monetary policy discipline was strengthened with the implementation of inflation targeting in February 1991. Inflation targeting provided an effective anchor for inflation expectations that allowed increased nominal stability (observed, for example, in an increase of longer-duration labour and financial contracts) and, more generally, brought increased macroeconomic stability (that is, lower business cycle volatility).

The financial sector went through a significant internal restructuring in the mid 1990s. Most financial institutions reduced their share of loans to the energy-producing sector and increased their share directed to consumer financing. This allowed for a substantial improvement in the cyclical performance of the financial sector. Also, in order to understand the role of financial institutions in the monetary policy transmission mechanism, it has to be noted that mortgages are in general more sensitive to monetary policy actions than in the US; the share of mortgages with variable rates, or adjustable after one or two years, is higher in Canada.

Finally, it is worth mentioning the gradual deregulation observed in Canadian product markets since the 1980s, like the energy-producing and transportation sectors.

It makes a lot of sense to suspect, as it is argued in this paper using different pieces of evidence, that these and similar policies increased the resilience of the Spanish and Canadian economies in the previous cycle.

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2. General Discussion

Most of the discussion centred on the underlying differences between the structures of European and 'successful' countries' economies. One participant questioned why the characteristics of mortgage markets in continental Europe are so different from the US, for example, and suggested that the lack of development of the European market might reflect less desire by European households to smooth consumption, due to weaker expectations about future income. While noting that this may be true, another participant added that the inflexibility of European mortgage markets is due mainly to stricter government regulation and political inertia. However, this emphasis on government regulation was challenged by a third participant, who argued that inflexibility is deeply ingrained in European legal systems and, in particular, in the inability of creditors to access collateral following default. This participant noted that flexibility might increase with legal harmonisation, although others expressed reservations that this process could be quite prolonged.

A second issue raised was the role of openness, rather than domestic demand resilience, in smoothing output volatility. One participant questioned the absence of globalisation as a reason for the reduction in volatility in Cotis and Coppel's paper, arguing that greater openness increases the effectiveness of monetary policy. In response, Jean-Philippe Cotis argued that while this is true, the reduction in volatility is more evident in domestic demand than GDP – particularly in the most recent recession – a point that was supported by other participants.

The importance of country idiosyncrasies for the paper's results was also discussed at some length. One participant suggested that the reunification of Germany and the ERM devaluation were important in stimulating the recovery of the non-'successful' countries in the early 1990s, thereby contributing to the decline in the cyclical performance of these countries between the early 1990s and early 2000s. Accordingly, it was suggested that this idiosyncrasy makes the relative improvement in the performance of the 'successful' and non-'successful' countries during the past decade more pronounced. Similarly, it was noted that the reduction in European volatility has been much less than that seen in the US (Table 4 of the paper), and that this may be due to US-specific factors (such as volatility in government spending and interest rate ceilings) which were important in increasing US output volatility, in particular during the 1970s. This suggestion that idiosyncrasies have played an important role was accepted by Jean-Philippe Cotis. However, he added that a striking feature is how similar the economic performance of the 'successful' countries has been, despite their geographical diversity, and that this surely has something to do with the common traits among these countries (inflation-targeting-type monetary policy and flexible markets).

A more general concern raised by a participant was that researchers should not focus on output gaps when looking for the effects of structural reforms. The problem is that output gaps filter out changes in trend growth, but trend growth is likely to be more responsive to structural change than is the volatility of growth (particularly if the transmission of shocks is unaffected by structural reforms). Hence, given that there is little evidence of changes in trend growth, it is likely that supply-side reforms have had only a minor part to play in the reduction of the standard deviation of output, in contrast to the authors' findings. This point was accepted by Jean-Philippe Cotis, but with the qualification that the structural reforms addressed in the paper are also important for demand. For this reason, it was argued that they may also impact output dynamics, and thereby have reduced output volatility.

Finally, a few participants raised the question of whether the focus of 'successful' countries on core inflation over a relatively short horizon would lead to longer-term problems. Indeed, one participant suggested that these economies might be *too* responsive to monetary policy changes, due to the substantial increase in household leverage in those countries over recent years. In response to this, it was argued that this is preferable to having an economy which is rather insensitive to policy changes, as appears to be true of some other countries in the paper.

What Caused the Decline in US Business Cycle Volatility?

Robert J Gordon[1]

Abstract

This paper investigates the sources of the widely noticed reduction in the volatility of American business cycles since the mid 1980s. Our analysis of reduced volatility emphasises the sharp decline in the standard deviation of changes in real GDP, of the output gap, and of the inflation rate.

The primary results of the paper are based on a small three-equation macro model that includes equations for the inflation rate, the nominal federal funds rate, and the change in the output gap. The development and analysis of the model goes beyond the previous literature in two directions. First, instead of quantifying the role of shocks in general, it decomposes the effect of shocks between a specific set of supply-shock variables in the model's inflation equation, and the error term in the output gap equation that is interpreted as representing '*IS*' shifts or 'demand shocks'. It concludes that the reduced variance of shocks was the dominant source of reduced business cycle volatility. Supply shocks accounted for 80 per cent of the volatility of inflation before 1984 and demand shocks the remainder. In contrast, roughly two-thirds of the high level of output volatility before 1984 is accounted for by the output errors (demand shocks) and the remainder by supply shocks. The output errors are tied to the paper's initial decomposition of the demand side of the economy, which concludes that three sectors – residential and inventory investment and federal government spending – account for 50 per cent of the reduction in the average standard deviation of real GDP when the 1950–83 and 1984–2004 intervals are compared.

The second innovation in this paper is to reinterpret the role of changes in Fed monetary policy. Previous research on Taylor rule reaction functions identifies a shift in the Volcker era toward inflation fighting with no concern about output, and then a shift in the Greenspan era to a combination of inflation fighting and strong countercyclical responses to output gaps. Our results accept this characterisation of the Volcker era but find that previous estimates of Greenspan era reaction functions are plagued by positive serial correlation. Once a correction for serial correlation is applied, the Greenspan era reaction function looks almost identical to the pre-1979 Burns reaction function!

Thus the issue in assessing monetary policy regimes comes down to Volcker versus non-Volcker. Full-model simulations show that the Volcker reaction function,

1. I am grateful to Ian Dew-Becker and Chris Taylor for inspired research assistance, extended through many evenings and several weekends, and to Dan Sichel, Kevin Stiroh, and Mark Watson for discussions and references.

if applied throughout the 1965–2004 period, would have delivered substantially higher pre-1984 output volatility than the Burns-Greenspan alternative, with the corresponding benefit of a permanent reduction in the inflation rate of 5 percentage points per annum. Compared to the succession of three reaction functions actually in effect, application of the Volcker reaction function prior to 1979 would have deepened the 1975 recession, but made the 1981–82 recession milder, since by then inflation would have been partly conquered. The paper concludes by disputing the view that better monetary policies had any role in the reduced volatility of the business cycle – the Greenspan policies did not need to fight against inflation because there was no inflation, thanks to the reversal from adverse to beneficial supply shocks, and thanks to a reduction in the size of the output errors, or 'IS' shifts.

1. Introduction

> For well over a century business cycles have run an unceasing round. They have persisted through vast economic and social changes; they have withstood countless experiments in industry, agriculture, banking, industrial relations, and public policy; they have confounded forecasters without number, belied repeated prophecies of a 'new era of prosperity' and outlived repeated forebodings of 'chronic depression'.
> – Arthur F Burns (1947, p 27)

The joy of macroeconomics lies not only in its intrinsic importance to the solvency of governments and the welfare of ordinary citizens, but also in its endlessly changing topics and methods. Less than 20 years ago I edited an epochal volume with a star-studded[2] cast of authors, *The American business cycle* (Gordon 1986), and began my introduction to that volume with support for Burns' theme that business cycles continued their 'unceasing round', reminding readers that the recently completed 1981–82 recession was the deepest post-war slump, and that previous conferences and comments that the 'business cycle is obsolete' had proved to be wildly premature.[3]

Now, the tables have turned once again. In the tradition of instant obsolescence that has always marked macroeconomic pronouncements, going back to the universal view in 1929 that an era of permanent prosperity had arrived, that 1986 volume attesting to the permanence of business cycles appeared just as the relevance of its main themes began to erode. As documented by Blanchard and Simon (2001), Stock and Watson (2002, 2004) and others, the year of our conference, 1984, marked a sharp change from high to low American business cycle volatility.[4]

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2. Star-studded? An alphabetical list of last names of a subset of authors and discussants will suffice: Baily, Barro, Bernanke, Blanchard, Blinder, Deaton, DeLong, Dornbusch, Eckstein, Eisner, Fischer, Grossman, Hall, McCallum, Meltzer, Moore, Shiller, Sims, Sinai, Summers, Taylor, Temin, Watson and Zarnowitz.
3. Citations for the premature view included the Bronfenbrenner (1969) volume *Is the business cycle obsolete?* Also cited was a remark by Paul Samuelson that 'the NBER has worked itself out of one of its first jobs, namely, the business cycle' (Zarnowitz 1972, p 167).
4. The conference was held at the Dorado Beach Hotel, Puerto Rico, 22–25 March 1984, almost exactly at the moment when retrospective historical research has determined that the American business cycle experienced a sharp and permanent decline in volatility (see Figure 1).

The topic of this paper is the decline in the volatility of the American business cycle over the entire post-war era, defined as 1948 to early 2005. Since by almost any measure the most severe post-war business cycle was the recession of 1981–82, it is not surprising that the recent literature dates the decline in volatility at the period 1984–86, immediately after the end of that severe recession. This paper documents and reinforces the common view that the break in volatility occurred in the mid 1980s, but this paper is not about dating but rather about causes. Our examination of the decline in business cycle volatility primarily focuses on the standard deviation of changes in real GDP and on the level of the output gap, that is, the log ratio of actual to natural real GDP. We also place substantial emphasis on the even greater decline in the volatility of inflation, both because inflation is a goal of economic policy in itself, and also because volatile inflation feeds back to make output more volatile.

The set of causes that receive most emphasis in explaining the drop after 1984 in business cycle volatility is quite different from the older literature that attempts to explain why post-war (that is, post-1948) business cycles were milder than the Great Depression, or more generally, milder than all the business cycles that occurred before 1929. The earlier literature takes as its point of departure Arthur Burns' American Economics Association Presidential Address (1960). In his analysis, the first and most important cause of post-war stability was the greatly increased size of the federal government (as compared to pre-1929), particularly the automatic stabilisers inherent in government transfer payments and the personal income tax system. Also in the front rank of causes were the reduced pro-cyclical volatility of the money supply, as well as other money-related regulatory reforms, of which the 1934 introduction of federal deposit insurance must have been the most important.

But the literature on the decline in business cycle volatility within the post-war era, that is, before and after 1984, centres on quite a different set of causes. There is no discussion of the stabilising effect of the federal government, since the role of federal government spending is now recognised to be destabilising, as we will document below. Modest attention is paid to structural change, especially the shift from volatile durable goods to stable services, but there have been no suggestions that such compositional changes have contributed substantially to a reduction in overall volatility.

Rather, the 'contest' in the assignment of causes for the recent decline in volatility pits two worthy opponents, an improvement in the conduct of monetary policy versus a reduction in the adverse impact on macroeconomic stability of 'shocks'. This paper provides a separate analysis of the role of demand shocks and supply shocks. The reduced volatility of demand shocks is documented by examining the volatility of the major expenditure components of GDP and their changes. We focus on the reduced volatility of federal government spending, of residential housing, and of inventory changes as important sources of improved stability, and attribute these changes respectively to the reduced share of military spending in GDP, banking and financial market reforms, and information technology that improved sales forecasts and inventory management.

This paper goes beyond the recent research, particularly Blanchard and Simon (2001) and Stock and Watson (2002, 2004), in building an explicit model that identifies and quantifies the role of supply shocks as the basic explanation of higher inflation volatility in the 1970s and 1980s, and of reduced inflation volatility in the 1990s. This inflation equation is then joined together in a simple three-equation macro model by adding a Fed reaction function and an 'IS' equation that quantifies the response of changes in the real GDP gap to changes in both inflation and the short-term interest rate. Using either a single equation for inflation or the three-equation model, we can quantify the effect on output and inflation volatility of both the set of supply shocks and changes in the Fed's reaction function. The role of demand shocks is quantified by examining the role of errors in the model's IS equation for the output gap.

The paper begins with quantitative evidence on several measures of business cycle volatility, turns to the role of shifts in output shares and in sectoral volatility, and then tackles the paper's major task, the estimation and simulation of the three-equation macro model with its strong emphasis on the role of supply shocks in the inflation process. The small macro model is *not* a symmetric VAR model. Lag lengths and the role of levels versus rates of change are handled differently in each of the equations. However, despite its simplicity, the model provides a unique quantitative assessment of the sources of reduced inflation and output volatility after 1984.

Our major conclusion is that both demand and supply shocks mattered, and changes in monetary policy mattered much less in achieving the reduced volatility of both inflation and output. A key concept in our analysis of the three-equation model is the 'output error' – that is, the residual variation of the output gap that cannot be explained by responses to lagged inflation and interest rates. The output error represents 'IS shifts' such as changes in military spending and volatile residential investment, caused by inefficient pre-1984 financial regulations and institutions. Most of the reduced volatility of inflation after 1984 was caused by the behaviour of supply shocks and the remainder by reduced volatility of the output error, that is, IS shifts. About two-thirds of the reduced volatility of the output gap is attributed to the output error, with a small remaining role for supply shocks.

Perhaps the most surprising finding in this paper is that there has been no change in monetary policy after 1990 compared to the policies pursued before 1979, taking a narrow view of policy as the response coefficients in a Taylor rule monetary policy reaction function.[5] Policy was different only in the 1979–90 Volcker interval, when fighting inflation was paramount and no weight was given to stabilising output.[6]

5. This result does not deny that monetary policy might have improved in a broader sense, with better communication and transparency and credibility acquired from the pre-1990 fight against inflation.

6. We date the transition between the Volcker and Greenspan eras as occurring in 1990 rather than 1987, because Fed behaviour in 1987–90 resembles the Volcker set of responses more than the Greenspan set of responses.

Our results overturn other research that finds a strong emphasis on inflation fighting not just between 1979 and 1990, but after 1990 as well. We show that previous estimates of Taylor rule reaction functions are plagued by serial correlation. Once an autoregressive correction is applied to the Taylor rule equation, the post-1990 'Greenspan' policy turns out to look much the same as the pre-1979 'Burns' policy; both are equally different from the 1979–90 inflation-fighting 'Volcker' policy. If the Volcker function had been in effect throughout 1965–2004, instead of the succession of Burns-Volcker-Greenspan functions actually in effect, the fight against inflation would have started in the mid 1970s instead of 1981–82, the 1975 recession would have been deeper but the 1981–82 recession shallower, the pre-1984 volatility of the output gap about the same, and the pre-1984 rate of inflation somewhat lower.

2. Measures of Reduced Business Cycle Volatility

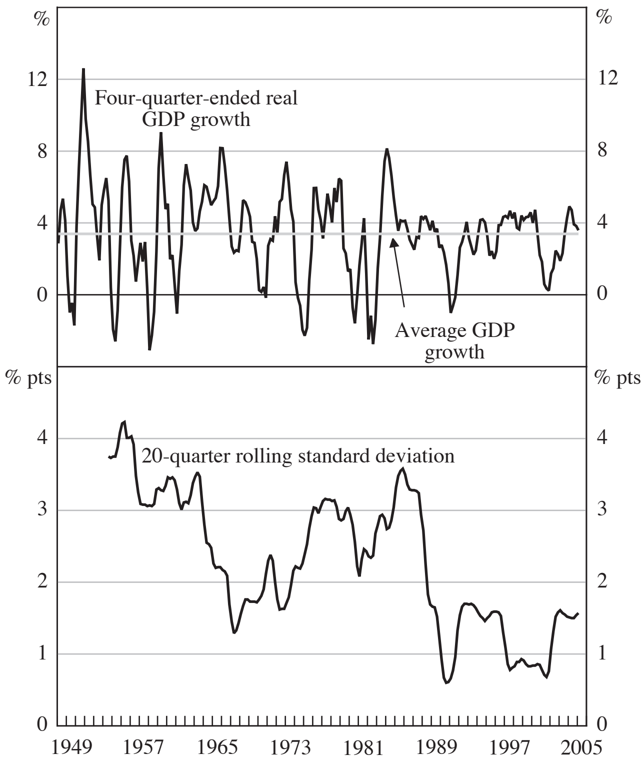
2.1 Four-quarter changes in real GDP

Perhaps the clearest way to become convinced of the decline in business cycle volatility over the post-war era is to study the plot in the top frame of Figure 1, showing four-quarter changes in the growth rate of real GDP over the 229 quarters between 1948:Q1 and 2005:Q1, spanning the entire quarterly database of the United States National Income and Product Accounts (NIPA). The top frame also plots a horizontal line representing the mean growth rate of real GDP over this period, which is 3.4 per cent per annum.

As shown in the top panel of Figure 1, the four-quarter percentage changes behave very differently before and after 1984. Prior to 1984, a saw-tooth pattern is evident, while after 1984 the fluctuations are much more moderate. The pre-1984 fluctuations are equally severe above and below the mean of 3.4 per cent per year. In contrast, there is nothing like this magnitude of volatility after 1984. The four-quarter growth rate of real GDP was never negative over the entire 22-year period between 1983 and 2005, except in the brief interval associated with the 1990–91 recession, namely the March to September quarters of 1991. In fact, some doubt has been cast on the NBER's declaration of a recession in early 2001, because the four-quarter change in real GDP never became negative in that episode and indeed never fell below 0.2 per cent in any quarter in 2001.

The lower panel of Figure 1 shows the rolling 20-quarter standard deviation of the four-quarter growth rate of real GDP, and highlights the decline in volatility evident in the top panel. There was a sharp and apparently permanent decline after 1987 to a range of between 0.5 and 1.5 percentage points. Because the calculation of the rolling standard deviation over a 20-quarter window causes the post-1983 drop in volatility to be reflected five years later, we can dramatise the movement toward stability by splitting the time period of the lower panel of Figure 1 at the December quarter 1987. The mean of the standard deviations plotted in the lower panel of Figure 1 is 2.8 percentage points for 1952:Q4–1987:Q4 and a much lower 1.3 percentage points for 1988:Q1–2005:Q1.

Figure 1: GDP Growth and Volatility

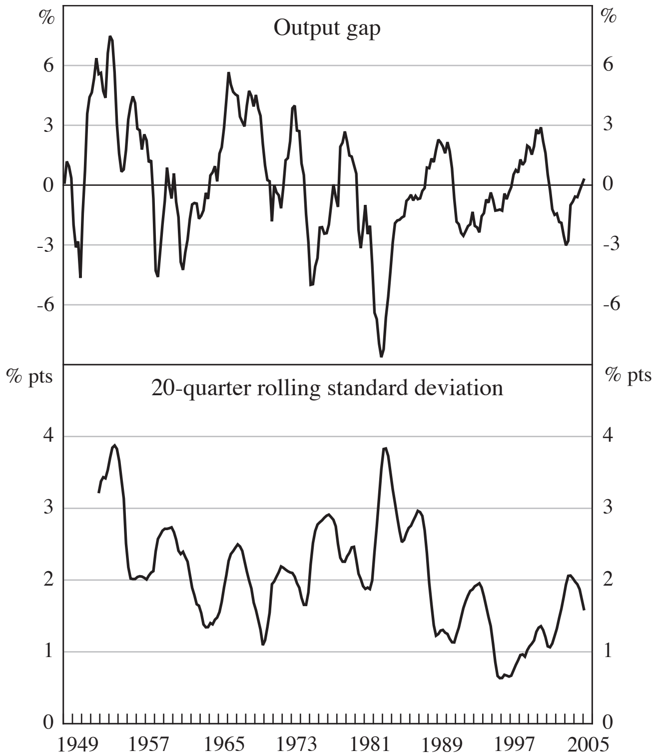


Sources: Bureau of Economic Analysis (BEA), NIPA tables; author's calculations

2.2 The output gap

In principle, part of the variance of real GDP changes could reflect changes in the growth rate of natural real GDP, and we would not associate these changes with business cycle volatility. The top panel of Figure 2 depicts the log output ratio, or 'output gap', as a percentage (100 times the log ratio of actual to natural real GDP). The dividing line of reduced output volatility at the year 1984 is not quite as stark in Figure 2 as in Figure 1, partly because the output gap is a *level* rather than a *rate of change* and thus cumulates and partially smooths out the volatile pre-1984 rates of change shown in Figure 1. However, there is still ample evidence of a decline in the volatility of the output gap after 1984. The lower panel quantifies the shift in the volatility of the output gap by plotting (in parallel with Figure 1) its rolling 20-quarter standard deviation. There is less dramatic evidence in the bottom frame of Figure 2 of a post-1984 drop in output volatility than in Figure 1. The volatility of the four-quarter changes drops by 55 per cent when 1952–87 is compared with 1988–2005, while the volatility of the output gap drops by a smaller 42 per cent.

Figure 2: Output Gap Level and Volatility

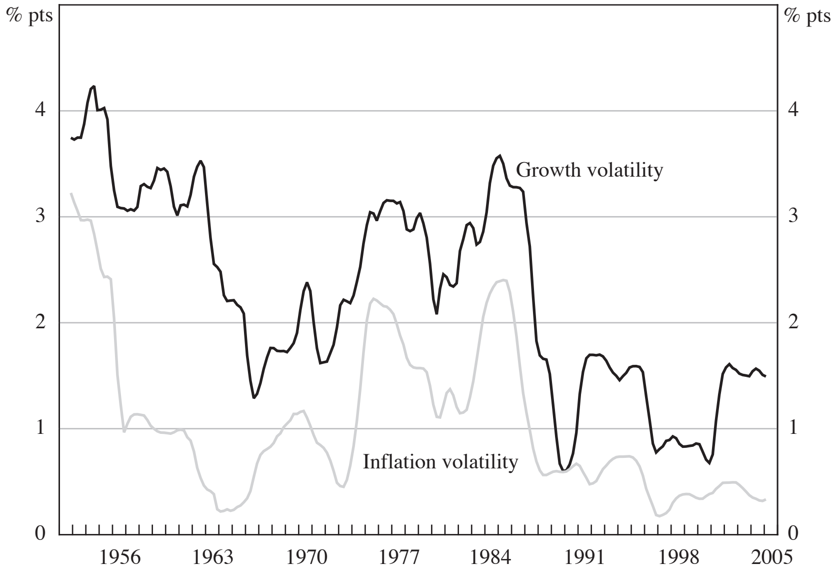


Sources: BEA, NIPA tables; author's calculations

2.3 Inflation and output volatility

An important source of high output volatility before 1984 was high inflation volatility, and we show later that the reduction of inflation volatility after 1984 made a substantial contribution to the post-1984 decline in output volatility. We will also show that high inflation volatility prior to 1984 can be linked to the behaviour of an explicit set of supply-shock variables. Figure 3 compares the 20-quarter standard deviation of four-quarter changes in real GDP and the GDP deflator, where the close relationship between output and inflation volatility is evident in the 1974–88 period. We also note that output volatility was relatively high between 1952 and 1962, despite the low volatility of inflation, and that very low inflation volatility between 2000 and 2005 did not prevent an increase in output volatility associated with the 2001 recession and subsequent recovery. (The averages of the rolling 20-quarter standard deviations for output and inflation are shown in Table 1).

Figure 3: Real GDP Growth Volatility versus Inflation Volatility
20-quarter rolling standard deviation of four-quarter-ended growth



Sources: BEA, NIPA tables; author's calculations

Table 1: Average of the Rolling 20-quarter Standard Deviation of Output and Inflation

	1952:Q4–1972:Q4	1973:Q1–1987:Q4	1988:Q1–2005:Q1
Real GDP	2.69	2.87	1.25
GDP deflator	1.11	1.67	0.48

Source: author's calculations

The fact that output volatility was so high between 1952 and 1972, despite relatively low inflation volatility, suggests that the role of shocks as a cause of high output volatility should include not only supply shocks but also demand shocks, including changes in military spending.

3. Sectoral Shifts in Volatility and Spending Shares

A simple method to learn about the sources of reduced output volatility is to decompose GDP into its 11 major expenditure components. We can ask which components had the greatest and least declines in volatility, and also determine if shifts in shares of spending among the components contributed to the overall reduction in volatility, for example, by a shift from volatile investment spending and federal government spending to relatively stable spending on consumer services.

The top section of Table 2 displays the standard deviation of four-quarter changes in 11 GDP expenditure components over the 1950–83 and 1983–2005 intervals.[7] In the top section of the table, only one component – non-residential structures – was more volatile in the second interval than in the first. The volatility of most components declined by less than the volatility of real GDP, indicating that the reduced volatility of total GDP was aided by an increase in the negative covariance across the components. The volatility of only two components – investment in residential structures and federal government spending – declined by more than the volatility of real GDP. Somewhat surprisingly, the volatility of inventory investment was virtually unchanged, although we subsequently qualify this conclusion with a different measurement technique.[8]

The bottom section of Table 2 shows the share of each of the 11 components in nominal GDP. Did shifts in the spending shares cause the economy to become more or less volatile? The largest increases in shares were for exports and imports – both much more volatile than real GDP as a whole. Working in the opposite direction was the increase in the share of consumption of services, which is much less volatile than real GDP, and the decline in the shares of structures investment and federal government spending, which are more volatile than real GDP.

How much of the decline in overall real GDP volatility was caused by lower volatility in each component of spending, and how much by shifts in shares away from volatile components and toward more stable components? The first column of Table 3 creates a hypothetical value for the standard deviation of total real GDP based on the sum of the standard deviations of the components (as shown in the top part of Table 2) times the nominal share of each component. This sum, 5.1 percentage points for 1950–83 and 2.5 percentage points for 1984–2005, is larger than the actual standard deviations of total GDP shown on the first line of Table 2 because the calculations in Table 3 ignore the complex covariances among the components. Intuitively, the calculations ignore such covariance effects as the crowding-out of investment by government spending, which automatically reduces economy-wide variance relative to the variance of the individual components.

The second column of Table 3 replaces the actual component shares for the second period with the shares for the first period. Compared to a –2.6 percentage point change in the actual sum of component standard deviations in the first column,

7. In Table 2 the standard deviations are calculated from the four-quarter changes over the entire interval shown, in contrast to Figures 1–3 where, for graphical purposes, the standard deviation is calculated over rolling 20-quarter periods, and Table 1 where these are then averaged.

8. The four-quarter change in inventory investment cannot be calculated, since inventory investment is frequently negative. As indicated in the note to Table 2, we took the first difference of inventory changes, divided by a 20-quarter moving average of inventory changes, and then calculated the standard deviation of the resulting ratio. One reason for the low value of the standard deviation in both periods is that much of the volatility of inventory changes appears in the 20-quarter moving average and disappears in the ratio.

Table 2: Expenditure Components of GDP

	1950–1983	1984–2005	Ratio of 1984–2005 to 1950–1983 (per cent)
Standard deviation of four-quarter real growth rates			
Real GDP	3.0	1.6	51
Consumption of durable goods	9.4	4.9	52
Consumption of non-durable goods	1.9	1.2	62
Consumption of services	1.2	0.9	74
Equipment and software investment	9.1	6.7	74
Non-residential structures	7.0	8.4	119
Residential structures	16.7	7.5	45
Inventory investment[(a)]	1.5	1.3	86
Federal government spending	11.6	3.8	33
State and local government spending	2.9	1.7	57
Exports	9.7	5.3	55
Imports	8.9	5.6	63
Total consumption	2.3	1.2	52
Total investment	13.4	8.6	64
Total government spending	6.9	2.0	29
Average share of nominal GDP (per cent)			
Consumption of durable goods	8.5	8.5	100
Consumption of non-durable goods	27.3	20.6	76
Consumption of services	26.7	38.1	143
Equipment and software investment	6.5	7.9	121
Non-residential structures	3.9	3.2	81
Residential structures	4.9	4.5	91
Inventory investment	0.8	0.5	59
Federal government spending	11.4	7.7	68
State and local government spending	10.0	11.5	115
Exports	6.1	9.7	159
Imports	–6.0	–12.1	202

(a) The standard deviation of inventory change is calculated by taking the first difference of real inventory change and dividing through by a 20-quarter moving average of inventory change. This series begins in 1952:Q2 rather than in 1950:Q1.

Source: BEA, NIPA Tables 1.1.3, 1.1.5, 1.1.6 and 5.6.5B there is a –2.3 percentage point change when shares are held constant, implying that changes in shares contributed modestly to stabilisation, but explain only a small fraction of reduced volatility. The third column shows the opposite combination – combining the actual 1984–2005 shares with the component standard deviations from the first period – and the reduction in the sum of standard deviations is only 0.6 of a percentage point. Our conclusion from Table 3 is that roughly 20 per cent of the post-1983 reduction in business cycle volatility was due to shifts in shares away from more volatile components and toward more stable components, and the remaining 80 per cent was due to the reduction in volatility of each component.[9]

Table 3: Decomposition of Post-1983 Decline in Real GDP Volatility Between Changes in Component Volatility and Changes in Shares

	Actual deviations and shares	Actual deviations and 1950–1983 shares	Actual shares and 1950–1983 deviations
1950–1983	5.05	5.05	5.05
1984–2005	2.48	2.73	4.47
Difference between 1984–2005 and 1950–1983	–2.57	–2.32	–0.58

Source: BEA, NIPA Tables 1.1.3, 1.1.5, 1.1.6 and 5.6.5B

Since improved business cycle volatility can be traced to a reduction in the volatility within the 11 components of spending, which components contributed the most? The best way to answer this question is to use the Bureau of Economic Analysis' calculations of the contribution of each component to changes in real GDP. Table 4 displays the standard deviation of the four-quarter moving average of these 'contributions' of the 11 components, as well as the sum of those 11 standard deviations. The standard deviations are displayed in the first column for 1950–83, in the second column for 1984–2005, the difference between these is in column three, and the percentage contribution of each component to the total is in column four. By far the biggest contributor to lower volatility was federal government spending, and almost as big a contribution was made by the sum of residential investment and inventory investment. These three components contributed 74 per cent of the total reduction in volatility, leaving the remaining 26 per cent to be explained by the remaining eight sectors, particularly consumer durable and non-durable goods spending.

However, the story told in the top section of Table 4 is incomplete because it does not take into account the covariance among components, such as the crowding-out of private investment by government spending. In order to examine the effects of these covariances, we compute the standard deviation of real GDP minus the

9. The 20 per cent figure is the percentage ratio of –0.6 on the bottom line in the third column to –2.9, the sum of the numbers on the bottom line in the second and third columns.

Table 4: Standard Deviations of Four-quarter Moving Average of Contributions to Per Cent Change in Real GDP
1950–2005

	1950–1983	1984–2005	Difference 1950–1983 vs 1984–2005	Percentage contribution to sum of components
Real GDP	3.14	1.61	–1.53	
Sum of components	7.48	4.57	–2.91	100.0
Consumption of durable goods	0.83	0.42	–0.41	14.2
Consumption of non-durable goods	0.55	0.25	–0.30	10.2
Consumption of services	0.35	0.33	–0.02	0.7
Equipment and software investment	0.59	0.55	–0.05	1.6
Non-residential structures	0.30	0.29	0.00	0.0
Residential structures	0.83	0.32	–0.51	17.4
Inventory investment	1.25	0.73	–0.51	17.6
Federal government	1.44	0.31	–1.13	38.9
State and local government	0.26	0.19	–0.08	2.7
Exports	0.53	0.52	–0.01	0.5
Imports	0.55	0.66	0.11	–3.8
				Per cent of real GDP
GDP minus residential structures	2.78	1.44	–1.34	87.5
GDP minus inventory investment	2.44	1.33	–1.11	72.5
GDP minus federal government	3.18	1.61	–1.57	102.5
GDP minus residential, inventories, and federal government	1.93	1.19	–0.74	48.3

Source: BEA, NIPA Table 1.1.2

contribution of specified components in the bottom section of the table. Excluding the three volatile components one at a time yields modest or negligible reductions in volatility. But when all three volatile components are excluded together, the contribution to stability is greater than when each is excluded separately. Without the contribution of these three components the standard deviation of real GDP in the first period is 1.9 percentage points, or 61 per cent of the standard deviation of total real GDP. In the second period, excluding these three components yields a standard deviation of 1.2 percentage points, or 74 per cent of the standard deviation of total real GDP. The reduction in volatility across the two periods is 0.7 of a percentage point when the three components are excluded compared to 1.5 percentage points for total real GDP, indicating that these components account for half of the reduction in volatility. This contrasts with our conclusion from the top section of the table that these three components accounted for 74 per cent of the decline in volatility. The smaller contribution in the bottom half of the table reflects the covariances among the three components. These results seem to suggest that sector-specific structural changes on the demand side of the economy may have been as important as inflation-related supply shocks in achieving overall economic stabilisation. This is particularly evident in Figure 3, which shows that inflation volatility was relatively low, yet output volatility was relatively high, during the interval 1957 to 1967.[10]

4. Inflation and the Role of Supply Shocks

The rest of this paper develops a small econometric model to assess the role of changes in demand and supply shocks and changes in monetary policy as causes of reduced business cycle volatility during the post-1983 period. Our approach differs from that of Blanchard and Simon (2001), who called attention to many of the same factors, including the correlation between output and inflation volatility (displayed in Figure 3 above), but who did not develop an econometric model to quantify the exact role of the different causes. Our approach is closer to that of Stock and Watson (2004), who used several different macroeconometric models to assess the role of less volatile shocks.

Like Stock and Watson's (SW) 'SVAR' model (2002), our model consists of three equations, one each for the inflation rate, the short-term interest rate following a Taylor rule specification, and output (what SW call the '*IS*' equation).[11] However, we go beyond Stock and Watson in our specification of the inflation process. Instead of subsuming all of the supply shocks in the inflation equation into the error term, as do Stock and Watson in their 'SVAR' model, we use a more tightly specified inflation equation in order to identify the nature of the supply shocks. Thus when we ask the question, 'how much would the volatility of inflation and output have been reduced with no inflation shocks?', we will set to zero a specific set of 'shock' variables, not the error term in the inflation equation. Later we will go beyond the inflation equation to discuss the specification of the interest rate and output process; there we will also emphasise 'shocks' in the responses of interest rates and output that are not directly related to the other endogenous variables in the model.

4.1 The 'mainstream' model of inflation and the role of demand and supply shocks

The inflation equation used in this paper is almost identical to that developed 25 years ago by Gordon (1982) and Gordon and King (1982).[12] It builds on earlier work (Gordon 1975, 1977) that combined the Friedman-Phelps natural rate hypothesis with the role of supply shocks in directly shifting the inflation rate and

10. A detailed analysis of the role of financial innovations in achieving the reduced volatility of residential housing and consumption spending is provided by Dynan, Elmendorf and Sichel (2005).

11. As shown in Table 6, the model contains a fourth equation that translates the output gap into the unemployment gap. This fourth equation plays no essential role in the analysis and could easily be substituted out of the model.

12. The '25-year' interval refers to the conference at which the 1982 paper was given in roughly its final form, held at Brookings Institution in November, 1980.

creating macroeconomic externalities in a world of nominal wage rigidity. The term 'mainstream' model refers to a Phillips Curve that has three distinguishing characteristics: (1) the role of inertia is broadly interpreted to go beyond any specific formulation of expectations formation to include other sources of inertia, such as wage and price contracts; (2) the driving force from the demand side is an unemployment or output gap; and (3) supply-shock variables appear explicitly in the inflation equation.[13] The way that this general framework is specified in practice in this paper can be written as:

$$p_t = a(L)p_{t-1} + b(L)D_t + c(L)z_t + e_t \tag{1}$$

where lower-case letters designate first differences of logarithms, upper-case letters designate logarithms of levels, and L is a polynomial in the lag operator. The dependent variable p_t is the inflation rate.[14] Inertia is conveyed by a series of lags on the inflation rate (p_{t-1}). D_t is an index of excess demand (normalised so that $D_t = 0$ indicates the absence of excess demand), z_t is a vector of supply shock variables (normalised so that $z_t = 0$ indicates an absence of supply shocks), and e_t is a serially uncorrelated error term. Distinguishing features in the implementation of this model include unusually long lags on the dependent variable, and a set of supply-shock variables that are uniformly defined so that a zero value indicates no upward or downward pressure on inflation.

The estimated version of Equation (1) includes lags of past inflation rates, reflecting the influence of several years of inflation behaviour on current price-setting, through some combination of expectation formation, overlapping wage and price contracts, and buyer-supplier relations. If the sum of the coefficients on the lagged inflation values equals unity, then there is a 'natural rate' of the demand variable (D_t^N) consistent with a constant rate of inflation.[15] The basic equations estimated in this paper use current and lagged values of the unemployment gap as a proxy for the excess demand parameter D_t, where the unemployment gap is defined as the difference between the actual rate of unemployment and the natural rate (or NAIRU), which is allowed to vary over time.

The estimation of the NAIRU combines the above inflation equation, in which the unemployment gap serves as the proxy for excess demand, with a second equation that explicitly allows the NAIRU to vary with time:

$$p_t = a(L)p_{t-1} + b(L)\left(U_t - U_t^N\right) + c(L)z_t + e_t \tag{2}$$

13. The work of Staiger, Stock and Watson (1997, 2001) is included within the label 'mainstream approach'.

14. Note, in particular, that lower-case p in this paper represents the first difference of the log of the price level, not the price level itself.

15. While the estimated sum of the coefficients on lagged inflation is usually roughly equal to unity, that sum must be constrained to be *exactly* unity for a meaningful 'natural rate' of the demand variable to be calculated.

$$U_t^N = U_{t-1}^N + \eta_t, \mathrm{E}\eta_t = 0, var\left(\eta_t\right) = \tau^2 \quad (3)$$

In this formulation, the disturbance term η_t in the second equation is serially uncorrelated and is uncorrelated with e_t. When the standard deviation, τ, equals zero, then the natural rate is constant, and when τ is positive, the model allows the NAIRU to vary by a limited amount each quarter. If no limit were placed on the ability of the NAIRU to vary each time period, then the time-varying NAIRU would jump up and down and soak up all the residual variation in the inflation Equation (2).

The starting point of this research is a particular version of the reduced-form inflation Equation (2) that includes the gap between the actual unemployment rate and the NAIRU, as well as the lagged dependent variable (inflation). As in previous work, this specification is augmented with five variables that are interpreted as supply shocks (the z_t variables in (1) and (2) above); namely, the change in the relative price of non-food non-oil imports; the effect on inflation of changes in the relative price of food and energy; the effect on inflation of changes in the relative price of medical care; the acceleration in the trend rate of productivity growth; and dummy variables for the effect of the 1971–74 Nixon-era price controls.[16] Lag lengths (shown in Table 5) were originally specified in Gordon (1982) and have not changed since then.

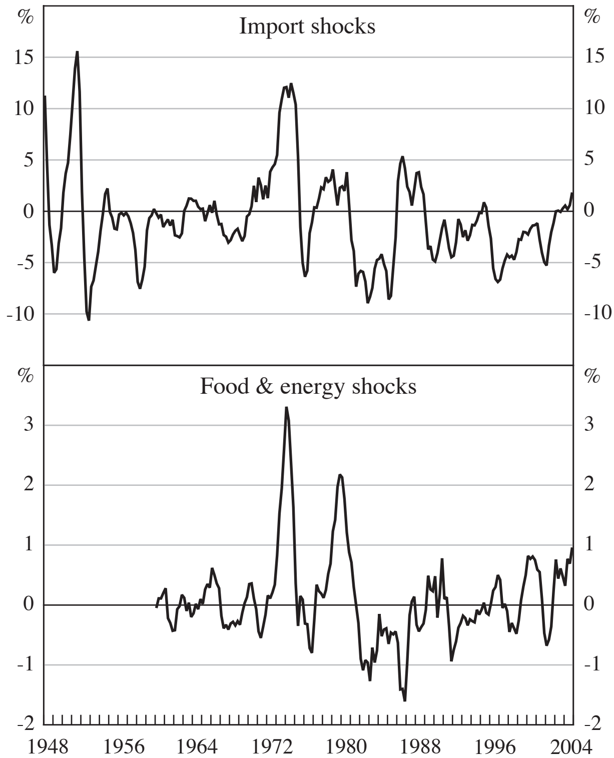
Figure 4 displays four-quarter moving averages of the relative import price variable and of the food-energy effect. The central role of the import price variable in explaining the spike of inflation in 1974–75 is clearly visible, as is its role in the Volcker disinflation of 1982–85, the accelerating inflation of the late 1980s, and the slowdown of inflation in 1997–99. The food-energy effect has somewhat different timing. Note also the different orders of magnitude of the import and food-energy effects, reflecting the fact that they are defined differently.[17]

In this paper we go beyond previous work by entering into the equation an additional 'z' variable, specified as the growth rate of the GDP (or personal consumption expenditures, PCE) deflator minus the growth rate of that deflator excluding expenditures on medical care services (as in the case of food-energy prices). The

16. The relative import price variable is defined as the rate of change of the non-food non-oil import deflator minus the rate of change of the dependent variable (GDP deflator or PCE deflator). The relative food-energy variable is defined as the difference between the rates of change of the overall PCE deflator and the 'core' PCE deflator. The Nixon-control variables remain the same as originally specified in Gordon (1982). The medical care variable is defined in the same way as the food-energy variable, that is, as the difference between the inflation rate of the deflator for PCE or GDP, and the inflation rate for that deflator when medical care spending is deducted from total PCE or GDP. The productivity trend is a Hodrick-Prescott filter (using 6 400 as the smoothness parameter) minus a six-year moving average of the same H-P trend. The only changes from the previous published paper on this approach (Gordon 1998) is the introduction of the medical care variable and the productivity trend variable (see Eller and Gordon 2003).

17. Namely, the import variable is the change in the relative price of imports, which reaches a peak of about 12 per cent in 1974–75. The food-energy variable is not the relative price of food and energy, but rather the difference between the growth rates of the PCE deflator including and excluding food and energy, and this variable peaks at 3.2 per cent in 1974–75.

Figure 4: Import and Food & Energy Supply Shocks
Four-quarter moving average

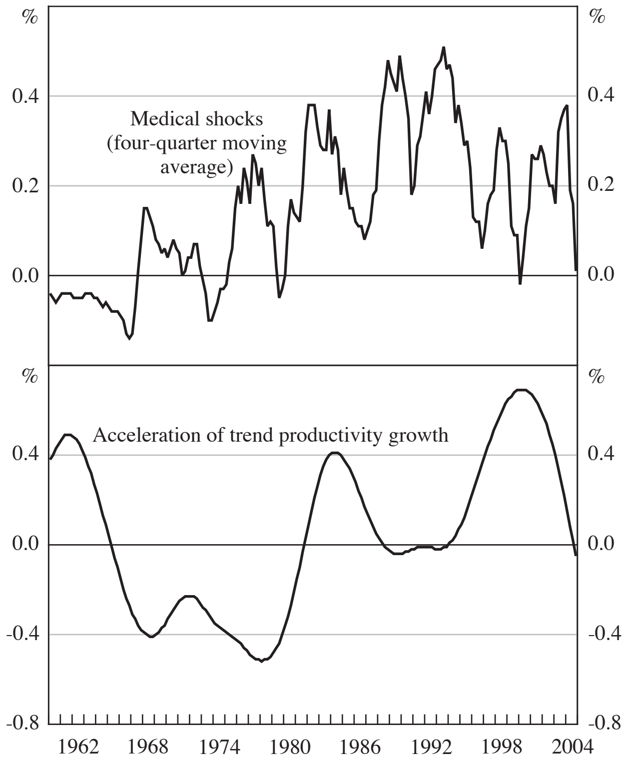


Sources: Bureau of Labor Statistics; author's calculations

top panel of Figure 5 plots the four-quarter moving average of the medical care effect, and this exhibits a succession of cyclically volatile positive values (that is, medical care inflation was faster than the inflation rate in non-medical care goods and services). The excess rate of medical care inflation peaked between 1988 and 1993 and dipped between 1996 and 2000, helping to explain why inflation in the late 1990s was so low.

Besides the addition of the medical care variable, the other major change in the current inflation equation involves productivity growth. In previous papers, the difference in the growth rates of actual and trend productivity entered into the inflation equation, and this was called the 'productivity deviation' variable. But the difference between actual and trend growth misses the main impact of the post-1995 productivity growth revival, which is the acceleration in the growth of the trend itself. Here we adopt the approach to trend estimation in Gordon (2003), and create a productivity trend growth acceleration variable, equal to a Hodrick-Prescott filter version of the productivity growth trend minus a six-year moving average of the

Figure 5: Medical and Productivity Supply Shocks



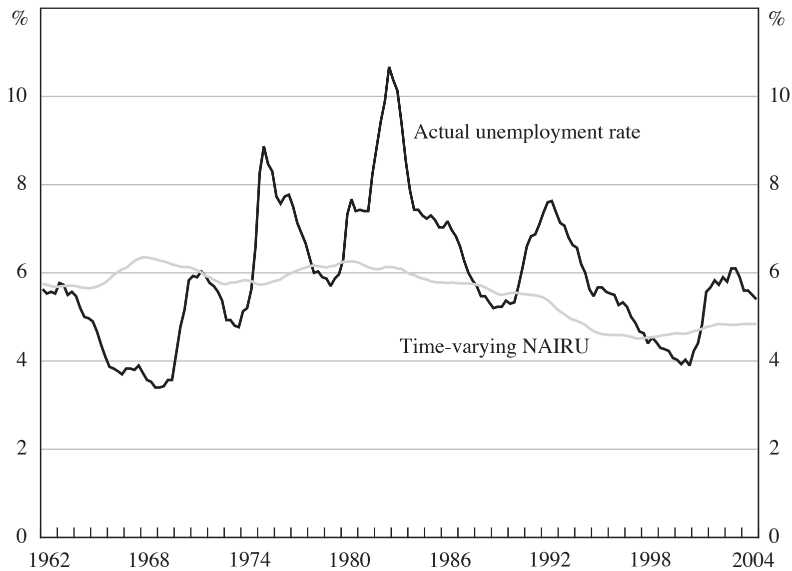
Sources: Bureau of Labor Statistics; author's calculations

same trend. This productivity trend acceleration variable is plotted in the lower panel of Figure 5. Its phase of deceleration between 1965 and 1983 might be as important a cause of accelerating inflation in that period as its post-1995 acceleration was a cause of low inflation in the late 1990s.

4.2 Estimating the Time-varying NAIRU

The time-varying NAIRU, or 'TVN', is estimated simultaneously with the inflation Equation (2) above. For each set of dependent variables and explanatory variables there is a different TVN. For instance, when supply-shock variables are omitted, the TVN soars to 8 per cent and more in the mid 1970s, since this is the only way the inflation equation can 'explain' why inflation was so high in the 1970s. However, when the full set of supply shocks is included in the inflation equation, the TVN is quite stable, as shown in Figure 6.

Figure 6: Actual Employment Rate versus Time-varying NAIRU



Sources: Bureau of Labor Statistics; author's calculations

The TVN series associated with our basic inflation equation for the PCE deflator does not fall below 5.6 per cent, or rise above 6.3 per cent, over the period between 1962 and 1988. However, beginning in the late 1980s, the TVN drifts downwards until it reaches 4.5 per cent in 1998, and then it gradually rises to a final value of 4.9 per cent in the December quarter 2004. Thus we concur with the general consensus that the TVN is currently roughly in the vicinity of 5.0 per cent, but the TVN plotted in Figure 6 is distinctly lower over the 1996–2000 period than the previous published series displayed for the PCE deflator in Gordon (1998), which reached a minimum value of 5.1 per cent in mid 1998, in contrast to the mid-1998 value of 4.5 per cent shown in Figure 6.

4.3 The inflation equation: estimated coefficients and simulation performance

Table 5 displays the estimated coefficients for the model's Equation (2) for the GDP and PCE deflators. The sum of coefficients on the lagged inflation terms is always very close to unity, as in previous research.[18] The sum of the unemployment

18. The inclusion of lags 13–24 (years 4 through 6) is strongly significant in an exclusion test. As stated in the notes to Table 5, we conserve on degrees of freedom by including six successive four-quarter moving averages of the lagged dependent variable at lags 1, 5, 9, 13, 17, and 21, rather than including all 24 lags separately.

Table 5: Estimated Equations for Quarterly Changes in the GDP and PCE Deflators
1962:Q1–2004:Q4

Variable	Lags	Coefficient estimates: GDP deflator	Coefficient estimates: PCE deflator
Lagged dependent variable[(a)]	1–24	0.98**	1.01**
Unemployment gap	0–4	–0.63**	–0.56**
Relative price of imports	1–4	0.11**	0.07**
Food-energy effect	0–4	0.65**	1.04**
Medical care effect	0–4	1.12	1.11**
Productivity trend acceleration	0	–0.62*	–0.71**
Nixon controls 'on'	0	–1.45**	–1.65**
Nixon controls 'off'	0	2.19**	1.81**
$\bar{R}^2$		0.90	0.95
Standard error of estimate		0.76	0.61
Sum of squared residuals		82.3	52.3
Dynamic simulation[(b)] 1995:Q1–2004:Q4 (per cent)			
Mean error		–0.13	–0.05
Root mean-squared error		0.52	0.41

Notes: ** and * indicate that coefficient or sum of coefficients is significant at the 1 and 5 per cent levels, respectively.

(a) The lagged dependent variable is entered as the four-quarter moving average for lags 1, 5, 9, 13, 17 and 21, respectively.

(b) Dynamic simulations are based on regressions for the sample period 1962:Q1–1994:Q4 in which the coefficients on the lagged dependent variables are constrained to sum to unity.

Source: author's calculations

gap variables is around –0.6, which is consistent with a stylised fact first noticed in the 1960s that the slope of the short-run Phillips curve is about minus one-half. The consistency of our current results with this long-standing stylised fact provides evidence of the stability of the slope of the Phillips curve over time.

Of the supply shocks, the change in the relative import price and relative food-energy effect are consistently significant in both columns, with plausibly sized positive coefficients. The coefficient on the relative price of non-food non-oil imports is 0.11 in the GDP deflator equation and 0.07 in the PCE deflator equation. The PCE coefficient of 0.07 is about half of the 14 per cent share of imports in nominal GDP. We would have expected the import price coefficient to be smaller for the GDP deflator than for the PCE deflator, rather than the reverse, since imports are excluded from GDP but included in consumption. As expected, the coefficients on the food-energy variable are much higher in the equation for the PCE deflator than for the GDP deflator, because imported energy is a part of consumption, but not part of GDP (although energy products, the prices of which are determined on global markets, form some part of GDP). The coefficient on the medical care effect is close to unity for both deflators. The coefficients for the Nixon control variables are highly significant, have the expected signs, and are of similar magnitude to those in past research.

While most papers presenting time-series regression results display coefficients, significance levels, and summary statistics, few go beyond that and display results of dynamic simulations. Yet the performance of the inflation equation is driven in large part by the role of the lagged dependent variable terms, making dynamic simulations the preferable method for testing. To run such simulations, the sample period is truncated 10 years before the end of the full sample period, and the coefficients estimated from the sample through 1994 are used to simulate the performance of the equation for 1995 to 2004, generating the lagged dependent variables endogenously. Since the simulation has no information on the actual value of the inflation rate, there is nothing to keep the simulated inflation rate from drifting far away from the actual rate. The bottom of Table 5 displays results of this dynamic simulation. Two statistics on simulation errors are provided, the mean error (ME) and the root mean-squared error (RMSE). The simulated values of inflation are extremely close to the actual values, with a mean error over 40 quarters of only –0.13 per cent for the GDP deflator equation and a minuscule –0.05 per cent for the PCE deflator equation. For both equations, the RMSE of the simulations is substantially lower than the standard error of the estimate for the 1962–94 sample period. These simulation results are substantially better than those reported in Gordon (1998).

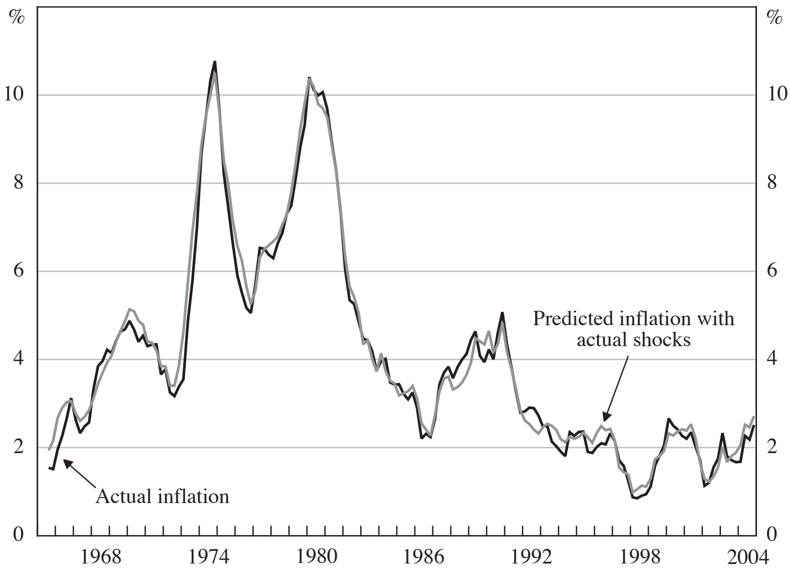
4.4 Long simulations with and without supply shocks

The aim of the rest of the paper is to assess the role of shocks and changes in monetary policy as causes of the marked reduction in business cycle volatility documented above. The role of supply shocks in the inflation equation can be examined by running alternative simulations that use the full set of supply-shock variables and alternatively set them to zero, either one at a time or together.[19] We use the full set of information provided by our data – the coefficients presented above in Table 5 – and run simulations of the inflation equation with the shock variables alternatively included and excluded.

Figure 7 compares actual four-quarter changes in the PCE deflator with a dynamic simulation of the PCE deflator equation for the 160 quarters between 1965:Q1 and 2004:Q4, using the 1962–2004 period to estimate the coefficients as in Table 5. The dynamic simulation stays on track remarkably well over this long period. The same simulation is copied to Figure 8 and compared there with an alternative simulation that sets all supply-shock variables to zero. That is, inflation in this alternative simulation depends only on the simulated values of the lagged dependent variable terms plus the current and lagged values of the unemployment gap. Simulated

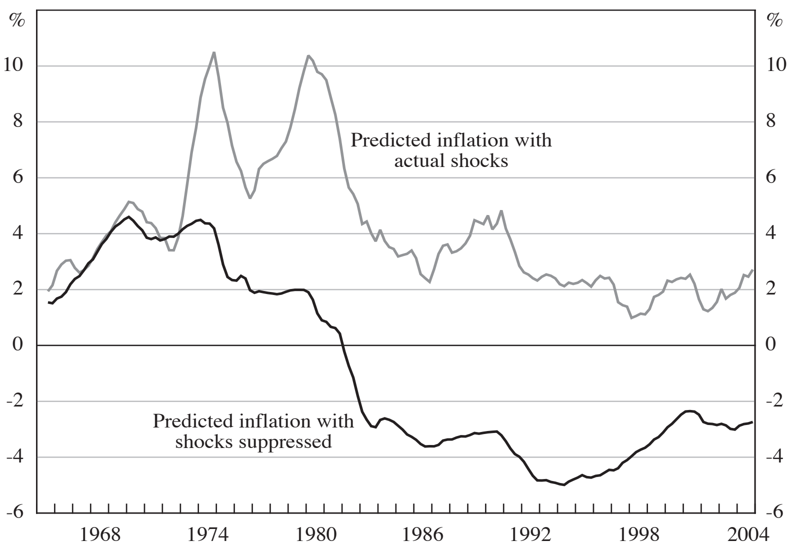
19. We cannot use the technique of truncating the sample period, as in the previous section, because we are particularly interested in the adverse supply shocks of the 1970s, and a simulation based on an equation truncated at, say, 1973 would have too little information and degrees of freedom to estimate coefficients on the supply-shock effects.

Figure 7: Actual and Predicted Inflation for the PCE Deflator



Sources: BEA, NIPA tables; author's calculations

Figure 8: Predicted Inflation With and Without Supply Shocks



Source: author's calculations

inflation with no shocks remains roughly equal to the full-shock simulation through early 1973, and then stays consistently below the full-shock simulation by a very large amount for the next 30 years. Since the only variable driving a rise or fall in inflation is the unemployment gap, the severe recessions of 1974–75 and 1981–82 cause marked declines in the inflation rate, moving into negative territory in 1981, with a further fall in 1991–92 and a rise between 1995 and 2001. Notice that the difference between the two simulations narrows in the late 1990s, since the full-shock simulated value of inflation fails to rise between 1995 and 2001, due to the role of beneficial supply shocks, while the no-shock simulated value accelerates by about 2.5 percentage points.

The prediction of deflation in Figure 8 highlights the problem of running a single-equation simulation in a multi-equation world. If there had been no adverse supply shocks in the 1970s, the recessions of 1974–75 and 1981–82 would have been much less severe or perhaps would not have happened at all. To develop a more realistic quantitative assessment of what would have happened without supply shocks in the inflation process, we need to develop a small macro model that allows us to trace the chain of causation from lower inflation volatility to lower output volatility, back to the behaviour of the unemployment gap term in the inflation equation.

5. Properties of a Four-equation Macro Model

There are numerous small macro models that could be used in this study, but none of them include the explicit treatment of supply shocks that is needed to adequately address the sources of inflation volatility. For instance, the 'SVAR' model used by Stock and Watson (2002, 2004) subsumes the role of supply shocks into the error term rather than modelling their role explicitly. The model developed in this paper starts with the inflation equation developed above and adds three extra equations. In order to evaluate the role of changing monetary policy responses, we add an equation for the nominal federal funds rate based on the Taylor rule, as in the SVAR model. Monetary policy can then influence output directly, and inflation indirectly, in the third equation, which makes the change in the output gap a function of lagged inflation and the change in the federal funds rate. Earlier we referred to this as a 'three-equation' model, but for convenience we add a fourth equation that links the unemployment gap (the demand variable in the inflation equation) to current and lagged values of the output gap. Using a notation that is consistent with the treatment of inflation above, the four-equation model can be written:

$$p_t = a(L)p_{t-1} + b(L)\left(U_t - U_t^N\right) + c(L)z_t + e_{pt} \tag{4}$$

$$R_t = T^* + p^* + d(L)\left(p_t - p^*\right) + f(L)G_t + e_{Rt} \tag{5}$$

$$\Delta G_t = h(L)\Delta p_{t-1} + j(L)\Delta R_t + e_{gt} \tag{6}$$

$$U_t - U_t^N = k(L)G_t + e_{Ut} \tag{7}$$

The symbol G stands for the level of the output or real GDP gap, that is, the log ratio of actual to natural real GDP, and ΔG stands for the first difference of the output gap. The Taylor rule equation for the federal funds rate includes the Fed's target for the real funds rate (T^*), its target for the inflation rate (p^*), the current and lagged deviations of the actual inflation rate from the inflation target, and current and lagged levels of the output gap. The output gap equation makes the change in the gap a function of one or more lags of the first difference of the inflation rate and of the change in the interest rate. Finally, the Okun's Law equation makes the level of the unemployment gap depend on the current value and one or more lags of the output gap.

The columns of Table 6 list the four dependent variables in the model, with the middle columns providing alternative sets of results for the interest rate equation. The choice of the three sub-intervals reflects apparent changes in Fed reactions – corresponding roughly to the three periods identified by Stock and Watson (2004, Table 5) – with breaks in 1979:Q3 (the start of the Volcker period) and in 1990:Q2 (the end of the period in which the Fed appeared to fight inflation aggressively while ignoring output deviations).

The second column of Table 6 shows coefficients in the inflation equation for the GDP deflator, which is identical to the equation already discussed in the first column of Table 5. The six middle columns show estimated Taylor rule equations for three periods split in 1979 and 1990. As a shorthand, we will refer to the three sub-intervals respectively as the 'Burns', 'Volcker', and 'Greenspan' responses. Let us first examine the first set of coefficients shown for each sub-interval, labelled 'AR(1) Correction? No'. These coefficients show that before 1979, the Burns Fed 'accommodated' inflation, raising the nominal interest rate by less than half of any increase in the inflation rate, hence reducing the real interest rate and stimulating demand. After 1979, the inflation response jumped from 0.45 to 1.46, so that the Volcker Fed raised the nominal federal funds rate more than the increase of inflation above its target rather than less. The Greenspan Fed continued to respond aggressively to higher inflation, but also responded aggressively to the output gap, raising the nominal federal funds rate by almost a full percentage point in response to a positive output gap of 1 per cent. These coefficients reflect the widespread impression that the Greenspan Fed combined the best of both worlds, aggressively fighting inflation while also vigorously working to stabilise the output gap. Indeed, these coefficients for the Greenspan Fed correspond very closely to those for several alternative models surveyed by Stock and Watson (2004, Table 5, p 24).

However, this consensus conclusion is flawed by the extreme degree of positive serial correlation evident in the interest rate equation, especially for the Greenspan interval. To summarise what follows, the Burns and Volcker coefficients survive a serial correlation correction with their Taylor rule coefficients essentially intact, but the Greenspan coefficients turn out to be fragile. Let us take a simple version of the interest rate Equation (5), with the fixed constant term and lagged effects suppressed:

Table 6: Coefficients from Four-equation Model
Estimated for 1962:Q1–2004:Q4

		Dependent variable								
			Nominal federal funds rate							
	Lags included	Inflation rate	1960:Q1–1979:Q2 'Burns' AR(1) correction?		1979:Q2–1990:Q2 'Volcker' AR(1) correction?		1990:Q3–2004:Q4 'Greenspan' AR(1) correction?		Δ output gap	Unemployment gap
			No	Yes	No	Yes	No	Yes		
Endogenous variables										
Inflation	1–24	0.98**								
Inflation minus inflation target	0–1		0.45**	0.66**	1.46**	1.55**	1.43**	0.57*		
Δ inflation rate	1–4								0.17	
Federal funds rate error term	1			0.89**		0.70**		1.00**		
Δ federal funds rate	2–10								–1.06**	
Level of unemployment gap	0–4	–0.63**								
Level of output gap	0–1		0.24**	0.49**	–0.03	0.11	0.95**	0.60**		
Level of output gap	0–2									–0.52**
Exogenous variables										
Relative price of imports	1–4	0.11**								
Food-energy effect	0–4	0.65**								
Medical care effect	1–4	1.12**								
Productivity trend acceleration	0	–0.62*								
Nixon controls 'on'	0	–1.45**								
Nixon controls 'off'	0	2.19**								
$\bar{R}^2$		0.90	0.62	0.91	0.69	0.82	0.31	0.95	0.20	0.88
Standard error of estimate		0.76	1.50	0.74	1.70	1.37	1.56	0.39	0.75	0.50
Sum of squared residuals		82.3	165.9	39.85	126.7	71.2	130.9	7.9	87.2	41.7

Note: ** and * indicate that coefficient or sum of coefficients is significant at the 1 and 5 per cent levels, respectively.
Source: author's calculations

$$R_t = d\left(p_t - p^*\right) + fG_t + e_{Rt} \tag{8}$$

where $e_{Rt} = \rho e_{Rt-1} + u_{Rt},\, u_{Rt} \sim N(0, s)$.

To correct for the serial correlation represented by the positive value of ρ, we estimate Equation (8) in the following alternative form:

$$R_t = \rho R_{t-1} + d\left(p_t - p^*\right) - \rho d\left(p_t - p^*\right) + fG_t - \rho f G_{t-1} + u_{Rt} \tag{9}$$

To correct for serial correlation, the interest rate equation was re-estimated using 'feasible general least squares' (FGLS), a procedure which estimates the basic equation, then regresses the residuals on their lag in order to find the autoregressive (ρ) coefficient, and then differences the terms based on that coefficient.[20] The alternative results are shown in the columns in Table 6 labelled 'AR(1) Correction? Yes'. The correction makes little difference for the Volcker coefficients and slightly increases both the inflation and output gap responsiveness of the Burns reaction function. But the effect on the Greenspan coefficients is profound; the inflation response changes from an inflation-fighting 1.43 to an inflation-accommodating 0.57. The coefficient on the output gap falls by one-third, from 0.95 to 0.60. With the serial correlation correction, the Greenspan coefficients turn out to be almost identical to the Burns coefficients. In this sense, compared to pre-1979, the Greenspan era represents no improvement in monetary policy at all! All the model simulations displayed and discussed in the rest of this paper use the version of the interest rate equation that is corrected for serial correlation.

The '*IS*' equation for the first difference of the output gap, shown in the second-last column of Table 6, shows an insignificant positive response to the first difference of the inflation rate, suggesting no direct feedback from a sharp increase of inflation to a sharp decrease in output, as might have been suggested by the economy's behaviour in the 1970s. The responses to changes in the nominal federal funds rate are of plausible size and highly significant; an increase in the funds rate by 100 basis points causes a decline in the output gap of 1 percentage point, with a long lag distributed over the next 10 quarters.[21] The final column in Table 6 exhibits the Okun's Law equation, showing that the unemployment gap responds to the output gap over the current and first two lagged quarters with a highly significant coefficient of –0.52.

20. I am grateful to my research assistant Ian Dew-Becker for noticing the serial correlation problem in the Greenspan equation and implementing the FGLS procedure to fix it.

21. The current and first lags of the interest rate are omitted in the output gap equation because of simultaneity; in the short run, changes in output and interest rates tend to be positively correlated as '*IS* shifts' move the economy along the '*LM* curve'.

5.1 Single-equation model simulations

The aim of building the model is to use it to decompose the sources of business cycle volatility. For this purpose we will focus on four different sources of volatility and its post-1983 reduction, namely the set of supply shocks included in the inflation equation; the error term in the interest rate equation; the error term in the output gap equation; and shifts in the parameters in the interest rate equation that reflect changes in Fed policy.[22] In this section we will examine the performance of each equation without model interactions; that is, each equation's predicted values are examined using actual historical values for the endogenous explanatory variables. Subsequently we will examine outcomes that feed back simulated values of the endogenous variables.

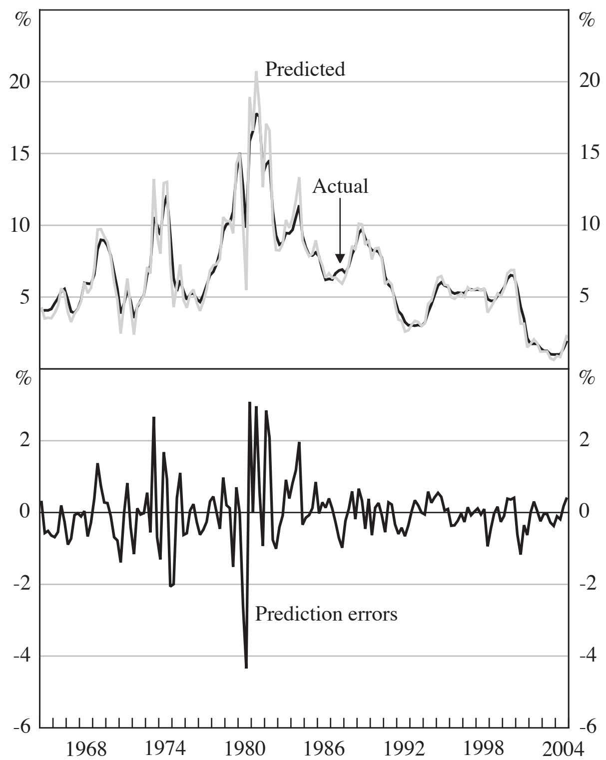
Having already examined the simulation performance and role of supply shocks in the inflation equation (see Figures 7 and 8), we now turn to the single-equation behaviour of the interest rate equation, taking its explanatory variables as exogenous. All the simulations in this paper assume that the inflation target (p^*) in Equation (6) is 2.0 per cent and that the real interest rate target (T^*) is 3.0 per cent. As in Table 6, the coefficients on inflation and the output gap are allowed to shift in 1979 and 1990. The fitted performance of the equation is extremely close to the actual values, as shown in the top frame of Figure 9, which is no surprise in light of the correction for serial correlation. Without that correction, the equation (using the estimated coefficients shown in Table 6 without the AR(1) correction) misses three aspects of interest rate behaviour after 1990. First, the Fed's 'pre-emptive strike' of raising the nominal federal funds rate sharply in 1994 is not captured by the equation. Second, the flatness of the rate between 1995 and 2000 is not captured; a Taylor rule would have increased the rate substantially more in response to the move of the output gap from negative to positive. Finally, and most important, the standard Taylor rule approach cannot explain why the Fed reduced rates so fast and kept them so low between 2001 and 2004.

The central topic of this paper is the reduced volatility of the output gap, as already examined in Figure 2. The predictive performance of the output gap equation is shown in Figure 10. While the equation is estimated in first-difference form, the actual and predicted values of the first differences are converted back to the level of the output gap in Figure 10.[23] Clearly, the output gap has a life of its own that is not captured by the simple '*IS*' equation. The output gap equation misses about half of the boom of the late 1960s and of 1973, and predicts a much smaller recession in 1974–75 than actually occurred. In contrast, the equation's predictions overstate the severity of the 1980–85 slump, fail to capture the output gap's rise above zero in the late 1980s, and then completely miss the dynamics of the 1990s. The economy is predicted to be stronger in the early 1990s than the late 1990s, and in response

22. No attention is paid to errors in the Okun's Law equation, which is viewed here as a purely mechanical bridge between the output and unemployment gaps.

23. The errors in the first-difference equation are translated into errors in the level of the output gap by forcing the level errors to have a mean of zero over the 1965–2004 period.

Figure 9: Actual Federal Funds Rate and Predicted Values from Taylor Rule Equation

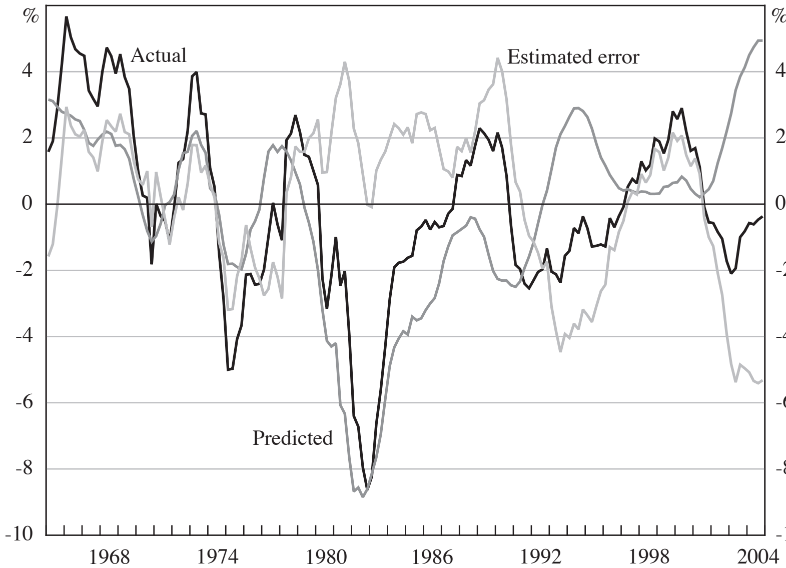


Sources: Board of Governors of the Federal Reserve System; author's calculations

to the Fed's aggressive rate reductions between 2001 and 2004, the economy is predicted to be much stronger in the current decade than actually occurred.

These errors in the output gap equation are not bad news for the model. Rather, they remind us that output depends on far more than movements back and forth along a fixed IS curve, as is implied by our model which makes changes in interest rates the only significant source of changes in the output gap. Obviously *shifts* in the IS curve matter as well, and it would take a much more complex model to capture the sources of these IS shifts. Missing from the predictions of the output gap equation in Figure 10 are such important events as Vietnam war spending in the late 1960s and the timing of the hi-tech investment boom of the late 1990s. In the full-model simulations discussed below we will explore the effects of suppressing the error term in the output equation.

Figure 10: Actual and Predicted Level of the Output Gap



Source: author's calculations

Table 7 summarises the single-equation results that are plotted in Figures 8, 9 and 10. The top four lines calculate standard deviations of the actual values of the inflation rate, federal funds rate, and the level and first difference of the output gap. The reported standard deviations for the actual inflation rate and output gap are similar to those in the discussions of Figures 2 and 3 above, with a decline in the standard deviation of the output gap of more than half after 1983, and a decline in the standard deviation of the inflation rate by almost 60 per cent. In contrast, the volatility of the interest rate declined by much less – about 30 per cent.

How well do the simulations (for the inflation equation) and predicted values (for the other equations) replicate the decline in the standard deviations of the actual variables? Simulated inflation falls by 68 per cent, even more than the actual value, and simulated inflation declines substantially whether supply shocks are included or excluded. However, as we have seen in Figure 8 above, much of the pre-1984 inflation volatility in the 'no-shocks' scenario is due to the role of deep recessions in forcing inflation into negative territory. A full understanding of the role of supply shocks requires us to unleash the full set of model interactions, since without supply shocks in the 1970s there would not have been the spikes of the interest rate in 1981–82, nor the deep recession of 1981–82.

The single-equation predictions for the federal funds rate differ from the other equations because the error term is so small, virtually eliminated by the serial correlation correction. The predicted value for the interest rate has a decline in its standard deviation of 32 per cent, identical to the actual decline. The output gap

Table 7: Single-equation Simulations

	1965–1983	1984–2004	Ratio of 1984–2004 to 1965–1983 (per cent)
Actual values			
Inflation rate	2.40	1.00	41.7
Federal funds rate	3.63	2.49	68.6
Level of output gap	3.52	1.56	44.3
First difference of output gap	1.10	0.54	49.1
Simulation results			
Simulated inflation	2.31	0.74	32.0
Simulated inflation without supply shocks	1.51	0.54	35.8
Contribution of supply shocks	2.57	0.67	26.1
Predicted federal funds rate with interest error	3.63	2.49	68.6
Predicted federal funds rate without interest error	3.51	2.33	66.4
Predicted first difference of output gap with output error	1.10	0.54	49.1
Predicted first difference of output gap without output error	0.53	0.31	58.5

Source: author's calculations

equation yields a predicted value (for the first difference of the gap) that has a decline in its standard deviation of 51 per cent, as compared to the actual decline of 55 per cent. Eliminating the error term in the output gap equation cuts the standard deviation by half before 1984 and by about 40 per cent after 1984, indicating that a reduction in the variance of the output error contributed to business cycle stabilisation after 1983.

5.2 Full-model simulations

To assess the role that supply shocks in the inflation equation played in reducing business cycle volatility, and the role of the error terms in the interest rate and output gap equations, we run full-model simulations with alternative shocks set equal to zero, one at a time and then all together. Table 8 contains five sections, one each for the standard deviation of inflation, the interest rate and the output gap, then the average value of inflation and the average absolute value of the output gap. Within each section there are five lines corresponding to the full-model simulations and alternative simulations that suppress the shocks one at a time and all together.

The contrast between the single-equation and full-model simulations can be seen by comparing Tables 7 and 8. This is summarised in Table 9, which shows the percentage ratio of the standard deviations for 1984–2004, relative to 1965–1983, using actual data for each of the three variables, the single-equation simulation values, and the full-model simulation values.[24]

Table 8: Standard Deviations of Full-model Specifications, Split-sample Taylor Rule
1965:Q1–2004:Q4

	1965–1983	1984–2004	Ratio of 1984-2004 to 1965–1983 (per cent)
Standard deviation of inflation rate (percentage points)			
All shocks	2.61	1.44	55.2
No supply shocks	0.60	0.67	111.7
No output error	2.11	0.99	46.9
No interest error	2.58	1.55	60.1
No shocks	0.00	0.00	–
Standard deviation of fed funds rate (percentage points)			
All shocks	3.43	1.56	45.5
No supply shocks	1.72	1.43	83.1
No output error	1.66	0.59	35.5
No interest error	3.08	1.50	48.7
No shocks	0.00	0.00	–
Standard deviation of output gap (percentage points)			
All shocks	3.28	1.82	55.5
No supply shocks	1.89	1.94	102.6
No output error	1.06	0.33	31.1
No interest error	3.12	1.88	60.3
No shocks	0.00	0.00	–
Average inflation rate (per cent)			
All shocks	5.48	2.86	52.2
No supply shocks	3.41	4.15	121.7
No output error	3.23	1.31	40.6
No interest error	5.40	2.82	52.2
No shocks	2.00	2.00	100.0
Average absolute value of output gap (per cent)			
All shocks	2.64	1.81	68.6
No supply shocks	1.77	1.69	95.5
No output error	1.28	0.84	65.6
No interest error	2.58	1.87	72.5
No shocks	0.00	0.00	–

Source: author's calculations

24. The middle section of Table 8 displays the standard deviation of the output gap; Table 9 refers to the standard deviation of the first difference of the output gap as in Table 7.

Table 9: Ratio of Standard Deviations
1984–2004 relative to 1965–1983, per cent

	Four-quarter inflation rate	Interest rate	Δ output gap
Actual values	41.7	68.6	49.1
Single-equation simulations	32.0	68.6	49.1
Full-model simulations	55.2	45.5	47.1

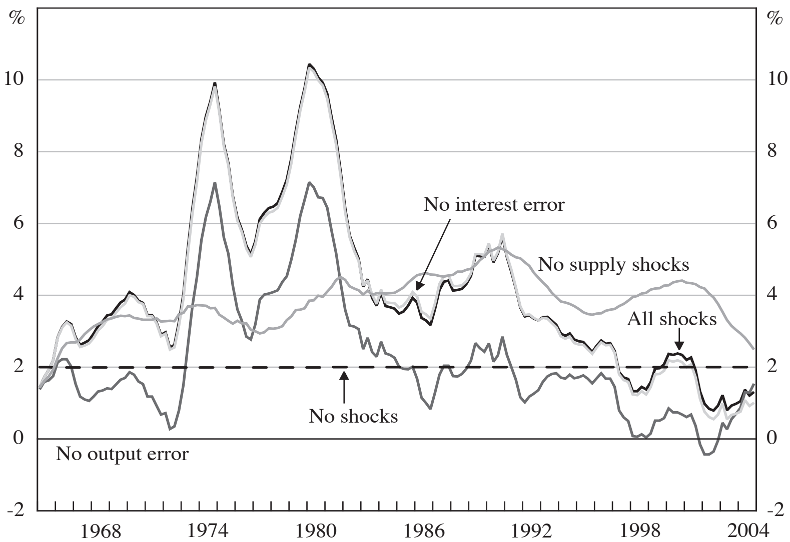
Source: author's calculations

Both the full-model simulations and the single-equation simulations include the exogenous effects of the supply-shock variables in the inflation equation, as well as the error terms in the interest rate and output gap equations. But they differ in that the former use endogenous model-generated values rather than actual values for the endogenous variables in each equation. While the model comes very close to duplicating the actual decline in the volatility of the output gap between the two periods, it understates the decline in the volatility of inflation and overstates the decline in the volatility of the interest rate.

Turning back to Table 8, we can now discuss the relative role of supply and demand shocks in explaining the model's simulated volatility. Because of the serial correlation correction, errors in the interest rate equation play no role in the explanation. While Table 8 displays the effect of suppressing the interest rate errors, they make virtually no difference and are not discussed further. We start with the alternative simulations for the inflation rate as described in the top section of Table 8. For the first period, suppressing the supply shocks eliminates almost 80 per cent of the standard deviation of inflation in the first period, while suppressing the output gap error eliminates about 20 per cent of the standard deviation of inflation in the first period. Suppressing supply shocks reduces the second period standard error by about half, and suppressing the output error reduces it by about one-third.

Figure 11 illustrates the role of supply shocks and the output error in explaining the behaviour of the inflation rate. The dark solid line shows the full model simulation, which is virtually identical to the single-equation simulations depicted in Figures 7 and 8. The interest error has little effect, but suppressing the output error reduces the inflation rate by a roughly constant 2 to 3 percentage points throughout the simulation period. Since the output equation cannot generate the excess demand of the late 1960s, without the output error the model forecasts less inflation throughout the full 40-year simulation period. What remains when the output error is suppressed represents the combined contribution of the supply shocks, causing a rise in inflation of 6 percentage points between 1972 and 1975, and a reversal in which inflation declined by about 5 percentage points between 1981 and 1984. Thus, ironically, the 'Volcker disinflation' that has usually been attributed to monetary policy should actually be credited in part to the reversal of supply shocks – not just the decline in the real price of oil, but also the effects of the dollar appreciation between 1980 and 1985.

Figure 11: Predicted Values of Four-quarter Inflation Rate



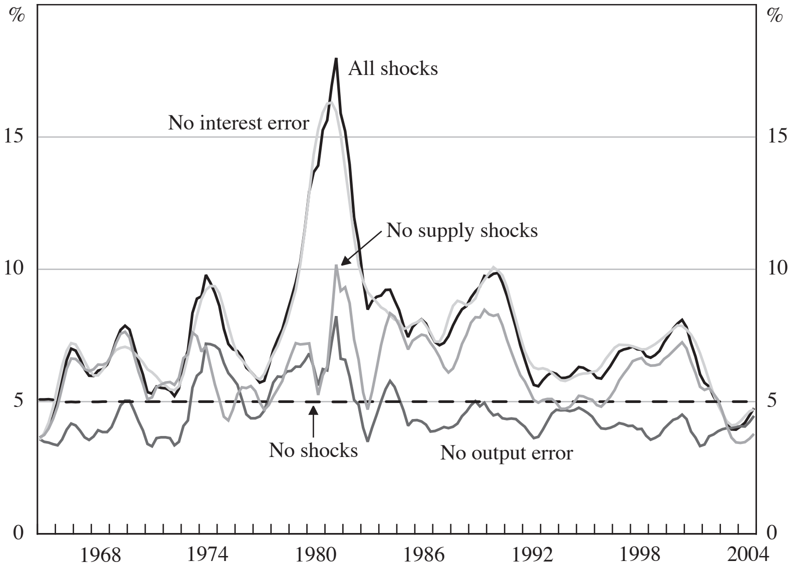
Source: author's calculations

Turning to the federal funds rate, Table 8 shows that in the first period, eliminating supply shocks reduces the standard deviation of the interest rate by half, as does eliminating the output error. In the second period, supply shocks have no impact on volatility, but suppressing the output error reduces the standard deviation of the interest rate by more than half. Thus much of the instability of the interest rate occurred through the effect of volatility of the output gap, generated by the output error directly, and indirectly by the effect of the output error in generating high inflation, rather than by monetary policy or supply shocks.

The simulations for the interest rate are displayed in Figure 12. Due to the correction for serial correlation, suppressing the model's own-equation interest rate errors makes virtually no difference. Compared to the basic model simulation, suppressing the supply shocks makes a big difference in holding down the interest rate between 1974 and 1985, but after 1985 this reduces the interest rate by only about 1 percentage point. Suppression of the output error also makes a big difference in reducing the interest rate throughout the 40-year simulation period, and particularly between 1977 and 1992. Recall that eliminating the output error works directly through the output gap term in the interest rate equation and indirectly though the effect of a lower output gap in reducing the inflation rate, and hence reducing the interest rate through the inflation term in the interest rate equation.

The next section of Table 8 tells a simple story, in which more than two-thirds of of the volatility of the output gap in the first period was caused by the output error and more than 80 per cent in the second period. Suppressing the supply shocks

Figure 12: Predicted Values of Four-quarter Moving Average of Federal Funds Rate



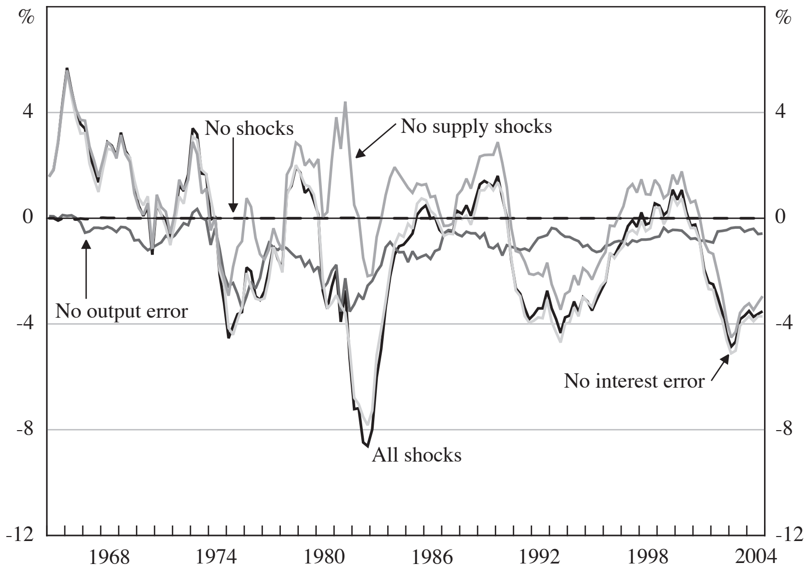
Source: author's calculations

eliminates more than 40 per cent of the output gap volatility in the first period, but none in the second period. Figure 13 displays alternative simulations of the output gap. Suppressing the supply shocks converts the double recessions of 1975 and 1981–82 into a long period of prosperity, with the output gap bouncing around between 4 per cent and –2 per cent over the entire 1975–92 period. Suppressing the output error dampens fluctuations in the output gap but still leaves the economy vulnerable to the effects of supply shocks, particularly between 1975 and 1985 when a decade-long recession would have occurred. With no output error, the output gap in Figure 13 would have been very close to zero throughout 1987–2004.

While this paper is about the reduction in business cycle volatility, particularly about the post-1983 reduction in the standard deviation of inflation and the output gap, the Fed's objective as captured in the model's interest rate equation is not the standard deviation of the inflation rate but rather its *average value*. As for the output gap, the Fed's goal is for the output gap to be zero, and hence to minimise the average absolute value of the output gap. The bottom two sections of Table 8 report the effect of shocks on these two central objectives of Fed policy.

Suppressing the supply shocks and the output error would each have reduced the inflation rate by 2 percentage points, or about 40 per cent in the first period. In the second period, suppressing the supply shocks actually raises the inflation rate by more than 1 percentage point, since on balance during the second period the supply

Figure 13: Predicted Level of Output Gap



Source: author's calculations

shocks were 'beneficial' rather than 'adverse'. In contrast, suppressing the output error in the second period eliminates more than half of the inflation simulated by the full model. In the first period, suppressing the supply shocks eliminates one-third of the average absolute value of the output gap, whereas suppressing the output error eliminates slightly more than one-half. In the second period, suppressing the supply shocks has little effect on the output gap, but suppressing the output error reduces its average absolute value by more than half.

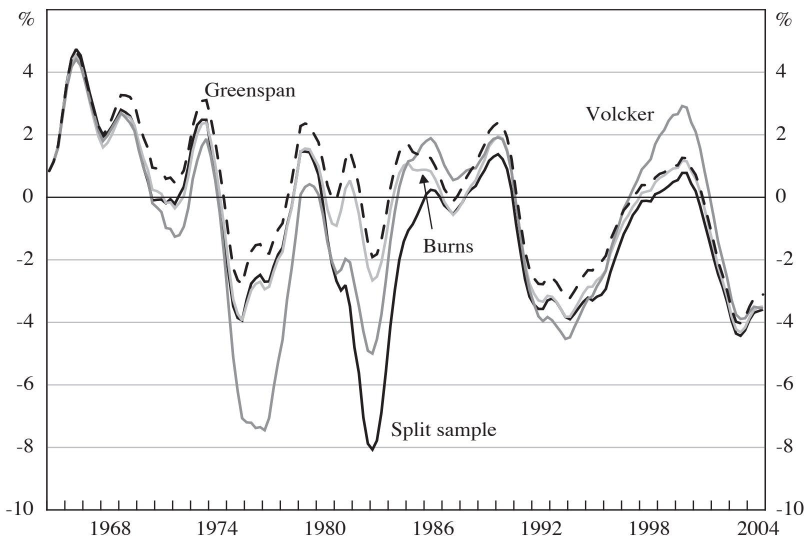
Overall, both the supply shocks and the output error contributed to the high volatility of inflation and the output gap before 1983, as well as to the high average value of inflation and the high average absolute value of the output gap. Suppressing the supply shocks makes the economy's behaviour in the first period similar to its behaviour in the second period, thus eliminating the puzzle of reduced volatility, and in fact suppressing the supply shocks makes average inflation in the second period *higher* than in the first period. Suppressing the output error makes the economy more stable and inflation lower in both periods. Without the output error, the output gap would have been much smaller and less volatile in both periods, and without the output error we still would have had a puzzle of improved post-1983 volatility that would have been resolved by the role of the supply shocks.

5.3 The role of changes in monetary policy

As shown in Table 6 above, the Fed's response to inflation and the output gap shifted over the three periods where breaks are allowed; 1960–79 ('Burns'), 1979–90 ('Volcker'), and 1990–2004 ('Greenspan'). The big shift from Burns to Volcker was an increase in the response coefficient of the nominal federal funds rate to an increase of the inflation rate (relative to the 2.0 per cent target), from well below unity to well above unity (that is, from a policy of inflation accommodation to a policy of inflation fighting). The Volcker Fed cared only about fighting inflation and placed no weight at all on reducing the output gap. After 1990, under Greenspan, inflation fighting remained, but the response to the output gap increased from zero to nearly unity, as is consistent with the Fed's aggressive rate reductions from 1991 to 1993 and in 2001–02. However, as we have seen in Table 6, the estimated coefficients for the Greenspan period are tainted by positive serial correlation. When a serial correlation correction is applied, Greenspan's credentials as an inflation fighter disappear, and the Greenspan coefficients emerge looking just like the Burns coefficients.

The difference made by these shifts in Fed policy is shown in Figure 14, which plots four alternative paths of the output gap; all these full-model simulations include the output error and all use the coefficients from Table 6 that are corrected for serial correlation. The dark solid line labelled 'split sample' allows the Taylor rule coefficients to shift across the three periods. The other lines force the coefficients for a particular sub-interval to apply to the full 40-year simulation period. Since the Volcker coefficients do not respond at all to output but respond strongly to

Figure 14: Simulations of Output Gap Under Various Taylor Rules



Source: author's calculations

inflation, it is not surprising that the Volcker coefficients imply deeper recessions in 1971 and especially in 1975–76. Since this aggressive early response to inflation would have moderated inflation, a smaller recession in 1981–82 is implied. Also, the Volcker coefficients, by not responding to the positive output gap from 1998 to 2001, would have allowed the output gap to go higher. The Burns coefficients are not distinguishable on the chart before 1979, since their effect is the same as the 'split sample' line. After 1979, the less aggressive response to inflation would have resulted in a milder recession in the early 1980s. The Greenspan coefficients yield roughly the same path as the Burns coefficients, with shallower recessions in both 1975 and 1981–82 than the Volcker coefficients.

The simulation results from Figure 14 are summarised in Table 10. The top section shows that if the Volcker coefficients had been in effect before 1979, the volatility of inflation would have been reduced by about 20 per cent in both the first and second periods. The Greenspan coefficients would actually have made the volatility of inflation slightly higher in the first period, albeit lower in the second period. The next section shows that the Burns and Greenspan coefficients would have reduced the pre-1984 volatility of interest rates by more than half, and even the Volcker coefficients would have reduced interest rate volatility somewhat, by fighting inflation earlier and making the peak interest rates of 1980–81 unnecessary.

Compared to the Volcker and split-sample outcomes, either the Burns or Greenspan coefficients would have reduced the standard deviation of the output gap in the first period by about one-third, as well as the average absolute value of the output gap (bottom section of Table 10). However, this improved performance on output volatility would have come at a cost of much higher inflation than the Volcker policy responses. In fact, by failing to fight inflation aggressively, the Greenspan coefficients would have yielded post-1983 average inflation of almost 8 per cent per year as compared to the 2.9 per cent average yielded by the split-sample policies and 2.8 per cent average yielded by the Volcker policies.

Which set of policies was 'best'? There is no answer to that question without placing welfare weights on the average rate of inflation as compared to the average absolute value of the output gap. If what counts is the economy's performance in the long run, then the Volcker policies win the contest compared to the Burns or Greenspan policies. Consider the contrast between the Volcker and Greenspan policies. The Volcker response achieved 2 percentage points lower inflation before 1984 at the cost of 1 extra percentage point of the average absolute value of the output gap, the classic inflation-output trade-off. It is after 1984 that the pay-off from the Volcker policies becomes evident, with a full 5 percentage points less inflation than the Greenspan policies at the cost of only 0.4 of a percentage point higher average absolute output gap.

Much of the long-run benefit of the Volcker inflation-fighting policies occurred through the creation of a large recession in 1975. Would the verdict on the policies change if our simulations were to begin in 1979 instead of 1965, thus preventing the Volcker policies from having a counterfactual 'head start'? Table 11 is laid out

Table 10: Standard Deviations of Full-model Specifications, Split-sample Coefficients and Full-sample Coefficients for Taylor Rule

	1965–1983	1984–2004	Ratio of 1984-2004 to 1965–1983 (per cent)
Standard deviation of inflation rate (percentage points)			
Split-sample coefficients	2.61	1.44	55.2
Burns	2.62	1.26	48.1
Volcker	2.09	1.14	54.5
Greenspan	3.08	1.08	35.1
Standard deviation of fed funds rate (percentage points)			
Split–sample coefficients	3.43	1.56	45.5
Burns	1.62	1.41	87.0
Volcker	2.73	1.49	54.6
Greenspan	1.56	1.39	89.1
Standard deviation of output gap (percentage points)			
Split-sample coefficients	3.28	1.82	55.5
Burns	2.25	1.98	88.0
Volcker	3.39	2.44	72.0
Greenspan	2.04	1.96	96.1
Average inflation rate (per cent)			
Split-sample coefficients	5.48	2.87	52.4
Burns	5.63	5.53	98.2
Volcker	4.44	2.81	63.3
Greenspan	6.53	7.92	121.3
Average absolute value of output gap (per cent)			
Split-sample coefficients	2.64	1.91	72.3
Burns	1.90	1.78	93.7
Volcker	2.78	2.15	77.3
Greenspan	1.94	1.72	88.7

Source: author's calculations

as per Table 10, showing the effects of the alternative monetary policy reaction functions in simulations that cover 1979–2004 in the first column and 1990–2004 in the second column. For the simulations starting in 1979, the Volcker policies achieve an average reduction of the inflation rate of 2 percentage points, at the cost of an average absolute output gap that is 0.7 of a percentage point higher. There is little difference between the policies in the simulations that begin in 1990.

Table 11: Standard Deviations of Full-model Specifications, Alternative Starting Dates and Coefficients for Taylor Rule

	Simulation starts in 1979:Q3	Simulation starts in 1990:Q3
Standard deviation of inflation rate (percentage points)		
Burns	1.68	2.07
Volcker	2.17	2.21
Greenspan	1.77	2.14
Standard deviation of fed funds rate (percentage points)		
Burns	1.64	3.26
Volcker	2.93	3.17
Greenspan	1.69	3.18
Standard deviation of output gap (percentage points)		
Burns	1.89	2.42
Volcker	2.52	2.69
Greenspan	1.81	2.35
Average inflation rate (per cent)		
Burns	5.98	3.72
Volcker	3.87	3.47
Greenspan	5.81	3.60
Average absolute value of output gap (per cent)		
Burns	1.69	2.12
Volcker	2.38	2.47
Greenspan	1.65	2.09

Source: author's calculations

5.4 The sacrifice ratio

If maintained throughout 1965–2004, the Volcker policies would have yielded an average inflation rate during 1984–2004 that would have been 5 percentage points lower than if the Greenspan policies had been maintained throughout 1965–2004. This hypothetical Volcker accomplishment was achieved at the cost of much deeper recessions in 1975 and 1981–82 than under the hypothetical Greenspan policies. A standard way to measure this trade-off is the 'sacrifice ratio', defined as the cumulative decline in output divided by the permanent fall in the rate of inflation. In the simulations in Table 11 that start in 1979:Q3, the Volcker policies would have delivered a cumulative annual output gap 15.2 percentage points lower (that is, more negative) than the Greenspan policies over the simulation through 1985:Q4, to achieve an inflation rate exactly 2.0 percentage points lower in the

December quarter 1984 (and on average 2.0 points lower between 1986 and 1990). This yields a sacrifice ratio of 15.2/2, or 7.6, much higher than casual calculations of the sacrifice ratio observed in the actual data. For instance, the full-model simulation achieves a reduction in the four-quarter-ended inflation rate from 9.9 per cent in 1980 to 3.9 per cent in 1985, a decline of 6 percentage points, at the cost of a 20.7 cumulative percentage points negative output gap, for a sacrifice ratio of 3.5 (20.7/6.0).

What accounts for the difference between the Volcker and Greenspan sacrifice ratio of 7.6 and the apparent actual ratio of 3.5? Much of the disinflation of the early 1980s was achieved not just by the reduction in output and higher unemployment due to monetary policy, but also through a reversal of supply shocks, in particular the decline in oil prices from 1981 to 1986 and the decline in relative import prices associated with the 1980 to 1985 appreciation of the dollar. As shown in Figure 8 above, a single-equation simulation of the full inflation equation generates a reduction in the four-quarter-ended inflation rate of 8.1 percentage points between 1980:Q1 and 1986:Q4, compared to a reduction of 5.5 percentage points when the supply shocks are suppressed. In this sense about two-thirds of the disinflation of the early 1980s was achieved by tight money while the other one-third was due to a reversal of supply shocks. Admittedly, the supply shocks are partly endogenous, and some unknown fraction of the reversal of the supply shocks was in part a side-effect of tight monetary policy, especially that due to the appreciation of the dollar.

6. Conclusion

This paper investigates the sources of the widely noticed and discussed reduction in the volatility of American business cycles since the mid 1980s. Our analysis of reduced volatility emphasises the sharp decline in the standard deviation of changes in real GDP, of the output gap, and of the inflation rate. A preliminary examination of the data supports the conclusion of the previous literature that there was a break in US macroeconomic behaviour in 1983–84, after the end of the 1981–82 recession. Since then, expansions have been longer and recessions both less frequent and shallower. The aim of the paper is to determine the causes of the decline in volatility and allocate the decline among supply shocks, demand shocks, and improvements in monetary policy.

The first substantive section of the paper divides economic activity into the 11 major expenditure components of GDP. At this level of disaggregation about 80 per cent of the decline in output volatility can be attributed to lower volatility in the 11 individual components, and the remaining 20 per cent to a shift in spending shares toward more stable components, especially consumer services, and away from more volatile components, particularly investment in residential structures, inventory investment, and federal government spending. Taking covariances into account, these three sectors account for 50 per cent of the reduction in the average standard deviation of real GDP when the 1950–1983 and 1984–2004 intervals are compared, even though these three components accounted for only 17 per cent of nominal GDP in the first interval and 13 per cent in the second interval.

Up to this point the paper concludes that demand shocks played a major role in the reduction of volatility, particularly the reduced importance of federal military spending and the financial market reforms that helped to stabilise residential investment. In addition, information technology and other innovations helped reduce the importance of inventory fluctuations. Joining demand shocks as a disruptive force before 1984 were supply shocks that shifted the Phillips Curve primarily in an upward direction before 1981 and primarily in a downward direction after 1981. A simple piece of evidence that both demand and supply shocks mattered in the history of the American business cycle is provided in Figure 3, which shows that inflation and output volatility moved closely together between 1973 and 1988, but that there was ample output volatility in the 1950s and 1960s when inflation was relatively stable, and to a lesser extent there were episodes of sizeable output volatility after 1988, despite the relatively stable and quiescent inflation rate.

The paper develops a small macroeconomic model designed to measure the impact of supply shocks in the inflation equation and unidentified errors in the equations determining the federal funds rate and the output gap. The inflation equation included in the model builds on my own previous research, updating the so-called 'mainstream' model. Supply shocks included in the inflation equation include changes in the relative price of imports, the effect of changes in food-energy prices, the effect of changes in medical care prices, the effect of accelerations and decelerations in the productivity growth trend, and the effect of the Nixon-era price controls.

The inflation equation incorporates a natural rate of unemployment or 'NAIRU' that varies with time; its primary movement is a decline from about 6 per cent in the late 1980s to a minimum of about 4.5 per cent in the late 1990s, with an upward drift to about 4.8 per cent by 2004. Low inflation in the 1995–2004 period is explained in the model by the declining NAIRU, by accelerating productivity growth, and by the role of falling relative import prices between 1995 and 2002 and negative food-energy and medical care effects during particular sub-intervals. The inflation equation is tested not just by the usual criteria, that is, the significance and signs of coefficients and the goodness of fit, but also by dynamic simulations which generate the lagged dependent variables over long periods of time after the sample period; 40 quarters in the simulations reported here.

The inflation equation is joined by a second equation that determines the federal funds rate according to a standard Taylor rule specification that allows the responses of the funds rate to inflation and to the output gap to vary over three sub-intervals; 1960–79; 1979–90; and 1990–2004. The third equation relates changes in the output gap to past changes of the inflation rate and the funds rate. A symmetric analysis of shocks is developed. The specific supply-shock variables in the inflation equation can be included or set equal to zero. To develop a parallel treatment of shocks to interest rates and to the output gap, we allow the error term in those equations to be either included or excluded from model simulations.[25]

25. The model includes a fourth equation, a simple Okun's Law relation to create a bridge between the unemployment gap included in the inflation equation and the output gap.

A very surprising finding in this paper is that the biggest driver of the business cycle, and of reduced post-1984 output volatility, is the error term in the output gap equation. Only about half of the standard deviation of actual output gap changes can be attributed to responses to inflation and interest rates; the remaining half is soaked up by the equation's error term. We interpret the output response to the interest rate as movements along a given IS curve, while the output errors represent shifts of the IS curve. Several important historical episodes, including the large and positive Vietnam-related output gap of the late 1960s, and the smaller but still positive 'new-economy'-related output gap of the late 1990s, are exogenous events and do not represent responses to monetary policy. The emphasis on the role of the output error term in the model is entirely consistent with, and complementary to, the decomposition analysis earlier in the paper that pointed to residential and inventory investment and to federal government spending as the main sources of output volatility prior to 1984.

The simulations of the full model provide important roles for both supply shocks in the inflation equation and for the error term in the output gap equation. About 80 per cent of inflation volatility and its reduction is explained by the supply-shock terms in the inflation equation, but a substantial 20 per cent is explained by the output error term – for example, the role of the otherwise unexplained late 1960s expansion in generating the acceleration of inflation from 1965 to 1971. Similarly, the explanation of interest rate volatility before 1984 is also shared between supply shocks and the output error. Supply shocks created inflation that generated an interest rate response, especially in the 1970s and early 1980s, while the output error made interest rates more volatile, both directly through the output gap term in the interest rate equation and indirectly through the inflation term.

The reduced volatility of business cycles, more than anything, refers to output volatility rather than inflation or interest rate volatility. In explaining why the standard deviation of the output gap was so high before 1984 and why it declined so much, more than half of the explanation in the model is provided by the error term in the output gap equation. Our final emphasis on 'IS' shifts as sources of output volatility before 1984 is consistent with the decomposition analysis that singled out residential and inventory investment, and federal spending, as the culprits lying behind these IS shifts.

Perhaps the most surprising result in this paper is that, when monetary policy is assessed solely in terms of alternative Taylor rule reaction functions and their effect, there was no difference between the 'Greenspan' monetary policy in effect in 1990–2004 and the 'Burns' reaction coefficients in effect in 1960–79. Only the 'Volcker' reaction coefficients in effect during 1979–90 represented a substantial departure. Previous impressions that the Greenspan reaction function represented a desirable combination of aggressive fighting against *both* inflation and the output gap are based on statistical estimates plagued by positive serial correlation. When a serial correlation correction is applied, the Greenspan reaction to inflation drops from an inflation-fighting value well above unity to an inflation-accommodation value well below unity, and is little different from the Burns-era coefficient.

The model can be simulated to apply the Taylor rule reaction functions from the Burns, Volcker, and Greenspan eras to the entire 1965–2004 history. Here we encounter a classic inflation-output trade-off. Applying the Volcker inflation-fighting coefficients throughout the 1965–2004 period, in contrast to applying the Greenspan coefficients to the full period, would have yielded a permanent reduction in the post-1984 inflation rate of 5 percentage points, at the cost of much weaker output over most of the 1974–84 period. The sacrifice ratio calculated for the period 1980–85 from the differences between the outcomes of the Volcker and Greenspan policies is 7.6, compared to a sacrifice ratio of 3.5 in the actual data. The paper attributes this difference to the reversal of adverse supply shocks during the 1981–85 interval.

Which monetary policy was 'best'? The answer depends on the time period in question and the length of the time horizon. A Volcker-like anti-inflation reaction function introduced in 1965 would have worsened output volatility but yielded much lower long-run inflation than a hypothetical Greenspan-like policy introduced in 1965. However, a 'split' policy based on the actual historical succession of reaction functions, with Burns ceding to Volcker in 1979 and Volcker ceding to Greenspan in 1990, would have achieved the same long-run post-1984 inflation and output gap outcomes as a pure Volcker policy.

Numerous qualifications and caveats are warranted. The Greenspan policies may have the same statistical reaction function as the Burns policies but are better in ways that the simple interest rate equation cannot capture, including faster reactions (the pre-emptive strike against inflation in 1994 and the sharp interest rate cuts in 2001–02). At a deeper level, the reason the Greenspan reaction function shows a low 'accommodative' response to inflation is that there was no inflation to be fought against, thanks to the beneficial set of supply shocks in operation in the late 1990s. With adverse instead of beneficial shocks, the Greenspan reaction function might have looked much like Volcker's. Finally, the treatment of all supply-shock terms in the inflation equation as exogenous needs to be qualified. Changes in the relative price of imports, and to a lesser extent changes in oil prices, reflect exchange rate movements that respond to monetary policy. We conclude that a reversal of supply shocks played an important role in the disinflation of the early 1980s and subsequent stabilisation of output, but that reversal was itself in part a response to the Volcker monetary policies.

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Discussion

1. David Wilcox[1]

In his seminal 1987 monograph entitled *Models of business cycles*, Robert Lucas challenged the premise of Bob Gordon's paper for this conference – and, indeed, much of the premise of the conference itself. As you will recall, Lucas demonstrates that in the context of a standard model of household decision-making, the welfare consequences of economic fluctuations are astonishingly small. In fact, the representative household in Lucas's model would be willing to give up less than 0.1 per cent of its consumption each year in return for being rid of the magnitude of fluctuations that have been typical of the experience in the United States since the end of World War II. A small welfare consequence indeed.

If Lucas's claim were correct, the global phenomenon of the stabilisation of real activity over the past two decades or so would be of little import. But I suspect that few, if any of us, in this room believe that Lucas's result is correct. Why not?

One line of attack has focused on two key aspects of Lucas's original formulation: his assumption that the household sector can be adequately modeled by positing a representative agent who suffers only the economy-wide average amount of income variability, and his specification of the representative agent's utility function. Gadi Barlevy (2005) at the Federal Reserve Bank of Chicago reviews the papers that have relaxed these two assumptions and concludes that the benefits of eliminating business cycle fluctuations could be equivalent to as much as 2½ per cent of lifetime consumption – far greater than the amount derived by Lucas.

Moreover, another line of attack has questioned the assumption implicit in Lucas's original calculation that business cycle stabilisation affects neither the average level nor the average rate of growth of consumption. For example, Barlevy (2003) pursues the idea that business cycle fluctuations are bad for the average pace of real growth because fluctuations cause a dearth of investment in some periods and a surfeit of it in others. If investment is subject to decreasing returns, this piling-up of investment in some periods reduces the average pay-off to a given amount of investment over time. On the empirical front, Ramey and Ramey (1995) show an empirical link between volatility and growth in international data.[2]

To be sure, this debate is not settled, but our collective understanding of the issue has advanced greatly over the past two decades; undoubtedly, it will be possible to say the same two decades from now. At the centre of this debate are some of

1. I am grateful to Karen Dynan, Doug Elmendorf, Dan Sichel and Peter Tulip for their comments on these remarks. The views expressed here are my own and are not necessarily shared by either the Board of Governors of the Federal Reserve System or my colleagues on the staff.

2. A methodological note of relevance to this conference arises from this. In the early part of their paper, Ramey and Ramey use an estimation technique that assumes that the variance of output is fixed over time, though it can vary across countries. Later in the paper, however, Ramey and Ramey adopt an alternative technique that allows the variance of output to vary both over time and across countries.

the keys for understanding why the topic of this conference, and the topic of Bob Gordon's paper, are so very important.

With that, let me turn to Bob's paper. This paper puts a wealth of useful material on the table and I am confident it will be widely cited in the literature on the stabilisation of real activity. While there are many interesting facts demonstrated in the paper, the real contribution is the emphasis it places on using an estimated structural model as the vehicle for attributing credit for the 'Great Moderation' to specific underlying causes. This strikes me as precisely the right approach and one that should be pursued extensively in future work on this topic.[3]

That said, the implementation in this paper leaves me sceptical, to say the least. For as Bob himself notes,

> Perhaps the most surprising result in this paper is that, when monetary policy is assessed solely in terms of alternative Taylor Rule reaction functions and their effect, there was no difference between the 'Greenspan' monetary policy in effect in 1990–2004 and the 'Burns' reaction coefficients in effect in 1960–79 (page 104 of Bob's paper).

Surprising indeed.

In fact, I find this conclusion impossible to swallow, partly because it flies in the face of so much of the earlier literature claiming to demonstrate that Greenspan has respected the 'Taylor Principle', which counsels central banks to raise the nominal policy rate at least one for one with increases in inflation, whereas the monetary policy-makers of the 1970s did not. Bob criticises that literature as being based on empirical specifications that are 'plagued' with serial correlation, and claims to show that any appearance of obedience to the Taylor Principle on Greenspan's part disappears once the plague is cured.

But quite aside from the academic literature, there is the evidence of one's own eyes: the period 1960–79 ended with the US perceiving itself as on the brink of economic disaster, due in no small part to the fact that inflation seemed to be galloping out of control. By contrast, the period 1990–2004 witnessed a gradual decline of inflation, effectively towards zero after taking account of measurement bias. Indeed, in the last years of Bob's sample, the Federal Reserve made clear that it perceived a risk, for a time, of inflation moving too low, before that possibility receded, due partly to a dose of unusually stimulative monetary policy. Moreover, far from seeing itself on the brink of disaster, the country has been enjoying a productivity revival during the past decade, and a case can be made that monetary policy had a hand in fostering that revival.

Another way of making essentially the same point is this: the inflation objective that Bob posits (2 per cent) was never met between the late 1960s and the early 1990s. It is hard to believe, looking at actual inflation as shown in Gordon's Figure 7, that the inflation outcome after 1990 reflected substantially the same monetary policy as the inflation outcome prior to 1979.

3. Roberts (2004), discussed below, also specifies a structural model for the same purpose.

The source of Bob's finding is difficult to pinpoint. One possibility is that it reflects his assumption that the inflation objective was constant at 2 per cent throughout the sample period. If, during the period since 1990, the inflation objective actually drifted downward, a specification estimated under the counterfactual assumption of a constant objective would suffer from serial correlation. This explanation is far from satisfying, however, because it fails to explain why the post-1990 coefficients should be so much more sensitive to serial-correlation correction than the earlier coefficients. Much remains to be sorted out.

I will mention here two other aspects of Bob's paper, but, in the interest of concision, not pursue them. First, he notes that his estimate of the slope of the Phillips Curve has not changed much over a very long period of time. This puts him at odds with a good deal of the remainder of the empirical literature[4] – a place, I should hasten to add, where I suspect Bob does not mind being. This literature argues that the Phillips Curve is substantially flatter now than, say, 20 years ago. While the evidence on this question is susceptible to alternative interpretations, a number of my colleagues at the Fed are sympathetic to the idea that the Phillips Curve is flatter now than before. But rather than seeing any flattening of the Phillips Curve as a defeat for that construct, they interpret it as a victory for monetary policy. In particular, they square the facts by positing that inflation expectations are now less responsive to fluctuations in resource utilisation than they used to be. As a result, in a fully articulated structural model, there is no instability in the equation that relates current inflation to expected inflation and other variables; instead, the instability occurs in the equation relating inflation expectations to resource gaps and other variables.

A second empirical note pertains to Bob's assumption that the equilibrium real interest rate (often denoted r^* for short) is constant throughout the sample period. The equilibrium real interest rate is embedded in the intercept of the estimated Taylor rule, along with the inflation objective and the coefficient describing the central bank's response to deviations of inflation from the objective. In the course of our normal analysis of the current economic situation, my colleagues and I expend an enormous amount of effort analysing the forces bearing on r^*. That effort leaves us convinced that r^* exhibits meaningful variation over time as, for example, equity values rise and fall, and productivity accelerates and decelerates. Future work might thus attempt to allow for time variation not only in the inflation objective, but also in r^*.

In the remainder of these comments, I would like to highlight some research conducted by colleagues of mine at the Federal Reserve that provides some interesting complements to Bob's paper.

In the first of these papers, Karen Dynan, Douglas Elmendorf and Daniel Sichel (2005) argue that financial innovation has contributed to the reduced volatility of real GDP growth over the past few decades. The forms of innovation they cite include the development of improved credit scoring and risk-based pricing of

4. See, for example, Atkeson and Ohanian (2001) and Staiger, Stock and Watson (2001).

credit, the securitisation of mortgage and other loans, and the emergence of the junk bond market. On the empirical front, they demonstrate – among many other facts – that the correlation between income and saving was markedly higher during the second half of their sample period, 'just as we would expect if households can now borrow more freely in order to smooth consumption' (p 24). They also show that a variable intended to capture the effects of Regulation Q, which imposed a ceiling on deposit rates, explains a substantial amount of the variation in residential investment before 1984, but essentially none after 1984. Both of these findings, and a range of other evidence they present, are consistent with the idea that financial innovation should be added to the list of candidate explanations (good luck, better inventory management, better monetary policy, and so forth) for why the volatility of real GDP growth in the US has come down.

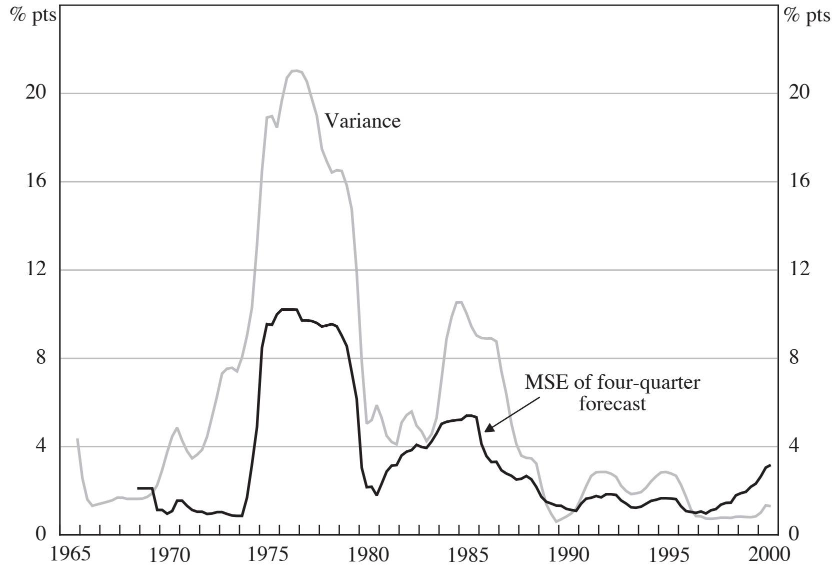
The second paper I wish to highlight is by John Roberts (2004), and is entitled 'Monetary policy and inflation dynamics'. Like Bob, John explores the implications of changes in the conduct of monetary policy for changes in economic performance. John takes the alleged flattening of the Phillips Curve as the chief motivation for his paper – putting him in the camp that is at odds with Bob in this regard – but John addresses as well whether changes in the conduct of monetary policy can explain the reduced volatility of real GDP and inflation. John conducts his investigation using a three-equation model of the US economy similar to the one employed by Bob, though with enough differences to make a comparison of the two papers potentially very useful and good science. As well, John uses FRB/US, the Federal Reserve staff's large-scale econometric model of the US economy.

In what I regard as a striking confirmation of Bob's results, John finds that changes in the conduct of monetary policy can account for only a little of the reduction of GDP *growth* volatility, but 'a large proportion of the reduction in the volatility of the GDP *gap*', exactly consistent with Bob's results. Oddly enough, however, and to prove that empirical economics is a tough, dangerous business, John finds only mixed results with respect to the ability of changes in monetary policy to explain the reduction in inflation volatility. Monetary policy does the whole job in John's simple three-equation model, but accounts for very little of the reduction in inflation volatility in FRB/US.

The third paper of relevance to this conference is by Peter Tulip (2005). In a paper just completed, Peter argues that GDP growth variability *per se* probably does not reduce economic welfare very much (otherwise, why would seasonal variation generally be ignored in the literature on the Great Moderation?), so he shifts the focus to unpredictability. Putting the forecast team at the Federal Reserve Board under the microscope, Peter asks whether the variability of *errors* in predicting the growth of GDP has declined in the same way that the variability of GDP growth itself has. His answer is this: 'less than you might have thought'.

Peter's findings are summarised in four key charts – numbers 4–7 in his paper. I will focus on Chart 5 (reproduced below as Figure 1), which pertains to four-quarter-ahead forecasts of real GDP growth. On the basis of this figure and its companions, Peter draws the following conclusions:

Figure 1: Variance and Unpredictability of Four-quarter-ended US GDP Growth



Note: Dates refer to the end point of a 5-year rolling window
Source: Tulip (2005)

- First, as shown by the grey line, the variance of four-quarter-ended real GDP growth has come down in real-time data, just as Gordon and others have documented using fully revised versions of the data.
- Second, as shown by the black line, unpredictability has declined as well, though by distinctly less. Indeed, the predictable component seems to have all but disappeared, and since the early 1990s, the mean-squared error of our forecast has exceeded the variance of GDP growth itself, the variable we are trying to predict.[5]
- Third, the decline in unpredictability is much more evident at short horizons (four quarters or less) than at long ones.
- Fourth and finally, inflation variability has come down, and – in a contrast with the GDP results – so has inflation unpredictability.

One interpretation of Peter's results is that monetary policy has succeeded so well in its pursuit of macroeconomic stabilisation that it has squeezed *all* the predictable variation out of GDP growth. Lack of forecastability is exactly what one would have expected, on the basis of a simple control-theory perspective, as the end result of a fully successful stabilisation policy.

5. The disappearance of the predictable component of real GDP growth seems to contradict the finding of Blanchard and Simon (2001) and Cecchetti, Flores-Lagunes and Krause (this volume) that data from the US show no significant evidence of a change in the dynamics of real GDP growth.

In the fourth and final paper I want to mention, Sean Campbell (2005) explores the related question of stock market volatility. One might have expected a substantial reduction in the variability of real activity to cause a similarly substantial reduction in the variability of asset returns. Indeed, as Sean shows, this intuition is validated in the context of a standard consumption-CAPM (capital asset-pricing model): when fundamental underlying uncertainty goes down, the variability of asset returns declines as well. But the real world has behaved differently. As Sean documents, the variability of returns in the US has declined only slightly over the last half century or so. How can these two facts be reconciled? Faced with a collision between theory and facts, Sean makes the wise decision to confront the facts and throw out the theory. In place of the workhorse consumption-CAPM, Sean substitutes the model developed by John Campbell and John Cochrane (1999), that gives a prominent role to habit formation. The aim of Campbell and Cochrane in developing this model is to explain the size of the equity premium – a puzzle of long standing in the finance literature. The beauty of Sean's research strategy is that he takes a model invented for one purpose and poses an altogether different question to it – namely, what should be the consequences for equity returns of a decline in the uncertainty about fundamentals? And the answer he derives is 'not much'. That is, the model predicts that much of the variability in asset returns derives from habits, which are intrinsic to the utility of consumers and not affected by the character of the external environment. When the external environment changes, the behaviour of asset returns changes as well, but only a little. In other words, Sean shows that the Campbell-Cochrane model delivers a very realistic answer to a question that is altogether different from the one it was invented to explain. In short, there is no puzzle in the seeming disconnect between reduced volatility of real GDP and little to no reduction in the variability of asset returns.

A concluding question is this: is the 'Great Moderation' more likely to prove permanent or transitory? Forever is an awfully long time, but certainly some of the evidence seems encouraging. The innovations in inventory management that have been highlighted by many authors will not go away, nor will the financial innovations discussed by Dynan *et al* (2005). Neither does the extreme volatility of government purchases noted by Bob Gordon's paper seem likely to return. As far as monetary policy is concerned, there is every reason to believe that the lessons that have been learned over the past twenty or thirty years will not be forgotten, and thus that whatever gains have accrued as a result will not be lost. The real wild card is the volatility of the supply shocks that seemed to have buffeted the real economy so dramatically in earlier times. If supply shocks are as important for the volatility of real activity as Gordon suggests, then a return to high volatility is well within the realm of possibility. On the other hand, it would be hard to argue that the last few years have been free of supply shocks – the most obvious example, though not the only one, being the fluctuations in the price of oil. And through it all, real activity around the world seems to have persevered amazingly well. Perhaps the most hopeful possibility is that the structure of the global economy has become more flexible, allowing even substantial supply shocks to be absorbed with much less distress than would have been the case in years gone by. If so, the Great Moderation may prove a long-lived phenomenon.

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2. General Discussion

A key focus of the discussion following Robert Gordon's paper was the assessment of the relative performance of various Federal Reserve Governors. Several participants felt that using the coefficients from the estimated Taylor rule to compare the performance of Burns, Volcker and Greenspan provides an unfair comparison, given that each reaction function is conditioned on the environment each Governor inherited and experienced. Moreover, some participants questioned whether the assessment could accurately capture the effect Volcker had in establishing credibility for the Federal Reserve. For this reason, there was support for the suggestion that a better comparison would be to ask what Greenspan would have done if he had inherited the Governorship in 1979. In response to all this, Bob Gordon argued that the question he is asking is not which Governor was best, but rather, how the economy would have looked under different policy regimes. He also argued that the role of credibility is partially captured by the specific way he models supply shocks. In particular, he argued that better-anchored inflation expectations are manifest in a reduction in the magnitude of food-energy shocks, given that this variable is specified as the difference between headline and underlying inflation.

There was also some discussion about the specific modelling approach used in the paper. In support of David Wilcox, a number of participants questioned the appropriateness of a constant rate for target inflation across all periods. Some thought that the failure to accommodate for a change in average inflation would help to explain the apparent autocorrelation in the Taylor rule equation. There was also some concern expressed about the technique of examining changes in the residuals over time, particularly for the output equation, since these may reflect the performance of the model, rather than changes in actual economic outcomes. To this end, it was suggested that the focus on the *unpredictability* of output growth in Peter Tulip's (2005) research, mentioned in the comments by David Wilcox, is a useful alternative.

In a similar vein, one participant challenged the omission of fiscal policy from Bob Gordon's model, suggesting that the appreciation of the US dollar in the early 1980s – which was instrumental in holding down inflation – was due to the fiscal expansion of the time. They argued that the exclusion of this variable may influence the output equation, increasing the size of output errors. Similarly, there was considerable support for the argument that the decline in import prices in the early 1980s should be attributed to monetary policy, rather than beneficial supply shocks, given that the exchange rate is a channel of monetary policy.

Finally, there was some discussion about whether the slope of the Phillips Curve has flattened over the past decade, picking up on the comments made by David Wilcox. One participant questioned whether Bob Gordon had tested the stability of the coefficients on the supply shocks over time, while another argued that there is clear evidence of a reduced autoregressive coefficient on inflation after 1990. However, Bob Gordon maintained his view that the slope of the Phillips Curve has not changed significantly throughout the post-war period, referring participants to his earlier work on this issue.

Assessing the Sources of Changes in the Volatility of Real Growth

Stephen G Cecchetti, Alfonso Flores-Lagunes and Stefan Krause[1]

Abstract

In much of the world, growth is more stable than it once was. Looking at a sample of 25 countries, we find that in 16, real GDP growth is less volatile today than it was 20 years ago. And these declines are large, averaging more than 50 per cent. What accounts for the fact that real growth has been more stable in recent years? We survey the evidence and competing explanations and find support for the view that improved inventory management policies, coupled with financial innovation, adopting an inflation-targeting scheme and increased central bank independence have all been associated with more stable real growth. Furthermore, we find weak evidence suggesting that increased commercial openness has coincided with increased output volatility.

1. Introduction

Today the world's economies appear to be much calmer than they were just a quarter-century ago. At the beginning of the 1980s, nearly two-thirds of the countries in the world were experiencing inflation in excess of 10 per cent per year. Today, it is one in six. Growth has risen as well. Two decades ago nearly one country in three was contracting. Today, five in six countries are growing at a rate in excess of 2 per cent per year.[2] But this is not the end of the story. Not only is inflation lower and output higher, they both appear to be more stable. The question is why.

Declines in the level and volatility of inflation are not that much of a mystery. The answer is almost surely better policy. Substantial changes in the operational framework of central banks over the past few decades have produced better inflation outcomes. Increased independence, as well as improved accountability and transparency have all played a role.[3] In an earlier paper, we find that improved monetary policy has been the driving force behind the better economic performance of the past decade.[4] But there we focus on weighted averages of output and inflation

1. Cecchetti: Brandeis University and NBER; Flores-Lagunes: University of Arizona; and Krause: Emory University. The authors would like to thank our discussant Mardi Dungey, as well as participants at the conference, especially David Wilcox. In addition, Margaret M McConnell, Anil K Kashyap, Jeffrey Miron and Leonardo Bartolini provided numerous helpful comments and discussions.

2. All of these numbers are computed from the International Monetary Fund's *World Economic Outlook* database.

3. For a detailed discussion of these issues see Cecchetti and Krause (2001, 2002).

4. See Cecchetti, Flores-Lagunes and Krause (2004).

variability, and usually on cases in which inflation variability has a relatively high weight. Concluding that low and stable inflation is a consequence of better monetary policy is, therefore, not a big surprise.

In this paper we move to an examination of output volatility alone. Using techniques pioneered by McConnell and Perez-Quiros (2000) in their study of US GDP, we confirm the basic finding that the volatility of output growth has declined.[5] In fact, it has fallen in 16 of the 25 countries we study – it is unchanged in 9. And on average, for the countries in which it fell, the standard deviation of innovations to output growth has been cut in half. But, as we will discuss in more detail, the timing of the decline in volatility is far from synchronised.

Documenting the fact that the world has become more stable is only the first step. We go on to survey various possible explanations. There are five major ones:

(1) improved inventory management policies; cited by Kahn and McConnell (2005), Kahn, McConnell and Perez-Quiros (2002), McConnell and Perez-Quiros (2000), and McConnell, Mosser and Perez-Quiros (1999);

(2) better monetary policy, as discussed in Clarida, Galí and Gertler (2000) and our previous work;

(3) financial innovation and improvements in risk sharing, as discussed in Dynan, Elmendorf and Sichel (2005);

(4) increased international commercial openness, as suggested in Barrell and Gottschalk (2004); and

(5) luck in the form of smaller shocks, the answer given by both Ahmed *et al* (2004) and Stock and Watson (2002).

Additional explanations include the change in the composition of output, away from more volatile manufacturing and toward more stable services, and that reduced volatility is a consequence of changes in the methods used to construct the data.

The evidence is broadly consistent with improved inventory policy accounting for some portion of the decline in all 12 countries where we have the appropriate data. The better monetary policy hypothesis fares substantially worse, accounting for declines in output volatility in 10 of the 24 countries for which we have results. This is unsurprising given the fact that monetary policy faces a trade-off between inflation and output volatility, and that in the past two decades we have witnessed a dramatic shift towards keeping inflation low and stable.

While we have something to say about the implications of increased openness, our focus is primarily on the likely impact of financial innovation. To foreshadow our conclusions, we find that the volatility of output falls as a country's financial system becomes more developed and its central bank becomes more independent. Volatility fell by more in countries where credit became more readily available. Furthermore, we find weak evidence that more commercial openness, as measured

5. For the US, the fact that the volatility of GDP growth has fallen since 1984 has been confirmed by virtually everyone who has looked at the data. See, for example, Ahmed, Levin and Wilson (2004), Nelson and Kim (1999), and Stock and Watson (2002).

by the ratio of imports plus exports to GDP, is negatively correlated with volatility across countries.

The remainder of the paper is divided into four parts. In Section 2 we outline the econometric testing procedures used to identify breaks in the volatility of output growth, and then report the results for both the timing and size of the changes in volatility. Section 3 presents a discussion of the numerous candidate explanations for the changes in output volatility, and Section 4 presents the second stage of our empirical analysis, where we present evidence in an attempt to distinguish them. Section 5 summarises our conclusions. Unfortunately, our analysis is sufficiently crude that we are only able to establish a set of correlations that are suggestive of which way to go next.

2. Identifying and Estimating the Changing Volatility of Growth

We begin our analysis by looking for structural breaks in the volatility of GDP growth. We do this in a series of steps. First, we estimate an equation of the form

$$\Delta y_t = \mu + \rho \Delta y_{t-1} + \varepsilon_t \qquad (1)$$

where y_t is the log of real GDP or the price level, Δ indicates the first difference, μ is a constant, ρ is a parameter representing the persistence of GDP growth, and ε is an innovation that is independent over time, but need not be identically distributed. Equation (1) is estimated allowing for breaks in the mean and persistence of output growth.

The result of this first step is a series of estimated residuals, $\hat{\varepsilon}_t$. As noted by McConnell and Perez-Quiros (2000), the transformed residuals, $\sqrt{\frac{\pi}{2}}|\hat{\varepsilon}_t|$, are unbiased estimators of the standard deviation of ε_t. Using these, we proceed to the second step, which is to search for breaks in an equation of the following form:

$$\sqrt{\frac{\pi}{2}}\left|\hat{\varepsilon}_t\right| = \alpha + u_t \qquad (2)$$

That is, we look for breaks in the mean (α) of scaled absolute value of the estimated residuals from the simple regression (1), after allowing for the possibility of structural breaks in μ and ρ. (The details of the econometric procedures, which require a number of decisions, are described in Appendix A.)

We examine shifts in the volatility of growth in 25 countries. Briefly, we begin by taking the first-difference of deviations of the log of real GDP from an HP-filtered trend, then look for breaks in persistence and, conditional on those, search for breaks in volatility. This is exactly equivalent to studying the deviations of growth from a time-varying mean. Where available, we use quarterly data starting in 1970.[6] The results for this exercise are reported in Table 1. First, note that we identify at least one break in persistence for 10 of the 25 countries, with two breaks for two countries. We then find at least one break in volatility in all but 9 countries (Austria, Belgium, Chile, France, Japan, Mexico, Norway, Peru and Switzerland), and two breaks in 6 of the 25 countries we study (Netherlands, New Zealand, South Africa, Spain, Sweden and the UK). We allow for as many as five breaks, but in no country do we find more than two. While our dating of the breaks suggests that

Table 1: Timing of Breaks in Persistence and Volatility of GDP Growth

Country	Persistence		Volatility	
	1st break	2nd break	1st break	2nd break
Australia	1981:Q3***		1984:Q3***	
Austria	none		none	
Belgium	none		none	
Canada	1980:Q4*		1987:Q2***	
Chile	none		none	
Denmark	none		1994:Q3***	
Finland	none		1995:Q2*	
France	none		none	
Germany	none		1993:Q3***	
Greece	none		1991:Q1***	
Israel	none		1985:Q2**	
Italy	1979:Q4**		1983:Q3***	
Japan	none		none	
Mexico	1984:Q1***	1995:Q1***	none	
Netherlands	1986:Q3*		1983:Q4*	1994:Q3*
New Zealand	none		1975:Q3*	1987:Q3***
Norway	none		none	
Peru	none		none	
South Africa	1976:Q4***		1986:Q3***	1996:Q3*
South Korea	1992:Q2*		1980:Q3**	
Spain	1980:Q2***	1992:Q2**	1985:Q2***	1993:Q2***
Sweden	1992:Q2***		1984:Q3***	1993:Q1***
Switzerland	1980:Q1***		none	
UK	none		1981:Q2***	1991:Q4***
US	none		1984:Q2***	

Notes: Breaks are estimated using the first-difference of deviations of log real GDP from an HP-filtered trend, conditional on possible breaks in persistence. See Appendix A for details. All sample periods end in 2003:Q4. Sample period begins in 1970 for all countries except Austria (1976), Belgium (1980), Chile (1980), Denmark (1978), Finland (1975), Israel (1980), Mexico (1980), the Netherlands (1977), Peru (1980), and Switzerland (1972).

***, ** and * denote significance at the 1, 5 and 10 per cent levels, respectively.

Source: authors' calculations

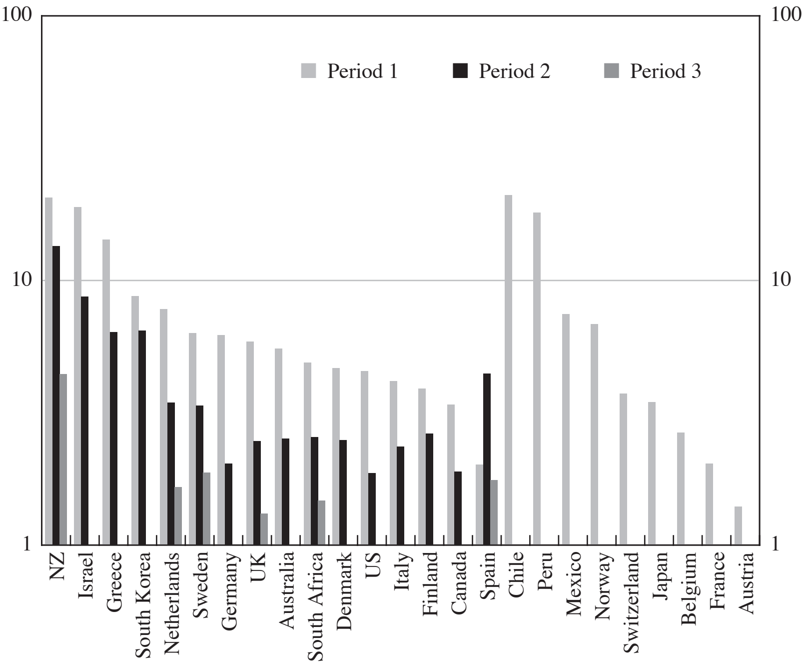
6. Our results are robust to the use of unfiltered GDP growth, assuming that we allow for breaks in the mean growth rate, μ in Equation (1), before testing for breaks in persistence.

persistence and volatility often change simultaneously within a country, these dates are not synchronised across countries. Of the total of 22 breaks in volatility that we identify, only one takes place in the 1970s, 12 are in the 1980s, and another 9 are in the 1990s.[7]

Figure 1 plots the volatility of output before and after the estimated break dates. Volatility declined for all countries for which we identified a single break. There was also a steady decline in output volatility in five of the countries for which we identified two breaks (the Netherlands, New Zealand, South Africa, Sweden and the UK), while Spain experienced an increase in volatility after the first break, and then a decline following the second break. None of the countries experienced an increase in the standard deviation of growth in the last period as compared to the first. Across all countries, the declines ranged from just over 10 per cent for Spain to almost 80 per cent for New Zealand (combining the two breaks). The average decline from the beginning to the end of each country's sample was close to 50 per cent. In other words, these are not small numbers.

Figure 1: Output Volatility Before and After Estimated Structural Breaks in Volatility

Standard deviation of GDP growth – log scale



Note: Estimated standard deviation of the real output growth (measured as deviations from HP-filtered trend) before and after estimated break dates, conditional on breaks in persistence.

Sources: IMF; OECD; authors' calculations

7. Our results are consistent with the timing of breaks identified by Smith and Summers (2002), who study Australia, Canada, Germany, Japan and the UK.

3. Explaining the Decline in the Volatility of Growth

Previous authors have delineated five possible explanations for the observed decline in output volatility. These include shifts to just-in-time inventory control methods, improvements in monetary policy, financial innovation, increases in openness to international trade, and luck. We summarise each of these, together with a discussion of some of the evidence drawn from the US case. In the next section, we explore the possible explanations for the cross-country declines in volatility documented in the previous section.

Before getting started, there are two hypotheses that we do not investigate or discuss: that the change in the variability of growth is a result of changes in fiscal policy or that it is an artefact of a change in data construction techniques. Both of these have been dismissed in the US case (see the appendix to Dynan *et al* 2005 for a summary). Data construction techniques have not changed all that markedly in the past 30 years and there is little evidence that the stabilising ability of fiscal policy has improved.[8] This still leaves a set of five possible explanations.

3.1 Changes in inventory control policies

Inventory changes account for a very small portion of GDP, averaging about ½ per cent and rarely exceeding 1 per cent of the total; they account for virtually none of trend growth. Even so, changes in private inventories account for something like 20 per cent of the volatility in quarterly GDP growth. From 1959 to 2003 the standard deviation of quarterly US total GDP growth, measured at a quarterly rate, was approximately 1 percentage point. Excluding inventory changes, this falls to 0.8 of a percentage point.

Given the importance of inventories in aggregate fluctuations, changes in inventory management policies could easily have an impact on the volatility of GDP. Improvements in technology that allow flexible production, smaller batch sizes, better monitoring of real-time sales, and the like have created substantial opportunities for reduced volatility. Today, an automobile assembly plant keeps only a few hours worth of parts on hand – the rest are in transit to the factory, timed to arrive at just the right moment. Similarly, a supermarket or superstore like Wal-Mart or Target will hold only one to two days' supply of most products. The result is a great deal of flexibility in responding to changes in demand and sales.[9]

8. We note, but do not investigate, the possibility that fiscal consolidations had an impact on the financial system, leaving it freer to accommodate private credit needs.

9. Recent press reports suggest that these large retailers have gone even further, no longer holding their store inventories on their own books. For example, a tube of Procter and Gamble-produced toothpaste on a Wal-Mart store shelf will be on Procter and Gamble's books until it is sold to the final consumer. Only when they are sold does Wal-Mart actually pay for the items that are in their stores. This change in accounting has the potential to drive reported retail inventories to very low levels, as well as reducing the volatility of measured inventories.

McConnell and Perez-Quiros (2000), Kahn *et al* (2002), and Kahn and McConnell (2005) marshal evidence in support of the view that changes in inventory management policies are the source of output's increased stability. They begin by noting that the volatility of output growth in the durable goods sector has fallen dramatically, but that the variance of final sales growth has not. McConnell and co-authors then show that inventory levels have fallen noticeably, and that the decline was most pronounced in the mid 1980s.[10] This is clearly consistent with the results in Table 2, which provides an accounting of the likely sources of the change in the variance of real growth in the US.

The standard deviation of quarterly real GDP growth (measured at a quarterly rate) dropped by 0.56 percentage points, from 1.11 to 0.55. Table 2 examines the decomposition of the variance of quarterly real GDP growth (which fell from

Table 2: Accounting for Changes in the Variance of Real Growth in the US

	1959–1983	1984–2003	Decline
Variance of real GDP	1.23	0.30	0.93
	Fraction of decline in variance attributable to:		
	Component	GDP excluding component	(Twice) covariance
Consumption			
Durable goods	0.04	0.69	0.28
Non-durable goods	0.03	0.86	0.11
Services	0.03	0.88	0.09
Investment			
Non-residential	0.03	0.74	0.24
Residential	0.06	0.83	0.11
Change in private inventories	0.35	0.54	0.12
Net exports	0.05	1.16	–0.20
Government	0.05	0.94	0.00
Federal	0.04	1.00	–0.04
State & local	0.01	0.94	0.05

Notes: The table shows the decomposition of the change in the variance of GDP growth from 1959–1983 to 1984–2003 into the variance of each component (individually), the variance of GDP excluding the component and twice the covariance of the two. This is done by noting that: $\text{var}(x+y) = \text{var}(x) + \text{var}(y) + 2\text{cov}(x,y)$. The variances and covariances are then scaled by the overall change in GDP variance, so that each row sums to 1.0.
Data on real GDP are constructed by splicing chained 1952, 1972, 1982 and 2000 series, component by component, from Bureau of Economic Analysis (BEA), NIPA Tables 1.1.6, 1.1.6B, 1.1.6C, and 1.1.6D.

Source: www.bea.gov/bea/dn/home/gdp.htm

10. Ramey and Vine (2004b) take issue with the inventory-sales ratio evidence used by Kahn *et al* (2002), noting that the drop seen in the nominal data is not mirrored in the real data. That is, when looking at the ratio of real, deflated, inventories to real sales, the drop emphasised by Kahn *et al* is no longer apparent.

1.23 to 0.30) into the portion that can be accounted for by various components. Arithmetically, the fall in the variance in GDP can be a consequence of the change in the variance of an individual component, the change in the variance of GDP excluding that component, or the change in (twice) the covariance of the component and GDP excluding the component. Each row of the table shows the fraction of the change of the variance accounted for by each of these. To see which components matter, look for rows in which the first column is big and the second column is far from 1. Inventories have that property. Looking at the covariances, we see that there is a role for non-residential construction and durable goods as well.

Cross-country comparisons point in the same direction. Table 3 reports the change in GDP volatility and the change in the volatility of the contribution to growth[11] attributable to inventory accumulation for a subset of 12 countries in our sample.[12] In all 12 cases, the decline in the standard deviation of the contribution of inventory changes to GDP growth is large. Furthermore, it is usually a substantial fraction of the overall decline in volatility, accounting, on average, for nearly 60 per cent of the decline in output growth volatility across countries.

The natural interpretation of these results has a potential flaw arising from the possibility that the increased stability of inventories could be a consequence of more stable demand. When demand is stable (because either shocks are smaller or monetary policy is conducted more efficiently), firms see less reason to hold inventories. With smaller shocks overall, everything will be smoother.[13] This argument is the centrepiece of the work of Herrera and Pesavento (2004), who find that the volatility of both inventories and shipments has declined.

11. Computationally, it is the growth of the component times the (lagged) share of that component in GDP. So, for example, if service consumption were to grow by 5 per cent, since it accounts for 40 per cent of total GDP, its growth contribution would be 5x0.4 = 2 per cent.

12. We report results for all countries that both exhibit at least one break in volatility and for which the OECD reports inventory data.

13. For a discussion see Ramey and Vine (2004a).

Table 3: The Changing Volatility of Inventory Accumulation

Country	Beginning of sample	Break date	Standard deviation of quarterly GDP growth at quarterly rate			Standard deviation of growth contribution from inventories accumulation		
			First sub-period	Second sub-period	Difference	First sub-period	Second sub-period	Difference
Australia	1974:Q3	1984:Q3	1.34	0.69	0.65	0.92	0.73	0.19
Canada	1979:Q1	1987:Q2	1.05	0.65	0.41	0.78	0.59	0.19
Denmark	1978:Q1	1994:Q3	1.20	0.67	0.53	1.59	0.96	0.64
Germany	1970:Q1	1993:Q3	1.78	0.56	1.22	0.73	0.48	0.25
Italy	1970:Q1	1983:Q3	1.09	0.64	0.45	1.06	0.86	0.20
Netherlands	1983:Q4	1994:Q3	0.86	0.57	0.29	1.14	0.65	0.49
New Zealand	1975:Q3	1987:Q3	3.41	1.18	2.23	1.85	1.03	0.82
South Korea	1970:Q1	1980:Q3	2.39	1.69	0.70	1.38	0.88	0.50
Spain	1985:Q2	1993:Q2	1.24	0.46	0.77	1.16	0.88	0.28
Sweden	1984:Q3	1993:Q1	0.95	0.43	0.52	0.92	0.81	0.11
UK	1981:Q2	1991:Q4	0.73	0.36	0.37	0.81	0.49	0.32
US	1970:Q1	1984:Q2	1.20	0.51	0.69	0.55	0.37	0.18

Notes: For countries in which there are two breaks, the 'beginning of sample' is the date of the first break. Changes in inventories are the series labelled 'stockbuilding'. Real GDP is volume data at market prices. All data are real, seasonally adjusted. Break dates are determined by the procedure described in the text, using the first difference of the HP-filtered log of GDP, starting in 1970.

Source: OECD *Economic Outlook* No 76

3.2 Better monetary policy

The second candidate explanation for the decreased volatility of output growth is that it is a result of improved monetary policy. Beginning in the mid 1980s, the structure of central banks changed in many parts of the world. There was an increase in independence and transparency, as well as a new-found commitment to low, stable inflation. And, as central bankers often emphasise, price stability is the foundation for high growth. In other words, inflation is bad for growth.

Today economists have a much better understanding of how to implement monetary policy than they did as recently as 20 years ago. To succeed in keeping inflation low and stable while at the same time keeping real growth high and stable, central bankers must focus on adjusting real interest rates either when inflation differs from its target level and/or when output deviates from potential output.

There are several pieces of evidence supporting the view that improved macroeconomic outcomes can be traced to better monetary policy. For the case of the US, Clarida *et al* (2000) show that the actions of the 1970s implied a policy reaction curve, or Taylor rule, in which inflation increases were met with insufficiently aggressive nominal interest rate increases. Under Chairman Arthur Burns, when inflation went up, the Federal Reserve increased their policy-controlled interest rate by less than one for one, so the real interest rate went down. The result was instability – both in inflation and output growth.

In an earlier paper, Cecchetti *et al* (2004), we develop a method for measuring the contribution of improved monetary policy to observed changes in macroeconomic performance and then use it to explain the observed increase in macroeconomic stability in a cross-section of countries. Our technique involves examining changes in the variability of inflation and output over time. We estimate a simple macroeconomic model of inflation and output for each of 24 countries, and use it to construct an output-inflation variability efficiency frontier. Specifically, for each country we specify the dynamics of inflation and output as a function of the interest rate – our measure of the central bank policy instrument – and some additional exogenous variables. Using the estimated model, we are able to compute the output-inflation variability frontier describing the best possible outcomes that a policy-maker can hope to achieve. Movements toward this frontier are interpreted as improvements in monetary policy efficiency. Our estimates suggest that improved monetary policy has played a greater stabilising role in 21 of the 24 countries (even though the comparison is between a base period – 1983–1990 – when many observers believe monetary policy had already greatly improved in many countries).[14] Seventeen countries experienced reduced supply shock variability, but overall this had a modest impact on performance.

Table 4 is derived from the results in that paper. However, in the current exercise we assume that the sole objective of monetary policy is to focus on output stability.

14. In the cases of Austria, Germany and Switzerland we find that monetary policy contributed to increased volatility. This is likely a consequence of a combination of events including the fiscal and monetary consequence of German unification and preparations for the creation of the European Monetary Union.

Table 4: Monetary Policy and Improved Economic Performance

Country	Output volatility, actual			Output volatility, minimising			Proportion of improved performance due to better policy
	1983–90	1991–98	Decline	1983–90	1991–98	Decline	
Australia	5.49	2.21	3.28	2.19	0.53	1.66	0.49
Austria	5.41	8.80	–3.39	0.51	2.03	–1.52	–0.55
Belgium	4.05	6.19	–2.14	1.63	2.48	–0.85	–0.60
Canada	8.20	5.76	2.44	2.12	0.56	1.56	0.36
Chile	68.29	14.02	54.27	26.27	3.38	22.90	0.58
Denmark	7.53	7.19	0.34	3.87	3.11	0.75	–1.23
Finland	5.69	11.94	–6.25	1.46	1.52	–0.06	–0.99
France	2.62	4.31	–1.69	0.61	1.75	–1.14	–0.33
Germany	3.99	6.82	–2.83	1.51	1.05	0.46	–1.16
Greece	5.47	1.99	3.48	3.34	1.13	2.21	0.36
Ireland	12.90	8.34	4.56	3.85	4.07	–0.22	1.05
Israel	9.20	4.49	4.71	3.56	1.14	2.42	0.49
Italy	3.29	5.34	–2.06	1.77	0.41	1.35	–1.66
Japan	14.80	9.08	5.73	0.82	1.94	–1.12	1.20
Mexico	9.20	16.11	–6.91	3.97	2.94	1.03	–1.15
Netherlands	4.38	3.23	1.15	2.37	1.09	1.28	–0.12
New Zealand	13.83	10.92	2.91	6.31	2.38	3.94	–0.35
Portugal	7.89	16.97	–9.08	3.72	3.22	0.50	–1.06
South Korea	21.83	16.53	5.30	8.46	4.69	3.77	0.29
Spain	3.03	8.54	–5.52	1.90	0.84	1.06	–1.19
Sweden	5.69	12.73	–7.04	4.07	3.25	0.82	–1.12
Switzerland	10.15	4.98	5.17	5.09	2.94	2.15	0.58
UK	3.64	2.90	0.74	1.38	0.38	1.00	–0.36
US	4.10	1.75	2.35	1.24	0.17	1.07	0.54

Notes: Actual output volatility is computed from the standard deviation of the growth in deviations of log industrial production from an HP-filtered trend. The column labelled 'Proportion of improved performance due to better policy' is the ratio of the (change in the actual – change in the optimal) to the 'change in the actual'.

Source: Computed using techniques described in Cecchetti *et al* (2004)

The columns labelled 'Output volatility, actual' report the observed decline in the volatility of output growth (measured using industrial production) from the 1980s to the 1990s. Output volatility fell in 14 of the 24 cases. Next, in the columns labelled 'Output volatility, minimising', the table reports the minimum attainable variance of output computed from an estimated structural model. This is the best performance that could have been obtained if policy-makers focused all of their attention on output stabilisation (and none on inflation stabilisation). In all but six of these cases, the best attainable outcome was lower output volatility in the second period, so innovation variances fell – this reflects either some 'good luck' (that is, smaller shocks) or the presence of favourable structural changes that reduced the effect of shocks in the economy. The difference between these two – the change in actual minus the change in minimal output volatility – is a measure of policy effectiveness. We do not report this difference to simplify the table presentation. The final column shows the proportion of the volatility change that can be attributed to policy; a negative number here implies that policy contributed to an increase in output volatility.

Overall, the results suggest that policy was a stabilising force in only 10 of the 24 countries. In the remaining 14, the contribution of policy was to increase the volatility of output. This should come as no surprise since, as we show in our other paper, the primary impact of policy during this period was to stabilise inflation. By focusing on inflation stability, policy-makers moved along an output-inflation volatility frontier and made output more volatile, not less.

It is worth emphasising that it is likely to be very difficult to distinguish better policy decisions from a better institutional environment, regardless of the actual macroeconomic outcomes. As two of us discuss in Cecchetti and Krause (2001), the acumen of policy-makers is irrelevant if they are operating in an institutional environment in which monetary policy is ineffective. There are a number of examples of changes that improve the ability of policy-makers' actions to influence inflation and output. The traditional ones include the degree of a central bank's political independence and the implementation of explicit inflation-targeting regimes. As noted by Krause and Méndez (2005), these sorts of institutional changes, as well as membership of the European Monetary Union, are associated with higher relative preference for inflation stability. For a country operating on its inflation-output variability frontier, this could lead to an increase in output volatility.[15]

Changes in financial structure can also influence the efficacy of monetary policy. For example, movements away from a government-controlled banking system can result in improved macroeconomic outcomes that are likely to be indistinguishable from those that come from improved policy-making itself. With that in mind, we now turn to a discussion of changes in the financial system.

3.3 Financial innovation

Dynan *et al* (2005) provide a detailed discussion of the potential link between the decline in the volatility of US GDP growth and American financial innovations of the 1980s. These include the development of active secondary markets for loans (especially for home mortgages), the increased popularity of junk bonds, the phasing-out of deposit interest rate controls, regulatory changes aimed at creating access to credit for low-income households, and the eventual elimination of the prohibition on interstate banks.

The case of home mortgages provides an excellent example. Prior to the mid 1980s, households wishing to borrow for the purpose of purchasing a home had to obtain financing from a local financial intermediary. This meant that they were reliant on

15. Cecchetti and Ehrmann (2002) find modest evidence that inflation-targeting countries experience slightly higher output volatility than non-inflation-targeting countries.

the ability of bankers to obtain sufficient deposit liabilities to provide the loan. If funds were plentiful in one locale, but scarce in another, there was no way for the funding to flow to where it was needed. The creation of asset-backed securities changed all of this.

In 1970, the Government National Mortgage Association (GNMA) issued the first mortgage-backed securities. These were pass-through securities composed of government guaranteed mortgages. The Federal National Mortgage Association (FNMA) then issued mortgage-backed securities backed by private insurance in 1981. Because of prepayment uncertainties, these initial asset-backed securities had durations that could not be computed with confidence. This problem was solved in 1983 when the Federal Home Loan Mortgage Corporation (FHLMC) issued the first tranched collateralised mortgage obligations (CMOs). CMOs divided the pool of mortgages into maturity categories based on when they are prepaid, and reduced the prepayment risk. The result was a very liquid mortgage market. McCarthy and Peach (2002) provide a detailed discussion of these changes to the US mortgage market, and find that it has damped the response of residential fixed investment to changes in monetary policy.

Today, mortgages are just the tip of the asset-backed security iceberg. With the exception of certain types of small-business loans, virtually every type of credit is securitised. This includes commercial and industrial loans, credit-card debt, student loans, and motor vehicle loans. The latter provide another interesting example. In early 2005 the business news reported the downgrading of US motor vehicle manufacturers. For example, Moody's and Standard and Poor's lowered General Motors long-term credit rating to the lowest investment grade level. At the same time, asset-backed car loans were receiving triple-A ratings. The default rate on these loans is predictable, so pools have very little risk in them.

All of this has come along with a dramatic increase in the use of debt by both households and businesses. Individuals can better smooth consumption in the face of short-term income variation, while firms can invest more steadily, even when faced with transitory revenue fluctuations.[16] Overall, risk is able to flow to those best able to bear it, thereby increasing the efficiency of the economy as a whole.

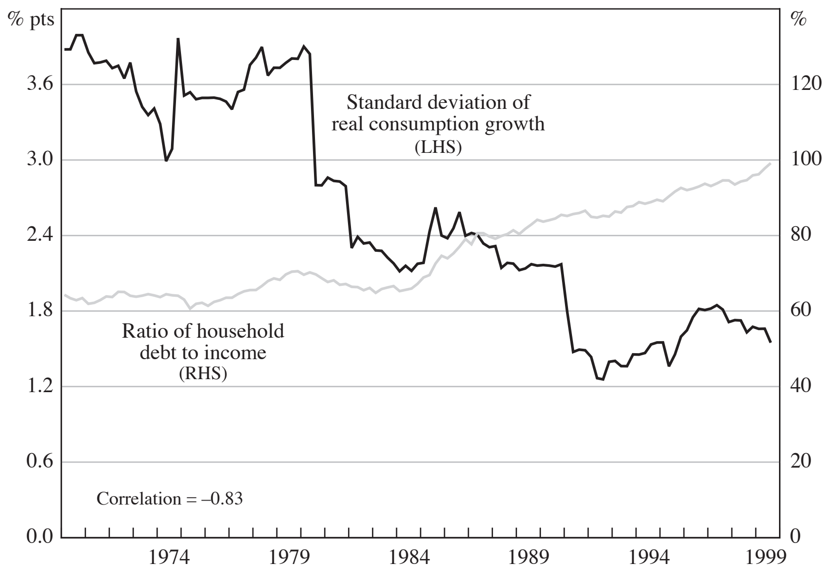
The improved ability of financial markets to efficiently distribute risk is consistent with Comin and Philippon's (2005) observation that firm-level volatility has risen even as aggregate volatility has fallen. In a world with poorly functioning financial markets, high transaction costs make it costly for investors to obtain diversified portfolios. As a result, they will push firms to diversify internally, creating large conglomerates like General Electric (GE). GE produces everything from light bulbs to power generating plants, jet engines and financial services. Diversification of this sort reduces the risk of the enterprise as a whole and is surely good for the managers

16. Campbell and Hercowitz (2005) link the reduced volatility of output to the increase in household borrowing resulting from the relaxation of collateral constraints in the 1980s. They point to increases in the availability of home equity loans as a potentially important source of an individual's ability to smooth consumption in the face of income volatility.

of GE. And if financial transaction costs are high, it is good for investors, too. But as financial markets become deeper and more liquid, investors will prefer to choose their own portfolio weights for the different sectors, and there will be a push toward smaller firms with more volatility. At the same time, aggregate volatility will fall.

Returning to the case of households, Figure 2 provides some evidence that debt has improved the ability of households to smooth consumption in the face of income shocks. The figure plots the ratio of total US household debt to personal income together with the backward-looking five-year rolling standard deviation of consumption growth. These two series clearly have trends, but if we look at the changes we see that a 10 percentage point increase in the ratio of debt to income was associated with a decline of 50 basis points (0.5 of a percentage point) in consumption volatility over the following five years. That is, the impact is economically meaningful.[17] While we make no attempt to prove that increased debt has *caused* consumption to be smoother, we note that many of the legal and regulatory changes that allowed financial innovations to occur during the late 1980s and 1990s seem independent of consumption growth.

Figure 2: Household Debt and the Volatility of US Consumption



Note: The figure plots the ratio of average total household debt, including mortgages and consumer credit, to personal income (grey line) and the standard deviation of quarterly real consumption growth at an annual rate over the next five years (black line).

Sources: Board of Governors of the Federal Reserve System, Flow of Funds Accounts; BEA

17. The *t*-statistic for the coefficient in a regression of the change in consumption volatility on the debt-to-income ratio is –1.7.

3.4 International openness

Over the last half of the 20th century, trade barriers were reduced or eliminated worldwide and transportation costs plummeted. The result has been a dramatic increase in the amount of cross-border trade in goods and services. In the US, for example, the ratio of imports plus exports to GDP has risen from just over 10 per cent in 1970 to 26 per cent today. Something similar has happened worldwide, with this measure of openness rising from 23 per cent in 1970 to 54 per cent in 2004.[18] With moves like the elimination of the multi-fibre agreement at the beginning of 2005, we can expect this trend to continue. More trade has also brought with it increased financial transactions. Current and capital account flows have both risen.

Greater commercial and financial openness can affect aggregate volatility in a number of ways. First, it provides an opportunity for international risk sharing – both purely financial and real. On the financial side, in the same way that mortgage financing in the US does not have to come from the geographic home of the borrower, now financing can come from outside a country.[19] Households, firms, and governments in one country now have access to funds from elsewhere in the world. In the same way, demand for real goods and services comes both from inside and outside a country. As the importance of trade flows increases, fluctuations in domestic aggregate demand become less important for domestic production.

A second mechanism by which openness can lower volatility is by allowing developed countries to send their more volatile industries offshore.[20] A developed country that is able to push its volatile manufacturing sector into the less-developed world will have a more stable domestic economy. As it turns out, this seems an unlikely explanation; the shift from goods to services in the US accounts for virtually none of the fall in the volatility of real growth.

These arguments also imply that larger countries could be more stable just because they are better diversified. Smaller economies, which are typically more open, may be more susceptible to certain shocks, given that their economic structure is more likely to be concentrated in a few industries. The result could be more, not less volatility. Emerging-market countries that are more open are more exposed to the impact of shocks arising from events like the Asian crisis of 1997. In the end, commercial openness could either raise or lower output volatility. We provide modest evidence for the former in the next section of the paper.

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18. These are the IMF *World Economic Outlook* aggregates.
19. In their study of 24 OECD countries, Buch, Döpke and Pierdzioch (2002) find that business cycles are less pronounced in countries with more open financial markets.
20. This would not lower volatility globally. Unfortunately, we do not have data to test this hypothesis.

3.5 Smaller shocks

A number of authors conclude that improved macroeconomic performance, especially in the US, is a consequence of smaller shocks. Ahmed *et al* (2004) and Stock and Watson (2002) provide the most detailed arguments for this case. Their results are based on the following logic. Any stochastic model of the economy can be thought of as combining some shocks with a propagation mechanism. If output volatility has declined it is either a consequence of a change in the nature of shocks or a change in the propagation mechanism. Both sets of authors are unable to find changes in the latter, so they ascribe the observed stabilisation of the real economy to the former.[21]

There are a number of issues that arise in evaluating the case for luck. First, there is casual empirical evidence against it. It is difficult to argue that the stability of the 1990s was mere good fortune. Surely, the decade was not a calm one for the financial markets. Major economic crises occurred in Latin America and Asia, and Long-Term Capital Management nearly collapsed, paralysing the bond markets. Raw materials prices fluctuated wildly. The price of oil spiked at more than US$35 a barrel late in 1990, then plunged below US$12 a barrel at the end of 1998 before beginning a steady rise to US$30 a barrel by the beginning of 2000.

Second, the observation that the shocks hitting the economy have been effectively smaller is completely consistent with the view that stabilisation has been a consequence of improved monetary policy. One possibility, and the one consistent with the previous discussion, is that central bankers have both created smaller shocks of their own and succeeded in neutralising the shocks that they have seen. The Clarida, Galí and Gertler result is clearly of the first type. Their finding that policy-makers engaged in destabilising behaviour is consistent with the idea that central bankers were exacerbating, rather than ameliorating, shocks. In standard econometric analyses these will show up as the 'monetary policy shocks' identified from residuals in structural models.

Finally, Kahn and McConnell (2005) show that improved inventory control policies are also consistent with the finding of smaller shocks. The intuition of their result is the same as the one for monetary policy. Economic agents are doing a combination of neutralising external shocks and making smaller mistakes. Again, the result is increased stability. More generally, the problem is that any improved structural flexibility not explicitly captured in a simple macroeconomic model will be wrongly attributed by researchers to good luck.

21. Ahmed *et al* reach their conclusion by noting that output can be written as an infinite-order moving average. The MA coefficients in this Wold representation correspond to a reduced form for coefficients in the transmission mechanism, and the innovations are simply the white noise shocks hitting the economy. Ahmed *et al* show that the primary source of stabilisation is the reduced magnitude of the shocks. This result is also consistent with the work of Arias, Hansen and Ohanian (2004), who suggest that the reduced volatility arises from a smaller variance of real shocks.

4. Financial Development, Trade Openness, Central Bank Structure, and the Volatility Decline

In the previous section, we focused on possible explanations for the volatility decline in the US. The next step is to examine evidence for the panel of 25 countries. Is it possible to explain both the dispersion in the level of volatility of real growth across countries as well as the change within countries? To see, we look at the correlation of estimates of the standard deviation of real GDP growth with measures of central bank structure, financial development, commercial openness, and the absolute size of each country. (These measures are discussed in more detail in Table 5.)

To assess the sources of changes in output volatility we use a country-specific fixed-effects model, with the periods separated by the estimated structural breaks. So, for a given country we regress the difference in the standard deviation of real growth (measured as changes in deviations from the HP-filtered trend), before and after the estimated volatility break date, on the change in the right-hand-side variables computed by the same break date. In order to avoid problems associated with extreme values (see Figure 1), we take the log of the standard deviation of output innovations.

The results shown in Table 6 are quite striking. First, they suggest that a more developed financial system, measured by bank credit to the private sector, is associated with lower volatility in GDP growth. This outcome is consistent with the lending view: more developed financial markets increase the impact of a given change in monetary policy, making stabilisation efforts more successful. The first row of the table shows that increases in this financial development variable are associated with large declines in volatility, and the effects are estimated precisely (p-values are all 0.05 or less).

An example helps to reinforce the size of the estimated effects. For the case of South Korea, we identify a break in volatility in the third quarter of 1980. The ratio of private Korean credit rose from 48 per cent of GDP before the break to 102 per cent after. The estimates in Table 6 suggest that this doubling of credit would reduce the standard deviation of Korean GDP volatility by between 44 per cent and 56 per cent.[22] In fact, the volatility fell by half. From this we conclude that financial development has played an important role in reducing the volatility of output.

Second, commercial openness is negatively, but not significantly, correlated with fluctuations in GDP growth. This result is consistent with our previous discussion – commercial openness can either raise or lower output volatility.

Turning to the importance of monetary arrangements, we do not find evidence supporting the view that higher central bank independence, measured by a lower average turnover ratio of central bank governors, is correlated with lower output growth volatility. This outcome is consistent with the evidence provided by

22. The estimated impact is equal to the inverse of e raised to the power of the change in the credit to GDP ratio times the coefficient estimate from the first row of Table 6.

Table 5: Possible Explanations for Variation in the Volatility of Growth

Financial development and openness to trade

1. *Private credit to GDP ratio*: extent to which private sector activities are financed through bank lending.
2. *Trade in goods to GDP*: the ratio of imports plus exports to GDP.

Central bank structure

3. *Central bank independence* (CBI): we compute an index that uses the average tenure of the central bank governor as a proxy for CBI as in Cukierman (1992) and de Haan and Kooi (2000). The turnover ratio of the central bank governor (TOR) has the advantage that it can be computed for a larger set of countries and for different periods, so it becomes technically possible to use it to construct a measure of CBI for the periods separated by the structural break.
4. *Inflation targeting*: we construct the variable by dividing the number of years an inflation-targeting regime has been in place for a particular country, by the number of years of the respective sub-period. For the information on the dates that inflation targeting was introduced we employ the data from Mishkin and Schmidt-Hebbel (2002).

Other variables

5. *Inflation volatility*: the log of the standard deviation of inflation.

Table 6: Output Volatility Panel Regression

Periods determined by structural breaks

Explanatory variable	(1)	(2)	(3)	(4)
1. Private credit to GDP[(a)]	–1.73	–1.49	–1.44	–1.35
	(0.00)	(0.00)	(0.00)	(0.00)
2. Trade in goods to GDP[(b)]	–2.03	–1.04	–0.58	–0.17
	(0.20)	(0.54)	(0.40)	(0.89)
3. Central bank turnover ratio	0.57			–0.13
	(0.63)			(0.87)
4. Inflation targeting		–0.39		–0.20
		(0.10)		(0.39)
5. Inflation volatility			0.51	0.46
			(0.01)	(0.03)
F-statistic for joint test	13.38	15.44	20.91	11.78
	(0.00)	(0.00)	(0.00)	(0.00)

Notes: *p*-values (in parentheses) are computed using standard errors that are robust to heteroskedasticity. The F-statistics are for the joint test that all of the slope coefficients in the regression are simultaneously zero.

(a) Ratio of domestic credit extended to the private sector by the banking sector to GDP.

(b) Ratio of imports plus exports to GDP.

Source: authors' calculations

Cukierman (1992) and others. However, the results for inflation volatility suggest that the higher the variance of inflation, the higher the variance of output.

Finally, the analysis suggests that adoption of an inflation-targeting scheme is correlated with reductions in the volatility of real growth. One possible explanation for this is that adoption of a disciplined monetary policy framework helps central bankers to move the economy toward the efficient frontier, reducing both output and inflation volatility. The evidence suggests that this effect is larger than the one associated with the trade-off faced by the policy-maker who, under optimal or near-optimal policies, may only be able to reduce inflation volatility at the expense of increasing GDP growth fluctuations.

A potential criticism of the results in Table 6 is the fact that, by employing a fixed-effects model, we are only able to include countries for which we have econometrically identified structural breaks in the volatility of real growth. This means ignoring the information from 9 of the 25 countries in our sample. To address this problem, and include the entire sample of countries, we arbitrarily break our data into sub-periods and examine changes between the initial and final four years of the sample period common to all countries; that is, between the period 1980:Q1–1983:Q4 and the one from 2000:Q1 to 2003:Q4. This division has the advantage that 17 out of the 22 structural breaks fall within the middle period (1984:Q1–1999:Q4), suggesting that we have retained much of the integrity of the subdivision studied above.

Table 7 reports these results. This alternative subdivision of the data does not affect the main results – financial development is negatively and significantly correlated

Table 7: Output Volatility Panel Regression
Comparison between 1980–83 and 2000–03

Explanatory variable	(1)	(2)	(3)	(4)
1. Private credit to GDP[(a)]	–1.20	–1.02	–1.14	–1.08
	(0.00)	(0.00)	(0.00)	(0.00)
2. Trade in goods to GDP[(b)]	–0.27	–0.40	–0.47	–0.25
	(0.74)	(0.61)	(0.56)	(0.76)
3. Central bank turnover ratio	1.25			0.87
	(0.26)			(0.52)
4. Inflation targeting		–0.21		–0.16
		(0.19)		(0.49)
5. Inflation volatility			0.07	–0.02
			(0.52)	(0.86)
F-statistic for joint test	10.78	10.86	10.12	6.13
	(0.00)	(0.00)	(0.00)	(0.00)

Notes: *p*-values (in parentheses) are computed using standard errors that are robust to heteroskedasticity. The F-statistics are for the joint test that all of the slope coefficients in the regression are simultaneously zero.

(a) Ratio of domestic credit extended to the private sector by the banking sector to GDP.

(b) Ratio of imports plus exports to GDP.

Source: authors' calculations

with the standard deviation of growth in real GDP, while the effect of openness to trade on output volatility remains insignificant. The only difference is that under this subdivision of the data, neither inflation targeting, nor inflation volatility seem to be correlated with the changes in growth fluctuations.[23]

5. Conclusion

While everyone who has looked agrees with the McConnell and Perez-Quiros (2000) observation that the volatility of real growth in the US fell by more than one-third in the mid 1980s, there is substantial disagreement over the causes of the decline. Is it inventory policy, monetary policy, or just luck? Could it be changes in financial development or possibly commercial openness? The purpose of this paper is to address these questions by examining data from a broad set of countries to see first, whether volatility changes occurred in the rest of the world, and second, to provide additional evidence to assess the causes of this change.

Our first result is that output volatility has fallen in a broad cross-section of countries; all of the 16 countries with at least one break experienced lower volatility in the more recent period. In assessing the causes of the change in the volatility of real growth, our primary findings link two previous results. For some time we have known that more stable economies grow faster.[24] We have also known that a sound financial system provides the foundation for economic development.[25] Countries with deeper, more sophisticated, financial systems grow faster. Our results show that financial development, as measured by the importance of bank lending, is linked to real economic stability.

Beyond the importance of financial development, we also provide evidence in favour of the view that improved inventory control policies played a role in the more stable growth that we have observed. Furthermore, increased commercial openness, measured by the ratio of imports plus exports to GDP, does not appear to be associated with more stable growth.

Finally, we should note that what we have done is established a set of correlations. Real volatility is negatively correlated with bank lending and positively correlated with the importance of trade flows. And a significant fraction of the decline in the volatility of real GDP, for those countries where it fell, can be accounted for by changes in the behaviour of inventory accumulation. What we have not done is show causal links. It is surely possible, for example, that financial systems are more prone to develop in countries that are more stable and that less stable countries may trade more. Determining the ultimate causes of these changes must be high on the agenda for future research.

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23. We perform other robustness exercises, such as expanding the analysis to include the decade of the 1960s (data available for a number of countries only) and restricting the analysis to the post 1980 period and beyond. We also use a measure of growth volatility without applying the HP filter. Our main conclusions are robust to these alternative measures and definitions of time periods.

24. See Ramey and Ramey (1995).

25. See Ross Levin's (1997) survey.

Appendix A

Let Δy_t denote the rate of growth of HP-filtered log real GDP. We assume a simple AR(1) model:

$$\Delta y_t = \mu + \rho \Delta y_{t-1} + \varepsilon_t \tag{A1}$$

Our first step, for each country, is to search for *multiple* breaks (up to five) in the AR(1) coefficient, that is, persistence (ρ) in Equation (A1).

After finding any breaks in the persistence of Δy_t, that model specification is used for the country in obtaining the residuals $\hat{\varepsilon}_t$. Then, following McConnell and Perez-Quiros (2000), each set of residuals is assumed to follow a normal distribution and the transformations $\sqrt{\frac{\pi}{2}}|\hat{\varepsilon}_t|$ are unbiased estimators of the standard deviation of ε_t.[26]

Finally, we search for *multiple* breaks in the mean of the following volatility equation:

$$\sqrt{\frac{\pi}{2}}|\hat{\varepsilon}_t| = \alpha + u_t, \qquad t = T_{j-1}+1,\ldots,T_j \qquad \text{for } j = 1,\ldots,m+1 \tag{A2}$$

We search for multiple breaks in the different series above using the GAUSS code made available by Bai and Perron (2003) that is based on theoretical results in Bai and Perron (1998). The reason for considering tests for multiple breaks is that tests for a single break typically have low power in the presence of multiple breaks (Bai 1997 and Bai and Perron 2003).

Bai and Perron (1998, 2003) present a number of tests that are available in their GAUSS programs. To decide on the number of breaks and the break dates we employ the 'sequential' method described below, which is reported by Bai and Perron (2003) to outperform other methods, based on simulations they conduct. First, we estimate up to five breaks in the series for each country. Second, we use the method proposed by Bai and Perron (1998) based on the sequential application of the sup $F_t(l+1|l)$ test, which is designed to detect the presence of $(l+1)$ breaks conditional on having found l breaks ($l = 0, 1, \ldots, 5$). The statistical rule is to reject l in favour of a model with $(l+1)$ breaks if the overall minimal value of the sum of squared residuals (over all the segments where an additional break is included) is sufficiently smaller than the sum of squared residuals from the model with l breaks. The dates of the breaks selected are the ones associated with this overall minimum.[27] We identify a break (or an additional break) if the test statistic allows rejection of the null hypothesis at a 10 per cent level of significance or higher.

26. Footnote 3 of McConnell and Perez-Quiros (2000) indicates that this absolute value specification of the error is more robust to departures from conditional normality. See also Davidian and Carroll (1987).

27. All testing procedures allow for serial correlation and different variances across segments in the residuals. In addition, the variance-covariance matrices used in constructing the various test statistics are robust to heterogeneity and autocorrelation by using Andrews (1991) automatic bandwidth with AR(1) approximation and a quadratic kernel. The residuals used are pre-whitened.

Appendix B

Data on private credit and trade on goods come from the World Bank *World Development Indicators*, December 2004 and from the Reserve Bank of Australia.

Turnover ratio of the central bank governor is constructed from information taken from each central bank's website, as well as inquiries to central bank staff.

Inflation targeting data are taken from Mishkin and Schmidt-Hebbel (2002).

GDP and CPI inflation data were obtained from the IMF *International Financial Statistics CDROM* (December 2004) and the OECD *Economic Outlook* No 76, December 2004.

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Discussion

Mardi Dungey

This is a particularly interesting paper in that it attempts to extend the recent analysis of observed declines in output volatility in a number of individual countries to a more generalised framework. There is, as always, more work to do before the question of whether changes in output growth volatility can be viewed as due to global or country-specific changes. I want to structure my remarks around two broad points. The first is to go over some of the existing ground on whether the fall in volatility is due to either real changes in the economy, or to the effects of smaller shocks (or luck, as it is sometimes denoted in the literature). Much of this ground is already covered in Stock and Watson (2002). The second point relates to the attempt to analyse this question in a multi-country framework, as opposed to the usual unilateral approach that is evident in the previous literature and is generally based around the US experience. Finally, I make some concluding remarks and suggestions for future directions with this line of research.

The empirical observation

A number of authors have noticed in recent years that the volatility of the growth rate in real output seems to have fallen in the past decade, compared with previous ones (particularly the 1970s). Examples in this literature include Blanchard and Simon (2001) and McConnell and Perez-Quiros (2000) for the US, Buch, Döpke and Pierdzioch (2004) for Germany, Debs (2001) for Canada, Buckle, Haugh and Thomson (2001) for New Zealand and Simon (2001) for Australia. In the wider context, Basu and Taylor (1999) examine pooled annual data from 1870 across OECD countries, and conclude that output volatility has varied over different periods distinguished by different exchange rate regimes: the gold standard, inter-war years, Bretton Woods and the current floating period. They find that output volatility (as opposed to output growth volatility) varies with regime, but the current regime remains the lowest in the historical period. The useful point to draw from the Basu and Taylor study is that merely because volatility is currently at an all-time low does not mean this trend will necessarily continue. In turning to explanations of what may have been the cause of the drop in observed volatility, this is an important point to bear in mind.

The possible explanations

The search for the contributing factors to the observed drop in output growth volatility, whether permanent or not, can be likened to attempting to run a growth regression of the form

$$\Delta y_{it} = a_i + BZ_{it} + \varepsilon_{it} \tag{1}$$

where Δy_{it} represents output growth, Z_{it} represents the set of uncorrelated explanatory variables, and ε_{it} represents stochastic shocks, drawn from some distribution. In their paper, Cecchetti *et al* make it very clear that the y_{it} should be considered as deviations from some trend, presumably representing a form of output gap, rather than as the raw output values themselves. Hence, if Equation (1) is the appropriate specification of (detrended) output growth, volatility can be specified as

$$\mathrm{var}\left(\Delta y_i\right) = \mathrm{var}\left(BZ_i\right) + \mathrm{var}\left(\varepsilon_i\right) \tag{2}$$

If we believe a linear specification is appropriate, which is the case described in the Cecchetti *et al* paper, then the observed empirical fact of a change in volatility between two periods can be characterised as:

$$\text{Period 1: } \mathrm{var}\left(\Delta y_{i|t=1\ldots t^*}\right) = B_1^2 \mathrm{var}\left(Z_{i|t=1\ldots t^*}\right) + \mathrm{var}\left(\varepsilon_{i|t=1\ldots t^*}\right) \tag{3}$$

$$\text{Period 2: } \mathrm{var}\left(\Delta y_{i|t=t^*+1\ldots T}\right) = B_2^2 \mathrm{var}\left(Z_{i|t=t^*+1\ldots T}\right) + \mathrm{var}\left(\varepsilon_{i|t=t^*+1\ldots T}\right) \tag{4}$$

It is immediately evident that there are three potential non-unique candidates to explain a reduction in var (Δy_i) from period 1 to 2:

(i) $B_1^2 > B_2^2$;

(ii) $\mathrm{var}(Z_{i|t=1\ldots t^*}) > \mathrm{var}(Z_{i|t=t^*+1\ldots T})$; or

(iii) $\mathrm{var}(\varepsilon_{i|t=1\ldots t^*}) > \mathrm{var}(\varepsilon_{i|t=t^*+1\ldots T})$

The first of these conditions states that the propagation of the explanatory variables to output has changed. The second states that the variance of the explanatory variables themselves has fallen, and the third says that the variance of the stochastic shocks hitting the system has declined.

There is some debate in the literature about the relative importance of these potential sources of change. Stock and Watson (2002) argue forcefully for the importance of reduced volatility in shocks, or 'good luck'. However, economists persist in looking for economic variables to explain the phenomenon, that is, concentrating on the second possibility given above.

There are a number of favoured candidates for the Z_i variables which may be the associated 'cause' of the decline in output volatility. Probably the current flavour is the role of inventories, also discussed by Cecchetti *et al*. However, the data characteristics of inventories are not a convincing explanator in their own right. Herrera and Pesavento (2004) and Maccini and Pagan (2005) both demonstrate the problems with inventories data as a sole explanator of declines in output volatility. If inventories have a role to play it is in combination with other variables. Cecchetti *et al* cover a number of favourites in their paper: monetary policy, financial innovation, international openness and smaller shocks.

Cross-country evidence

While other papers in this genre have concentrated on either single countries or pooled data across countries, this paper attempts to consider a wide range of countries. This has been constructed via a number of steps which I now want to discuss.

The initial step is to determine the break points in the output data. The authors propose a simple AR(1) model to first test for breaks in persistence in output growth. The results for the break dates are shown in their Table 1. However, it is of some interest to see more detail on the AR(1) coefficients and the nature of the individual series. Table 1, below, gives the autoregressive coefficient on output growth for each country, estimated without allowing for any breaks, and indicates whether Cecchetti *et al* (CFLK) found breaks in each series. It is noteworthy that both positive and negative autoregressive coefficients are found; some 8 of the 25 countries examined have positive coefficients, the remainder negative. Consistent with other literature, there is no real pattern observable in the persistence of output growth.

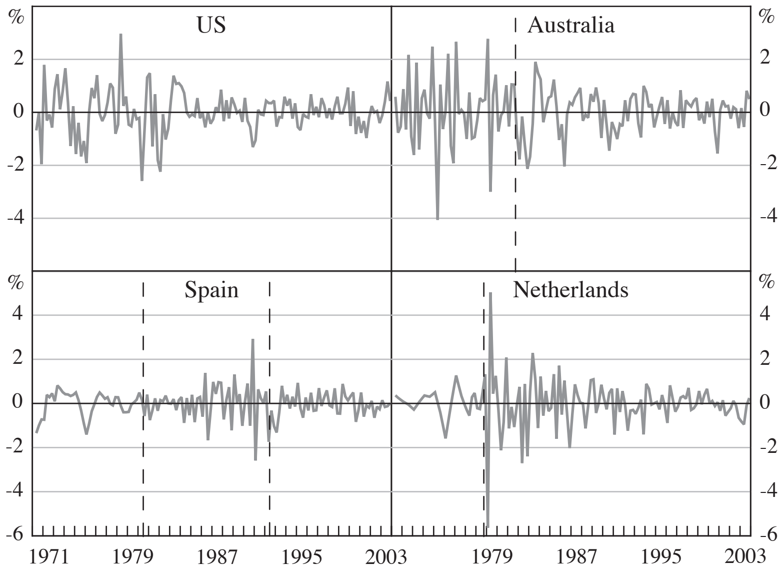
Table 1: Autoregressive Coefficients and Breaks in Output Persistence

	Total period AR(1)	Break found in CFLK		Total period AR(1)	Break found in CFLK
Australia	–0.08	yes	Mexico	–0.17	yes
Austria	–0.25	no	Netherlands	–0.29	yes
Belgium	0.22	no	New Zealand	–0.29	no
Canada	0.22	yes	Norway	–0.47	no
Chile	–0.08	no	Peru	–0.35	no
Denmark	–0.03	no	South Africa	0.12	yes
Finland	0.16	no	South Korea	–0.01	yes
France	0.13	no	Spain	–0.18	yes
Germany	–0.14	no	Sweden	–0.35	yes
Greece	–0.14	no	Switzerland	0.49	yes
Israel	–0.28	no	UK	–0.08	no
Italy	0.31	yes	US	0.18	no
Japan	–0.01	no			

Sources: Cecchetti *et al* (this volume); author's calculations

In examining the time series of output growth from Cecchetti *et al*, it is worth remembering that the data have first been filtered. What is represented as changes in the behaviour of output growth here is actually changes in the deviations of output from HP-filtered log levels of the data. Figure 1 illustrates examples of the Δy_{it} from the data. The top-left panel shows the US case where persistence has remained relatively constant over the period. The top-right panel shows the Australian case, where persistence seems to have dropped. But in the bottom panels for Spain and the Netherlands, the structure and timing of the change in persistence look quite different.

Figure 1: Growth in Output Gaps
Change in residuals from HP-filtered (log) output



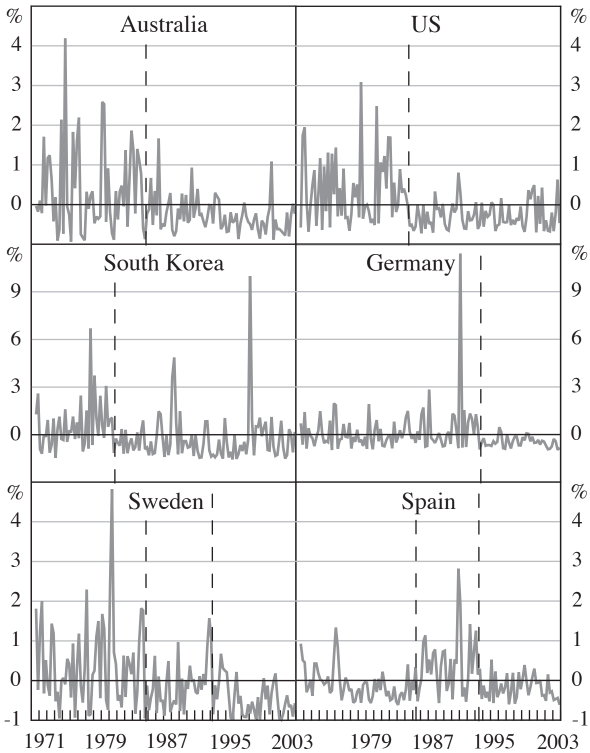
Source: author's calculations

A similar degree of diversity can be observed in the volatility patterns in Δy_{it}. Table 1 in Cecchetti *et al* gives identified break points in volatility for the individual countries. Figure 2 indicates three distinct types of patterns which are revealed across different countries. The first pattern is central to the Cecchetti *et al* argument, that volatility has decreased over the period since 1970, with an identifiable break in the process. Australia and the US are typical of this outcome (Figure 2, top panels).

The second type of country, represented here by South Korea and Germany (middle panels of Figure 2), shows a decline in volatility interrupted by substantial outlier events (the 1998 crisis for Korea and reunification for Germany). The third type of country is where volatility shows a multiple-phase pattern over the period, in most cases three regimes of seemingly declining volatility as shown in the bottom-left panel of Figure 2 for Sweden, but in the case of Spain a low/high/low volatility regime shown in the bottom-right panel of Figure 2. These multiple regimes in volatility have also been noted in Herrera and Pesavento (2004) in the US.

An important part of the Cecchetti *et al* paper is the estimates of the importance of possible changes in various Z_{it}. Having demonstrated that the output growth series of each country has a volatility break at relatively different times, the authors go on to exploit evidence on the contribution of monetary policy actions to output volatility in two distinct periods: 1983–1990 and 1991–1998. Figure 3 shows the timing of these estimated breaks in volatility in relation to these two periods. A number of countries do fall reasonably well into these two periods – those that experienced breaks in their data in the early 1990s. However, a substantial number of countries recorded in Table 1 of Cecchetti *et al* experienced a break in output growth volatility

Figure 2: Breaks in Output Volatility



Notes: Volatility represented by standardised residuals from Cecchetti *et al* Equation (1), estimated without allowing for breaks in persistence. Standardisation of residuals performed as per Cecchetti *et al* Equation (2). Dotted vertical lines represent dates of breaks in persistence, as estimated by Cecchetti *et al*.

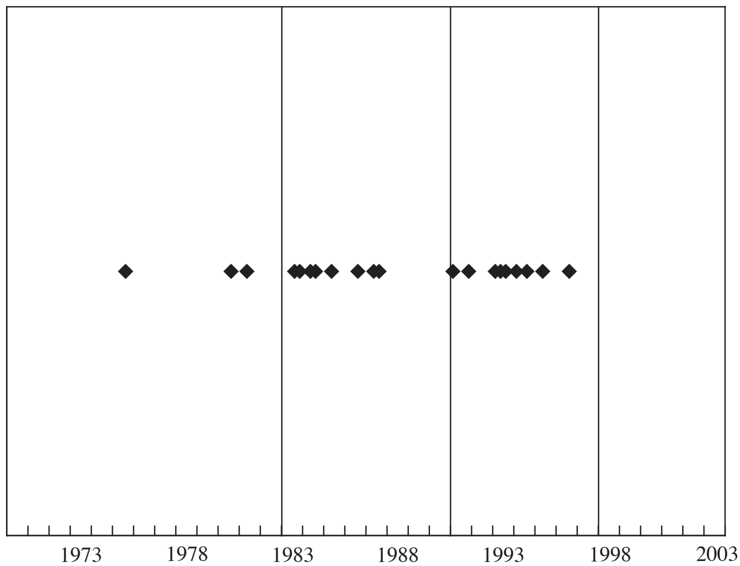
Source: author's calculations

in the early 1980s. For these countries, splitting the sample into two parts at the early 1990s implies no difference in the dependent variable. In short, it is difficult to reconcile this exercise with the evidence on individual country breaks, a point I return to below.

The Cecchetti *et al* contribution goes on to estimate a generalised relationship across countries using changes in output volatility growth before and after the identified volatility break points as dependent variables and changes in the volatility over the same break points of a set of explanatory variables. These include measures of central bank structure, financial development, openness and country size; see Cecchetti *et al* (this volume), Table 6. In the terminology of Equations (3) and (4) above, this amounts to regressing $\sqrt{\text{var}(\Delta y_{i|t=1...t^*})} - \sqrt{\text{var}(\Delta y_{i|t=t^*+1...T})}$ on $\sqrt{\text{var}(Z_{i|t=1...t^*})} - \sqrt{\text{var}(Z_{i|t=t^*+1...T})}$ across all countries, i=1...25.[1] There are a number

1. The authors use logs of the output growth innovations, but this is not important to the point here.

Figure 3: Volatility Growth Breaks



Source: Cecchetti *et al* (this volume)

of issues which this regression raises. The first is to note that since the breakpoint in each of these series differs, the time periods over which each of the variances is calculated is quite distinct, ranging from data covering 1970 to 1995 for the first period for Finland, to data covering 1970 to 1980 for South Korea. Implicitly, an important underlying assumption is that although this represents a search for the factors determining lower volatility, common world growth cycles are ruled out. This was done at an early stage when the filtering was carried out. An alternative procedure would be to filter all the series jointly for a common factor, prior to investigating any remaining idiosyncratic components, as has recently been applied across international consumer price inflation data in Ciccarelli and Mojon (2005). Although a number of authors argue that there is no evidence of a common global output cycle, there is also a substantial recent literature supporting its existence, for example Kose, Otrok and Whiteman (2003). An attempt to address this issue in the current application could prove fruitful. It would also be useful to see the results of common break point tests across series, such as those of Bai, Lumsdaine and Stock (1998), which were applied with some success to output by Luci Ellis in her PhD work (Ellis 2004). If output growth rates were shown to break at common points, then it would suggest some role for a common factor. The current paper suffers from inconsistency on this issue. On the one hand, the cross-country regressions conducted across diverse sample periods implicitly argue that there is no common factor. On the other hand, results such as those on the role of monetary policy implicitly argue that there is some commonality, when they are conducted on common sample periods. A clarification of the role of this assumption would be helpful in future work.

Concluding remarks

In summary, this paper is a step towards the interesting question of whether the fall in the volatility of output growth observed particularly in the US can be viewed as a global phenomenon. If it can, then the question of causality remains of substantial interest. It is difficult to imagine that one can argue that the characteristic is global but the underlying causes are intrinsically idiosyncratic to each country. Alternatively, if the causes of changes in output growth volatility are idiosyncratic to individual countries, then there should be demonstrated diversity in the paths of output volatility across countries. The current paper contributes by showing elements of both of these possibilities. It would be valuable to have the full side of both stories played out, to see which provides the dominant explanation for the empirical evidence.

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Declining Output Volatility: What Role for Structural Change?

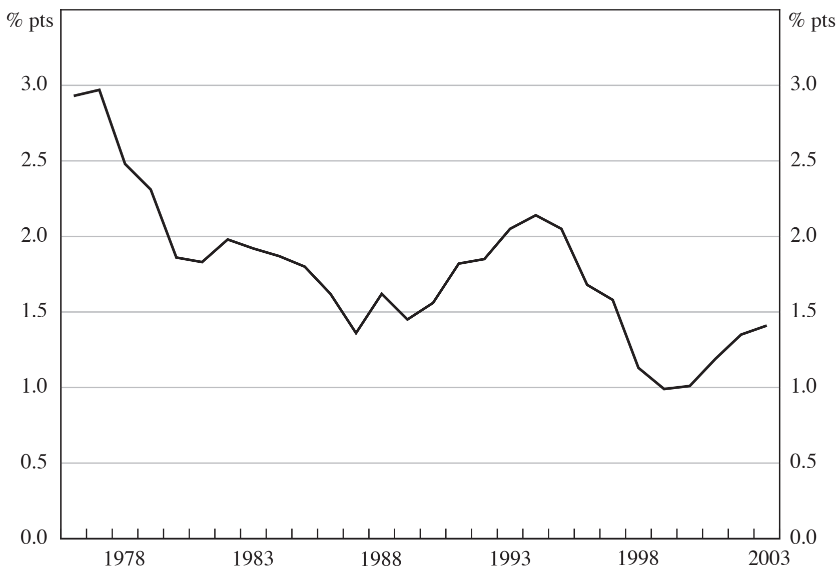
Christopher Kent, Kylie Smith and James Holloway[1]

1. Introduction

The past 25 years has been an era of significant reforms affecting the institutional features and operation of monetary and fiscal policies, as well as of product and labour markets across a range of industrialised countries. Over the same period, there has also been a considerable decline in the volatility of real output around the developed world. Figure 1 shows that, on average, across 20 selected OECD countries,[2] the standard deviation of the annual growth rate of GDP has fallen by more than 1 percentage point since the 1970s. Not surprisingly, there is a growing literature seeking to disentangle the varied (and interrelated) causes of this general decline, and to determine the explanatory role, if any, for structural reforms.

Figure 1: Average Output Volatility – 20 Selected OECD Countries

Standard deviation of annual GDP growth over
5-year backward-looking windows



Sources: ABS; Thomson Financial; World Bank *World Development Indicators*

1. The authors would like to thank Adrian Pagan, David Wilcox and seminar participants at the RBA for comments.

2. These are: Australia; Austria; Belgium; Canada; Denmark; Finland; France; Germany; Ireland; Italy; Japan; the Netherlands; New Zealand; Norway; Portugal; Spain; Sweden; Switzerland; the United Kingdom; and the United States.

Four factors that could explain the decline in the volatility of GDP have been proposed: changes in both the composition of GDP and the behaviour of its various components; the efficacy of monetary and fiscal policies; structural reforms in markets; and plain good luck, reflecting smaller and/or less frequent shocks.[3] Explanations related to the first three factors typically emphasise their role in reducing the responsiveness of an economy to exogenous shocks. In addition, these factors may have had some role in directly reducing the magnitude of shocks themselves. The fourth factor, good luck, may have led to a decline in the magnitude of the shocks globally over this period, regardless of any effect from the first three factors. The relative contribution of these four factors to the decline in output volatility is important since it has implications for future output volatility. By their nature, the first three structural factors are likely to have a more permanent effect on output volatility, while a decline in global shocks (irrespective of structural factors) may only be temporary.

Surprisingly, there has been little consensus regarding the relative contribution of these four factors to the reduction in output volatility. A variety of approaches have been used to determine their empirical relevance. One approach examines changes in the make-up and behaviour of various components of GDP for a given country.

A second approach examines the effectiveness of monetary policy as a tool of macroeconomic stabilisation. For example, Cecchetti, Flores-Lagunes and Krause (2004) estimate movements towards an efficiency frontier for inflation and output variability and movements in the frontier itself (by using estimates of simple structural equations for aggregate demand and supply). They find that better monetary policy (that is, a move towards the efficient frontier) accounts for most of the improvement in macroeconomic stability across a wide range of countries.

A third approach also uses estimates of structural models for given countries, but with the aim of decomposing changes in output volatility into two parts, that which is due to changes in the magnitude of shocks and that which is due to changes in the transmission of shocks (that is, model parameters). Changes in transmission are taken to reflect structural change, broadly defined to incorporate behavioural changes, the efficacy of macro-policies and structural reforms in markets. In stark contrast to the results of the aforementioned studies, Ahmed, Levin and Wilson (2004) and Stock and Watson (2004) find that most of the decline in output volatility in the United States is due to a decline in the magnitude and frequency of global shocks. For Australia, Simon (2001) also finds that most of the decline in output volatility is due to smaller shocks, with little role for structural factors. However, this approach implicitly assumes that shocks are independent of the structure of the economy. Simon acknowledges this limitation, noting that the decline in productivity shocks may have been related to structural factors, such as the shift towards more skilled workers and serviced-based industries, and financial liberalisation. Similarly,

3. See Bernanke (2004) and Stock and Watson (2004) for discussions of the literature. A fifth factor that has received attention is the possibility of a reduction in measurement error, though at least for the United States, this has been discounted (see Dynan, Elmendorf and Sichel 2005 for a discussion).

Clarida, Galí and Gertler (2000) argue that monetary policy (by better anchoring expectations) can reduce shocks arising from shifts in expectations for reasons unrelated to macroeconomic fundamentals.

A fourth, atheoretic, approach is based on cross-country panel data models with output volatility as the dependent variable and various measures of structural change as independent variables. Implicitly, coefficient estimates on these measures of structural change will jointly capture their effect on the responsiveness of an economy to shocks and the size of those shocks. Using G7 panel data, Barrell and Gottschalk (2004) find a significant role for indirect measures of monetary policy effectiveness and regulatory reform in explaining the decline in output volatility.

The aim of this paper is to re-examine the significance of a wide range of variables in explaining the decline in output volatility using this atheoretic approach, though with a few notable innovations. First, we use a larger panel (with 20 OECD countries). Second, we use direct measures of structural reforms which are less likely to suffer from possible endogeneity. Specifically, for monetary policy we construct a crude, but apparently effective, dummy variable that identifies two possible types of regimes according to the relative strictness with which policy-makers pursue the goals of low and stable inflation. For product markets we use a 'synthetic' indicator which allows a comparison of regulatory frameworks across countries and over time (Nicoletti *et al* 2001). Third, unlike existing studies of this type, we show that our results are robust to trends in common global shocks that are unrelated to structural change.

The structure of this paper is as follows. Section 2 provides a more detailed discussion of the mechanisms linking output volatility to the explanatory factors identified above; paying particular attention to the role of product and labour market reforms, which have received less attention in the literature. Section 3 describes the data in detail, and outlines the basic estimation methodology. Section 4 presents the results, considers an extension that controls for trends in common shocks, and provides a number of robustness checks. Section 5 concludes.

2. Explanations for Declining Output Volatility

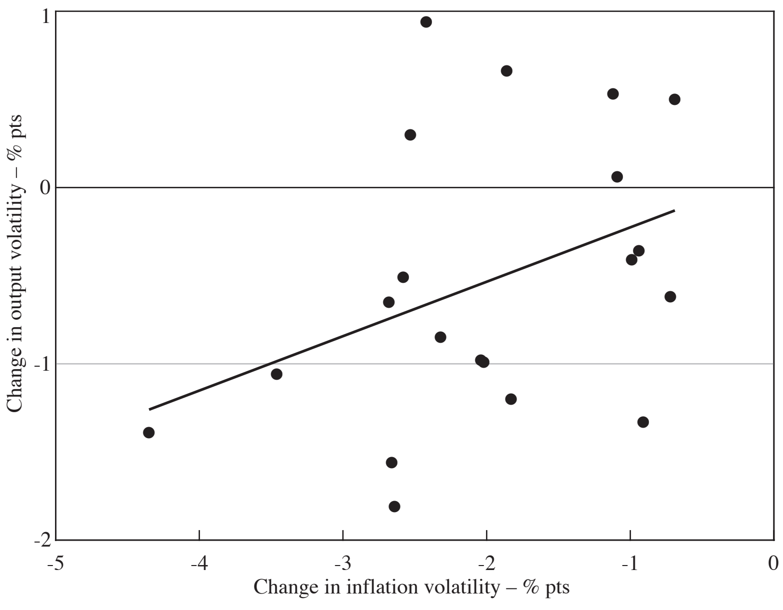
This section considers the mechanisms that could link output volatility to changes in monetary and fiscal policy, structural reforms in labour and product markets, and changes in the composition and behaviour of components of GDP. It also takes a preliminary look at some relevant trends in the data for 20 OECD countries (hereafter referred to simply as OECD countries) from the late 1970s to 2003.

2.1 Monetary and fiscal policy

The rise of monetary and fiscal policies as stabilisation tools in the post-World War II era was one of the earliest, and still prominent, reasons cited for the decline in output volatility in a number of countries. Blanchard and Simon (2001) and Romer (1999) find that monetary policy rather than fiscal policy has made the larger contribution to stabilising economic downturns. One explanation for this is that monetary authorities have actively counteracted some post-war shocks, such as the 1987 stock market crash, while fiscal policy, though effective, has had a more passive role (largely through the operation of the automatic stabilisers) in moderating business cycle fluctuations. The tendency across many countries in the past couple of decades for greater central bank independence and the adoption of monetary policy regimes that are stricter on inflation appears to have resulted in the widespread decline in inflation volatility. This is consistent with a reduction in the volatility of output in the case of demand shocks, since these push output and inflation in the same direction. And while supply shocks push inflation and output in opposite directions, output volatility may still decline under a more credible monetary policy regime if it helps to better anchor inflationary expectations. A number of papers using panel data have established a close link between the decline in inflation volatility and output volatility (Barrell and Gottschalk 2004, and Blanchard and Simon 2001, for example). This is readily apparent in our sample of OECD countries (Figure 2; summary statistics by country are available in Table 1 and in Figure B1 in Appendix B).[4] Interpreting this to imply causation is, however, made difficult by the problem of endogeneity, as inflation and output volatility are likely to be affected by common shocks. Hence, we argue that there is a need to capture

Figure 2: Change in Inflation Volatility versus Output Volatility – 1983–2003

20 OECD countries, linear trend added



Sources: ABS; Thomson Financial; World Bank *World Development Indicators*

4. See Section 3 for a description of the calculations underpinning this and other scatter plots. The start and end dates correspond to those used in the regression analysis later in the paper.

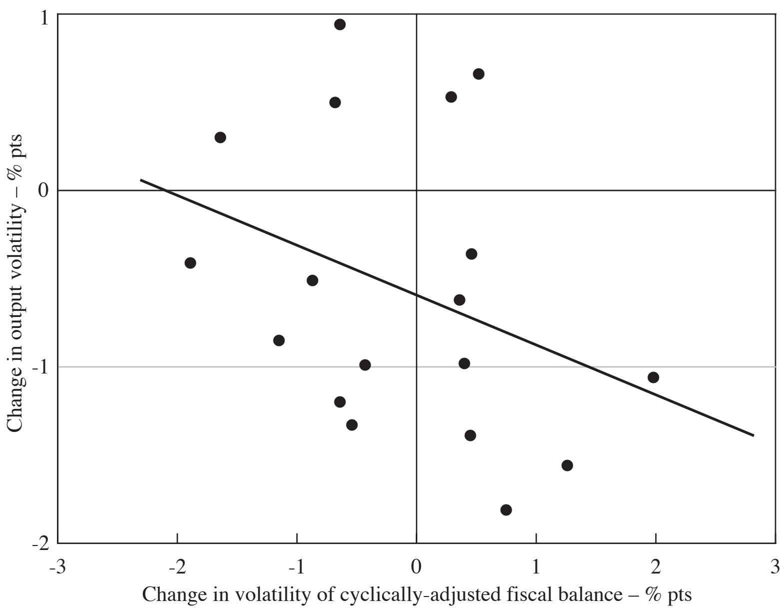
changes in monetary policy regimes with a more direct measure that is not likely to be affected by output volatility (see Section 3).

In principle, discretionary fiscal policy can be an effective tool for aggregate demand management if government spending and taxes are sizeable enough that modest variations may work to offset other cyclical impulses. In practice, fiscal policy may not move quickly enough to be countercyclical, and timing difficulties could actually lead fiscal policies to exacerbate output fluctuations. Perotti (2005), using structural VAR models for Australia, Canada, Germany, the UK and the US, finds that the magnitude of fiscal shocks declined around the early 1980s and that the transmission of these shocks has become more muted over time.

For OECD countries (on average and across countries) the relative size of the public sector (measured, for example, by public consumption as a share of GDP) has been generally stable since the late 1970s (at around 20 per cent). The volatility of discretionary policy (measured by the cyclically-adjusted fiscal balance, as a share of GDP) has not changed significantly over this period, although it has tended to rise in those countries which experienced larger declines in output volatility (Figure 3 and Table 1). However, interpreting this to imply something about causation is difficult; output volatility may have fallen in these countries due in part to more active discretionary fiscal policy working to dampen other cyclical influences, or in spite of it. Nevertheless, such a measure may provide a useful control for regression analysis.

Figure 3: Change in Fiscal Policy Volatility versus Output Volatility – 1983–2003

18 OECD countries, linear trend added



Note: New Zealand and Switzerland excluded due to incomplete data

Sources: Thomson Financial; World Bank *World Development Indicators*

Table 1: Summary Statistics *(continued next page)*

	GDP volatility[a]			Product market regulation[b]		Monetary policy regime[c]	Inflation volatility[d]			Days lost to labour disputes[e]		
	1978	1983	2003	1978	1998	Strict inflation regime	1978	1983	2003	1978	1983	2003
Australia	1.0	2.4	0.6	4.5	1.6	1993–	3.0	2.9	0.3	580	481	49
Austria	2.8	1.9	1.2	5.2	3.2	1995–	2.4	1.5	0.8	1	1	65
Belgium	2.8	1.9	1.4	5.5	3.1	1979–	3.6	1.6	0.6	197	109	15
Canada	1.2	2.7	1.7	4.2	2.4	1992–	1.6	2.5	0.4	853	651	146
Denmark	3.3	2.2	1.0	5.6	2.9	1979–	2.5	2.1	0.3	72	98	39
Finland	1.3	1.9	1.5	5.6	2.6	1994–	3.9	2.0	1.0	400	294	41
France	1.7	0.9	1.5	6.0	3.9	1979–	1.9	1.7	0.6	167	101	77
Germany	2.6	1.9	1.3	5.2	2.4	Always strict	1.7	3.1	0.5	48	6	3
Ireland	2.7	2.1	3.1	5.7	4.0	1979–	5.1	4.0	1.5	487	526	58
Italy	3.3	2.0	1.2	5.8	4.3	1979–1992; 1999	2.7	2.8	0.4	993	848	90
Japan	2.5	2.1	1.1	5.2	2.9	Always strict	7.2	2.3	0.3	91	13	1
Netherlands	1.9	1.5	2.0	5.3	3.0	1979–	2.6	1.7	1.0	10	24	11
New Zealand	3.7	1.5	0.8	5.1	1.4	1990–	2.2	3.9	1.2	229	241	16
Norway	1.4	2.6	1.1	5.0	2.5	2000–	1.3	3.4	0.7	64	44	58
Portugal	4.4	1.8	2.1	5.9	4.1	1992–	4.2	3.3	0.8	128	145	12
Spain	2.0	2.3	1.0	4.7	3.2	1989–	3.5	1.4	0.5	705	629	162
Sweden	1.8	1.0	1.7	4.5	2.2	1995–	0.7	2.7	0.8	30	225	34
Switzerland	3.8	1.4	1.5	4.5	3.9	Always strict	3.9	1.5	0.4	2	1	3
UK	2.1	2.2	0.8	4.3	1.0	1990–	5.7	5.0	0.7	351	441	22
US	3.0	2.5	1.5	4.0	1.4	1979–	2.1	4.1	0.7	396	170	41
Average	**2.5**	**1.9**	**1.4**	**5.1**	**2.8**		**3.1**	**2.7**	**0.7**	**290**	**252**	**47**

Table 1: Summary Statistics *(continued)*

	Openness[f]			Financial liberalisation[g]			Oil price volatility[h]			Government balance volatility[i]			GDP less change in inventory volatility[a]		
	1978	1983	2003	1978	1983	2003	1978	1983	2003	1978	1983	2003	1978	1983	2003
Australia	29	32	42	45	53	117				1.2	0.4	1.1	2.6	1.9	0.7
Austria	64	72	100	58	75	104				1.4	0.8	1.2	2.1	0.8	1.4
Belgium	110	127	161	24	29	78				0.7	2.2	0.3	1.7	1.2	1.5
Canada	47	51	80	96	105	139				2.0	1.2	1.6	2.6	3.3	1.7
Denmark	60	68	80	159	134	139				2.0	1.4	0.8	2.6	1.9	1.1
Finland	53	61	70	45	43	58				1.6	1.2	1.6	2.0	0.6	1.3
France	32	36	43	49	70	73				0.7	0.7	1.0	0.8	0.6	1.4
Germany	38	43	55	66	75	119				0.9	1.9	1.0	2.0	1.6	1.6
Ireland	96	104	170	27	36	110				–	2.8	2.1	4.8	2.5	3.6
Italy	44	46	53	81	62	79				1.2	2.0	0.8	1.1	1.8	1.8
Japan	25	27	20	85	87	110				1.3	1.0	0.6	2.9	1.3	0.9
Netherlands	96	106	122	41	58	143				–	1.5	0.8	0.6	1.2	2.2
New Zealand	54	60	64	18	21	121				–	–	0.6	4.0	2.7	0.8
Norway	78	78	72	53	52	100				–	1.0	2.2	1.4	2.8	1.1
Portugal	50	64	70	77	80	141				2.3	2.9	1.3	0.8	0.8	2.1
Spain	30	35	59	80	78	105				–	1.0	0.5	1.6	0.9	1.0
Sweden	55	61	83	40	40	44				–	1.2	1.7	0.7	0.7	1.7
Switzerland	62	69	82	89	115	160				–	–	–	3.2	1.9	1.5
UK	43	41	41	43	48	117				0.7	1.8	2.3	1.4	1.9	0.8
US	17	19	24	99	103	143				1.2	0.8	2.8	2.6	2.2	1.4
Average	**54**	**60**	**75**	**64**	**68**	**110**	**113.6**	**57.5**	**28.1**	**1.3**	**1.4**	**1.3**	**2.1**	**1.6**	**1.5**

Notes: Annual data from 1973 to 2003. Standard deviations and averages are taken over 5-year periods ending in the dates shown.
(a) Standard deviation of annual growth rate over a 5-year window.
(b) Averages of indicators on regulatory and market environment for seven energy and service industries, see Nicoletti *et al* (2001); scale 0–6 from least to most restrictive.
(c) Year country adopted a strict policy towards inflation.
(d) Standard deviation of the annual growth rate of the CPI deflator over a 5-year window.
(e) Number of working days lost due to industrial disputes divided by total employment, times 1 000; five-year average.
(f) The value of total trade as a per cent to GDP; five-year average.
(g) Total credit as a per cent to GDP; five-year average.
(h) Standard deviation of the annual growth rate of West Texas Intermediate crude oil price over a five-year window; measured in SDRs per barrel.
(i) Standard deviation of annual cyclically-adjusted government fiscal balance as a per cent to GDP over a 5-year window.
Sources: See Appendix B

Romer (1999) concludes that non-discretionary fiscal policy has played the larger role in moderating the fluctuations of business cycles, consistent with the post-war growth of a number of automatic stabilisers, including income tax, unemployment compensation and welfare programs. While this may be true, it would be difficult to establish without the aid of a structural model to identify shocks. Changes in the volatility of the non-discretionary fiscal balance (as a ratio to GDP) show no clear *long-run* trend across countries in our sample.[5]

2.2 Change in the composition and behaviour of GDP components

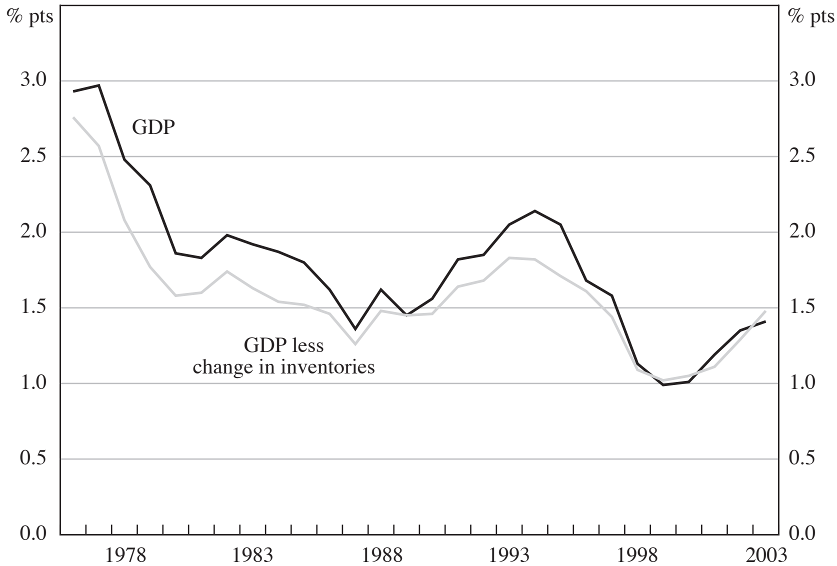
It is possible that firms have become more adept at managing demand shocks and that this has played an important role in reducing the volatility of output growth. In particular, it has been argued that improvements in information technology have helped firms to sharpen their inventory management, resulting in less pronounced swings in production and output (Dalsgaard, Elmeskov and Park 2002 and McConnell, Mosser and Perez-Quiros 1999). Kahn, McConnell and Perez-Quiros (2002) argue that the clear downward trend in the US inventory-to-sales ratio from the mid 1980s (after being steady since the 1950s) is attributable to improved inventory management techniques dating from the late 1970s and early 1980s, such as the adoption of flexible manufacturing systems and just-in-time inventory management. However, for Japan the decline in the inventory-to-sales ratio is a more recent phenomenon, while Khan and Thomas (2004) show that just-in-time methods have little effect on output volatility. Moreover, while supply-side factors may have played a role in the declining volatility of inventories, changes in the nature of demand may have also played a role. For example, more stable consumption would facilitate a reduction in the inventory-to-sales ratio and reduce the volatility of inventories. Hence, the role of improved inventory management in explaining the decline in output volatility is not entirely convincing (Sill 2004). On average across OECD countries, the decline in the volatility of GDP less the change in inventories is only slightly less than the decline in the volatility of GDP (Figure 4), and indeed for some countries, GDP less the change in inventories is actually more volatile than GDP itself (Table 1).

The shift away from the more volatile manufacturing sector and towards the service sector has also been suggested as an explanation for lower output volatility in developed economies (Dalsgaard *et al* 2002). However, this process has been underway since at least the 1950s and again it is unclear that it lines up with the timing of the shift to greater stability of the overall economy. Indeed, Blanchard and Simon (2001) find that changes in composition have not played an important role in the decline in output volatility; while the composition of output has changed over time, the effects have largely cancelled each other out.[6]

5. The non-discretionary fiscal balance (as a ratio to GDP) is measured as the difference between the primary fiscal balance and the cyclically-adjusted primary balance.

6. The real share of the goods sector in total value added – which tends to decline over time for most countries – was included in the regression analysis of Section 4 (results not reported). However, the coefficient on this variable was negative and statistically insignificant, and may have reflected a spurious trend; studies which focus on this factor suggest, if anything, the opposite sign (Maccini and Pagan 2005).

Figure 4: Average Output Volatility – 20 Selected OECD Countries
Standard deviation of annual GDP growth over
5-year backward-looking windows



Sources: ABS; Thomson Financial; World Bank *World Development Indicators*

We do not directly deal with these possibilities in this paper. First, data limitations make it difficult to reliably remove the effect of changes in inventories from GDP across all of the countries in our sample. Second, many of the factors commonly cited as driving the reduction in volatility of consumption and investment (particularly of inventories) may be captured by our explanatory variables.[7] And third, compositional and behavioural changes in the components of GDP that are driven by global changes in technology and preferences will be accounted for when we control for possible common trends in the data in Section 4.2.

2.3 Product and labour market reforms

The effect of a range of different types of market reforms on output volatility has been considered in the literature, though in a somewhat piecemeal approach, and largely ignoring labour market reforms. In the case of financial market reforms (typically proxied by measures of financial deepening), one hypothesis is that greater liquidity allows households and businesses to better smooth their consumption and investment in response to income shocks. Working in the other direction, however, financial sector reforms could initially be associated with significant financial

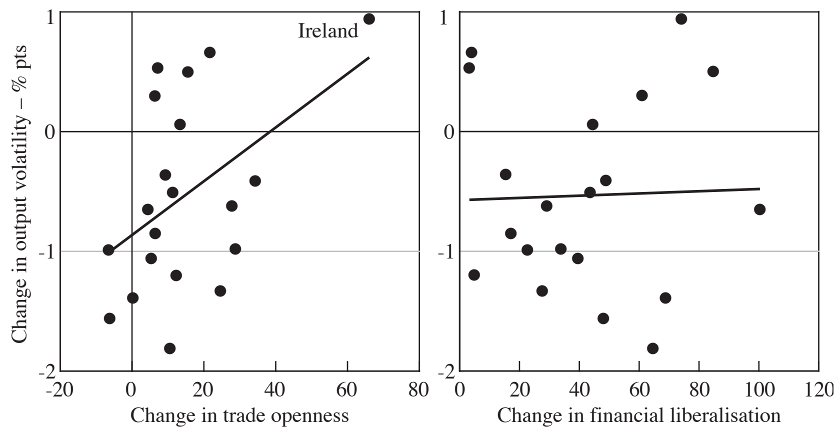
7. For example, Kolev (2005) proposes that a relaxation of credit constraints reduces the value of inventories as a source of collateral.

system instability and higher output volatility. Similarly, increased international integration of both goods and financial markets can provide diversification benefits, but at the same time it can also encourage greater specialisation in production, with greater exposure to sector-specific shocks; the net effect on output volatility in any given country is not clear. Empirical findings based on measures of international integration and financial system depth are mixed. Barrell and Gottschalk (2004) find that greater openness to trade and deeper financial systems are associated with lower output volatility, while Buch, Döpke and Pierdzioch (2002) and Easterly, Islam and Stiglitz (2001) find no such relationships, or unstable ones at best. Across OECD countries, there appears to be a positive relationship between changes in trade openness and output volatility over the past 20 years – that is, countries that became more open experienced a smaller decline in output volatility (Figure 5 and Table 1). There does not appear to be any consistent relationship between trend changes in the extent of financial liberalisation and output volatility.

One aspect of market reforms that has been somewhat overlooked is the combined effect of broad-based product and labour market reforms on an economy's responsiveness to shocks. Aggregate output volatility could fall if reforms encourage more efficient reallocation of resources across sectors and across firms in response to sector- and firm-specific shocks. Consistent with these, Comin and Philippon (2005) present evidence that firm-level volatility is positively related to product market

Figure 5: Changes in Trade Openness and Financial Liberalisation versus Output Volatility – 1983–2003

20 OECD countries, linear trends added



Notes: Trade openness is proxied by the ratio of the sum of exports and imports to GDP. Excluding Ireland from the linear trend makes it slightly more upward-sloping. Financial liberalisation is proxied by the ratio of total credit to GDP. Both variables are based on averages of annual data over the five years ending 1983 and 2003. See Section 3 and Appendix B for details.

Sources: ABS; Thomson Financial; World Bank *World Development Indicators* competition, and link this to a decline in the volatility of aggregate output. However, it is also possible that significant reforms could raise output volatility in the short-run as productive resources are dislocated from previously protected industries/firms, and take time to shift into more productive uses (OECD 1997).

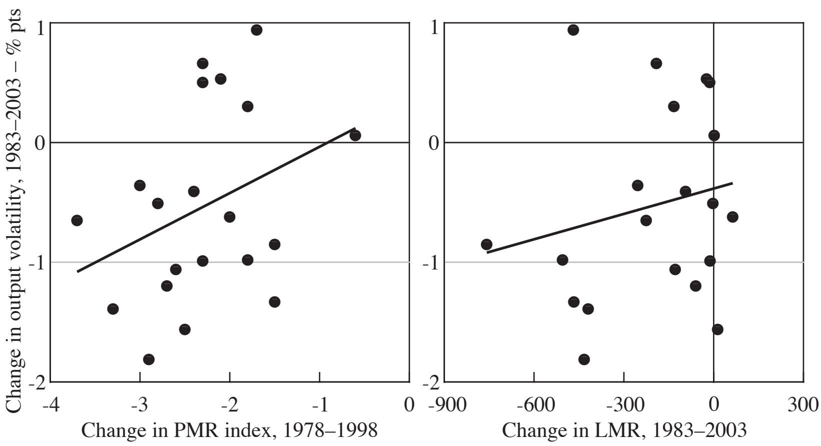
Reforms can encourage greater movement of resources across sectors/firms in a number of ways. Labour market reforms can reduce hiring and firing costs, including by allowing for more flexible work arrangements. They can also lead to increased wage flexibility, providing stronger market signals prompting labour to be allocated to its most productive use. Similarly, product market reforms can lead to price signals that better reflect profitable opportunities. In these ways, resources receive stronger signals of, and are better able to move in response to, shocks, allowing for greater dynamic efficiency. The global decline in the level and volatility of inflation potentially reinforces this effect by making relative price changes more apparent (Bernanke 2004).

Although shocks leading to cycles in activity will often be of an economy-wide nature, they will still encompass idiosyncratic elements. Consider a large negative aggregate shock, but with differential impacts across sectors. In a world with very limited (short-term) mobility of factors of production, those sectors suffering a relatively large negative shock will be left with a relative surplus of productive factors. If factors of production are able to move from less productive to more productive parts of the economy, the effects of the aggregate shock could be mitigated and output might not fall so far. Similarly, during a positive aggregate shock, output could be higher if resources moved to those areas benefiting from relatively larger gains in productivity and/or demand. Overall, flexibility can lead to a decline in aggregate output volatility if the gains of shifting resources during a downturn are larger than the gains of shifting resources during an upturn. This is possible in the case of decreasing aggregate returns to the mobile factors of production, as illustrated in a simple model presented in Appendix A.

Whether output volatility falls in response to more liberalised markets remains an empirical question. A glance at the data suggests that it is plausible: countries that undertook more sizeable product and labour market reforms experienced larger declines in GDP volatility over the past 25 years (Figure 6 and Table 1).

Figure 6: Changes in Product and Labour Market Regulations versus Output Volatility

20 OECD countries, linear trends added



Notes: Product market regulations (PMR) index runs from most (6) to least (0) restrictive. Labour market regulations (LMR) are proxied for by days lost per '000 employed per year. See Section 3 and Appendix B for detailed descriptions and sources.

3. Methodology and Data

This paper uses a fixed-effects panel data regression with output volatility as the dependent variable and measures of structural change as the independent variables. Data are annual from 1974 to 2003, except for the indicator of product market regulation, which is available only about every five years from 1978 to 1998 (the early 1980s observation is for 1982). Partly for this reason regressions are run with observations over five-year blocks. Output volatility is measured as the standard deviation of the annual growth rate of GDP within each five-year block; this and other key data are summarised in Table 1 (and in Figure B1 in Appendix B, which also includes a description of data sources). Blanchard and Simon (2001) also measure volatility according to the standard deviation of GDP growth rates, though they use quarterly data and a rolling five-year window (in Section 4.1 we test the sensitivity of our results by adopting a variant of this rolling window approach).[8]

A key innovation of this paper is to examine the role of direct measures of economic structure in explaining the volatility of output. We define a direct measure

8. Barrell and Gottschalk (2004) examine a measure of GDP volatility based on the standard deviation of the output gap. Estimates for Model 1a based on a measure of the volatility of the output gap (constructed by applying an HP filter to the log of GDP) produce a similar coefficient for product market regulations (though with a *p*-value of 0.15) and a larger (absolute) and statistically significant coefficient for the monetary policy regime (–0.88). Other coefficient estimates are qualitatively similar. While the average trend across countries of output volatility based on the output gap is similar to that based on output growth, it generally displays greater short-term volatility within countries.

as one which is closely tied to the actual regime/structure in place, as opposed to an indirect measure, which is a consequence of that regime/structure. One direct measure we consider is an index of product market regulation produced by the OECD, which provides an internationally comparable measure of the degree to which government policies inhibit competition. This index covers regulations related to barriers to entry (including legal and administrative barriers to entrepreneurship), public ownership, market structure, vertical integration and price controls (for more details see Appendix B; Nicoletti *et al* 2001; and Nicoletti and Scarpetta 2003). The index ranges from high regulation (6) to limited regulation (0).

The other direct structural measure we examine relates somewhat loosely to the 'effectiveness' or 'strictness' of the monetary policy regime, which ultimately affects the level and volatility of inflation.[9] This is measured by a dummy variable, which takes a value of 1 if the regime is deemed to be strict on inflation and 0 otherwise. As a benchmark, Germany, Japan and Switzerland are assumed to have had strict regimes throughout the sample period.[10] Monetary policy in the US is deemed to have become strict starting from the Volcker chairmanship and continuing through that of Greenspan. For all other countries, policy is deemed to have been strict during periods when they were either tied closely to Germany through membership of the Exchange Rate Mechanism and later the euro area, or following the adoption of inflation-targeting regimes. The possibility that the Exchange Rate Mechanism may not have been as effective as other strict monetary policy regimes, such as euro-area membership or inflation targeting, is also explored by including a separate ERM dummy variable.

As shown in Table 2, the crude dummy variable measure of monetary policy regimes appears to be related to both the level and standard deviation of inflation; across all countries, average inflation and average volatility of inflation fell substantially when moving to the stricter regime. This is also true of most countries individually, with the exception of Sweden.

Table 2: Monetary Policy Regime Dummy Variable and Inflation
Pooled results – annual data 1978 to 2003, per cent

	Less strict regimes (Dummy = 0)	More strict regimes (Dummy = 1)	Total period
Average inflation	8.0	3.5	4.9
Standard deviation of inflation	5.2	3.3	4.5

9. Bergman, Bordo and Jonung (1998) link different monetary policy regimes to changes in output volatility. They distinguish four regimes: the Gold Standard, the inter-war period, Bretton Woods and post-Bretton Woods. However, they fail to find any significant relationship, possibly because their regimes are too broadly defined; in particular, the post-Bretton Woods period captures an array of quite different policy regimes.

10. It could be argued that Japanese monetary policy has not been so effective over our full sample. Even if we alter our assumption and deem Japan's monetary policy regime to have been ineffective throughout the period, the results of the paper are essentially unchanged.

Ideally, we would also include a direct measure of labour market regulations in the regressions; however, a useful measure is not readily available.[11] Hence, we use a proxy based on the number of days lost in labour disputes. This shows a trend decline across most countries, which appears to be consistent with the variation in the extent of labour market reforms across countries. Further, because the approach to industrial relations reform has been quite different across countries, an outcome-based measure may be better than a direct measure. For example, Wooden and Sloan (1998) show that while Australia and the UK adopted different approaches to labour market reform, they have resulted in very similar labour market outcomes. Nicoletti, Scarpetta and Boylaud (1999) note that for 1998, there is a significant positive cross-country correlation between indices of employment protection legislation and product market regulations, suggesting that the latter might also proxy for labour market regulations in the regression analysis (the correlation between product market reforms and days lost in labour disputes is 0.26; see Table 3).

Other indirect structural measures considered are openness to international trade (proxied by the ratio of exports and imports to GDP) and financial liberalisation (proxied by the ratio of private sector financial assets or liabilities to GDP). Also, inflation volatility can be used as an indirect measure of the effectiveness of monetary policy regimes.[12] Finally, controlling for any effects due to changes in the behaviour of fiscal policy is achieved by including the volatility of the cyclically-adjusted primary budget balance (as a ratio to GDP). This measure of discretionary policy is preferred over the primary budget balance, which is endogenous with respect to output volatility since it includes the effect of automatic stabilisers.[13]

The distinction between direct and indirect structural indicators is relevant for the lag structure in the regressions. For direct measures we match the volatility of annual GDP growth over a given five-year period with the value of the structural indicator that applies in the year just prior to this (for example, output volatility over the five years ending 1983 is matched with the level of the product market regulations index in 1978). This captures the likely lagged effect of structural change, as well as having the desirable property of ensuring that the structural indicators are exogenous with respect to output volatility. In contrast, indirect measures of

11. The Economic Freedom of the World Index provides an overall measure of labour market regulations. While useful for cross-country comparisons, it tends to understate the degree of reform within countries over time – indeed, for Australia this measure suggests that the labour market was more regulated in recent years compared with the early 1990s notwithstanding significant reform over this period (Dawkins 2000). This may reflect the fact that this measure (and others like it) is only able to capture a limited set of factors that determine how the labour market operates, and it tends to rely heavily on subjective interpretations of the legal framework.

12. Barrell and Gottschalk (2004) and Blanchard and Simon (2001) find that the level of inflation is insignificant in explaining changes in output volatility.

13. Commodity price volatility was also examined. The results of Maccini and Pagan (2005) might suggest that the coefficient would be positive, in line with trend declines in the volatility of output and commodity prices. However, the coefficient estimate is negative (and significant). The inclusion of commodity price volatility pushes up the coefficient estimate on product market reform, possibly due to a multicollinearity problem (the correlation between the two variables is 0.65). Hence, commodity prices are ignored in what follows.

Table 3: Correlations – Five-year Block Data

	GDP volatility	Product market regulations	Days lost to labour disputes	Monetary policy dummy	Inflation volatility	Oil price volatility	Financial liberalisation	Trade openness
GDP volatility	1.00							
Product market regulations	0.25	1.00						
Days lost to labour disputes	0.24	0.26	1.00					
Monetary policy dummy	–0.28	–0.30	–0.46	1.00				
Inflation volatility	0.39	0.42	0.35	–0.47	1.00			
Oil price volatility	0.16	0.26	0.38	–0.34	0.42	1.00		
Financial liberalisation	–0.14	–0.45	–0.31	0.44	–0.43	–0.24	1.00	
Trade openness	0.04	0.14	–0.19	0.12	–0.08	–0.03	–0.15	1.00
Volatility of the cyclically-adjusted fiscal balance	0.07	–0.08	0.07	–0.16	0.16	0.02	–0.14	0.02

Notes: Correlations for the volatility of the cyclically-adjusted fiscal balance are based on only 90 observations due to missing data for some countries. Product market regulations and monetary policy variables are lagged as discussed in the text.

structural indicators are included in the regressions contemporaneously, consistent with other studies of this type. Finally, we control for one type of supply shock by including the volatility of oil prices contemporaneously.

In summary the basic regression takes the following form:

$$\sigma_{it}^{Y} = \beta_1 X_{it-1} + \beta_2 Z_{it} + \beta_3 W_t + \alpha_i + \varepsilon_{it} \qquad \text{for } i = 1,2,\ldots,20 \qquad (1)$$

where: σ_{it}^{Y} is the standard deviation of annual growth of real GDP for country i; X_{it} is a vector of direct structural indicators; Z_{it} is a vector of indirect structural indicators; W_t is a vector of other possible explanators, such as oil price volatility and a time trend; and t indicates each five-year block ending in 1983, 1988,…, 2003.

Simple correlations across the panel using data in five-year blocks are generally consistent with the graphical analysis in Figures 2, 3, 5 and 6. Most notably, the lag of product market regulation is positively correlated with output volatility, the lagged monetary policy regime dummy is negatively related to output volatility, and a decline in days lost due to labour disputes is associated with a decline in output volatility. Greater trade openness is associated with a (contemporaneous) rise in output volatility, while financial liberalisation is negatively related to output volatility. Volatility in inflation and oil price growth are positively related to output volatility. Of the cross-correlations among explanatory variables, the largest in absolute terms is the –0.47 correlation between the lagged direct measure of the strictness of monetary policy and the indirect inflation volatility measure. Looking at the correlation between the direct measure of product market regulation (lagged) and the three relevant indirect measures, the largest in absolute terms is with financial liberalisation (–0.45) followed by days lost to labour market disputes (0.26); the correlation with openness (0.14) is relatively low and positive (suggesting that, overall, this measure of openness may not be adequately capturing the trend towards lower trade barriers).

4. Results

4.1 Basic approach

The OLS estimates of Equation (1) are shown in Table 4. Model 1a is the full specification, with two direct structural indicators, three indirect structural indicators and oil price volatility as explanatory variables. Of these, only the two direct measures are statistically significant; less product market regulations (PMR) and a stricter monetary policy regime lead to lower output volatility in the subsequent five-year period. These results are robust to the exclusion of individual countries. Using a general-to-specific approach leads to the parsimonious Model 1b, with essentially unchanged coefficients on product market regulation and the monetary policy regime dummy variables. The inclusion of a separate Exchange Rate Mechanism (ERM) dummy variable suggests that other stricter monetary policy regimes have led to a greater reduction in output volatility. Point estimates suggest that adopting the ERM resulted in a 0.3 percentage point decline in output volatility, whereas a move to

Table 4: Panel Regressions Results for GDP Volatility – Equation (1)

Fixed-effects estimation, five-year blocks, the first ending in 1983, the last in 2003

		Model					
		Basic		Fiscal policy[(a)]	Inflation volatility	Barrell & Gottschalk (2004)[(b)]	Annual data[(c)]
Variables	**Period**	1a	1b	2	3	4	5
Direct structural measures							
Product market regulations	*t*–1	0.220**	0.202*	0.242**	0.175*		0.203***
Monetary policy regime	*t*–1	–0.370*	–0.346*	–0.386*			–0.427***
Indirect structural measures							
Days lost to labour disputes	*t*	0.0010	0.0009	0.0013*	0.0009		–0.0003
Openness	*t*	0.007		0.012		–0.013	–0.003
Financial liberalisation	*t*	0.007	0.008	0.008	0.009*	–0.001	0.003
Inflation volatility	*t*				0.184***	0.185**	
Fiscal policy volatility	*t*			0.068			
Other							
Oil price volatility	*t*	–0.001		–0.002			–0.019***
Number of observations		100	100	90	100	120	380
R^2 within[(d)]		0.198	0.192	0.228	0.223	0.168	0.193

Notes: ***, **, and * indicate that coefficients are significant at the 1, 5 and 10 per cent levels, respectively, using robust standard errors.

(a) Fiscal policy data are unavailable for New Zealand and Switzerland, which are excluded from this regression.

(b) Regression starts in 1978.

(c) Uses annual data and 7-year rolling windows to calculate volatility measures. Other data are annual, with the PMR index interpolated.

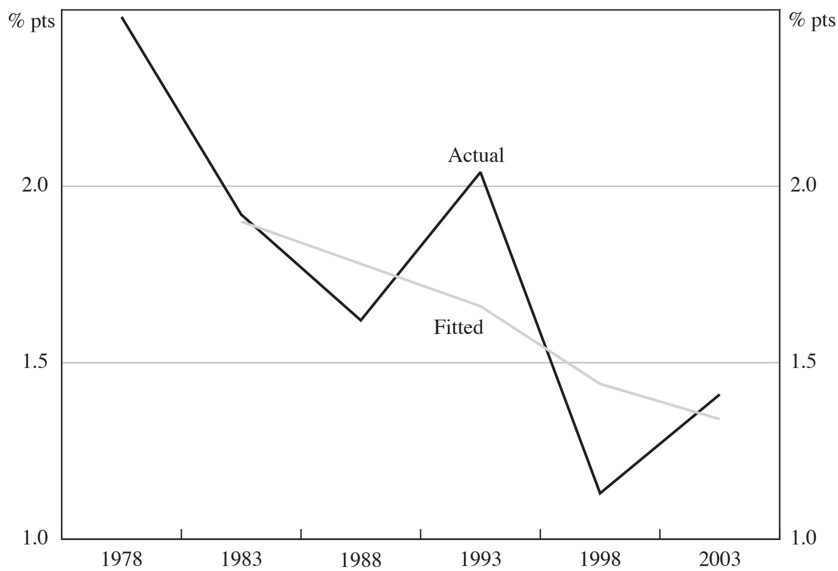
(d) The R^2 within does not take account of the explanatory power from the constant; the adjusted R^2 for Model 1a is 0.212.

other strict monetary policy regimes led to a larger decline of 0.5 of a percentage point. The inclusion of a separate inflation targeting dummy variable suggests that a change to this regime results in a larger reduction in output volatility (of 0.4 of a percentage point) than a move to other strict monetary policy regimes (0.3 of a percentage point). However, while these results are economically meaningful, they are not statistically significant and are not considered in regressions hereafter.

Point estimates imply that the average decline in the PMR index (from 5.1 to 2.8; Table 1) from 1978 to 1998 was associated with a decline in output volatility (from 1983 to 2003) of almost 0.5 of a percentage point, and that a move to a stricter monetary policy regime was associated with a decline in output volatility of about 0.4 of a percentage point.[14] Though statistically insignificant, the point estimate for financial liberalisation implies that the average rise in the ratio of credit to GDP (of 42 percentage points) was associated with a rise in output volatility of about 0.3 of a percentage point. Actual average output volatility declined by 0.5 of a percentage point.

Figure 7 illustrates that the Model 1a regression appears to explain much of the trend decline in output volatility; but clearly does not capture all of the short-term fluctuations in output volatility. This residual volatility appears to reflect a common global business cycle, with output volatility typically relatively high in the five years ending 1983, 1993 and 2003 (coinciding with global recessions) compared with the five years ending 1988 and 1998 (which were periods of extended global expansions). Including the lagged level of output volatility in the model (results

Figure 7: Averages of Actual and Fitted Output Volatility (Model 1a)



14. The cross-country average change in the monetary policy regime dummy was 0.75 from 1978 to 1998, given that some countries were always in the stricter monetary policy regime, while Italy and Norway were still not in the strict regime in 1998.

not reported) soaks up some, but not all, of this autocorrelation, without changing other coefficient estimates significantly. (Results from using individual time dummy variables are discussed in Section 4.2.)

Model 2 shows the results of controlling for possible changes in the behaviour of fiscal policy, as measured by the volatility of the cyclically-adjusted fiscal balance (as a ratio to GDP). The coefficient on this variable is positive, but insignificant. Results for the other coefficients are essentially unchanged with respect to Model 1a, although that on days lost to labour disputes is now significant.

Replacing the lagged monetary policy regime dummy variable with the contemporaneous measure of inflation volatility provides a slightly better fit of the data (Model 3 versus Model 1b). While this does not substantially alter the coefficient estimates for other variables, the coefficient on financial liberalisation is now significant at the 10 per cent level. The positive sign on the financial liberalisation coefficient contrasts with the findings of Barrell and Gottschalk (2004), but its significance is not robust to the exclusion of some countries from the regression (Finland, in particular) possibly reflecting a link between significant financial system instability and output volatility for some periods in these countries. Model 3 estimates suggest that the decline in average inflation volatility of 2 percentage points from 1983 to 2003 was associated with a decline in output volatility of about 0.4 of a percentage point.[15]

Model 4 uses a set of explanators close to that used by Barrell and Gottschalk (2004). We find that the coefficients on our measures of openness and financial liberalisation have the same sign as their results, but are statistically insignificant. This appears, in part, to reflect our use of data in five-year blocks; openness is significant in regressions based on rolling windows over annual data (see below), though only when excluding the direct measure of product market regulations (results not reported).

We test the robustness of our results to specifying our dependent variable in terms of a *rolling* standard deviation, in line with Blanchard and Simon (2001) and Barrell and Gottschalk (2004). To overcome our product market regulation variable being available only every five years, we use a linear interpolation to construct data at an annual frequency. Also, because annual data allow greater choice of window length over which to calculate standard deviations, we choose a length of seven years to better smooth through the business cycle. One drawback of using rolling standard deviations, however, is that we specifically introduce persistence into our regression, causing moving average errors. In this case, panel estimation using ordinary least squares is not appropriate because the assumption of independent errors is violated. However, the similarity of the results of Barrell and Gottschalk (2004) (who correct for this in their estimates) and Blanchard and

15. Model 3 is likely to suffer from endogeneity between inflation and output volatility, which would tend to bias the coefficient estimate on inflation volatility. One solution is to use instrumental variables estimation. The results (not reported) suggest a slightly higher coefficient on inflation volatility (0.34) and a lower coefficient estimate on PMR (0.10) but these variables are no longer statistically significant. Other coefficient estimates are largely unchanged.

Simon (2001) (who do not) suggests that a correction for moving average errors would not affect the results significantly.

Results using annual data are shown in Table 4 as Model 5. The encouraging finding, when comparing Models 1a and 5, is the similarity of the coefficient estimates for the direct structural measures – product market regulations and the monetary policy regime dummy. One odd result is that the coefficient on oil price volatility is significantly negative, which would imply that output volatility declines as oil price volatility rises. While oil price volatility is included to account for large supply-side shocks, over our sample the volatility of oil prices has been quite low and fairly stable compared with the levels of the 1970s.

Finally, one possibility worth considering is that the model should be specified in logarithmic form. Most of the coefficient estimates (not reported) from a fully specified logarithmic model are of the same sign as in Model 1a (the exceptions are oil price volatility and openness). Only the coefficient on financial liberalisation is significant.

4.2 Controlling for common shocks/trends

The range of model results above points to a fairly consistent relationship between a country's output volatility and both the extent of its product market regulation and nature of its monetary policy regime. Although the estimation technique used above is fairly standard, it fails to account for possible changes in the magnitude of common shocks over time. A number of studies that attempt to estimate common shocks directly suggest that these have declined over time, and this is certainly consistent with the trend decline in output volatility evident in 14 of the 20 countries in our sample.[16] Failing to account for a trend decline in the size of global shocks, could lead to spurious estimates of the coefficients of the trending explanatory variables we examine, including PMR and the monetary policy regime variables. While the oil price volatility variable can capture some global shocks, there are no doubt other significant supply and demand shocks which are not taken into account. Without loss of generality, the unexplained innovation to output volatility (from Equation 1) can be written in the following form:

$$\varepsilon_{it} = \kappa_t + \eta_{it} \tag{2}$$

where: κ_t is the common innovation, *not already captured by other explanatory variables*; and η_{it} is country-specific.

One way of dealing with trends in common innovations, κ_t, is to assume that they follow a linear time trend. Results of adding a time trend to the basic regression are shown as Models 6a, 6b and 6c in Table 5 (Models 1a and 1b are also shown for comparison). Model 6a shows that adding a time trend does not change the size of

16. Those countries with the highest output volatility in 1983 also experienced a larger decline in output volatility. At first glance this might suggest convergence of output volatility. However, closer inspection shows this is not the case, with seven countries moving from above to below average volatility, and seven moving from below to above average from 1983 to 2003.

Table 5: Panel Regressions Results for GDP Volatility – Equation (1)
Fixed-effects estimation, five-year blocks, the first ending in 1983, the last in 2003

		Model							
		Basic		Time trend			Time dummies		Good luck dummy
Variables	**Period**	1a	1b	6a	6b	6c	7a	7b	8
Direct structural measures									
Product market regulations	*t*–1	0.220**	0.202*	0.182		0.208	0.141	0.126	0.202*
Monetary policy regime	*t*–1	–0.370*	–0.346*	–0.340*	–0.366*		–0.213		–0.334*
Indirect structural measures									
Days lost to labour disputes	*t*	0.0010	0.0009	0.0009	0.0008	0.0011	0.0012*	0.0013*	0.0009
Openness	*t*	0.007							
Financial liberalisation	*t*	0.007	0.008	0.008	0.007	0.008	0.005	0.006	0.008*
Inflation volatility	*t*							0.159***	
Other									
Oil price volatility	*t*	–0.001							
Time trend				–0.019	–0.117*	–0.049			
Good luck dummy									–0.046
Time dummies		No	No	No	No	No	Yes	Yes	No
Number of observations		100	100	100	100	100	100	100	100
R^2 within		0.198	0.192	0.193	0.179	0.167	0.330	0.359	0.193

Note: ***, **, and * indicate that coefficients are significant at the 1, 5 and 10 per cent levels, respectively, using robust standard errors.

the coefficients on either the PMR or monetary policy regime variables, although the former becomes statistically insignificant (also true of the trend). Model 6b shows that the trend is significant when the PMR variable is removed, though the fit of the model is not as good as that of the basic parsimonious Model 1b. Also, the trend is not significant in the presence of the PMR variable, even when the monetary policy regime dummy variable is removed (Model 6c). In short, the PMR and monetary policy regime variables appear relatively robust to controlling for common trends by means of a time trend.

The common innovations, κ_t, could instead be accounted for by adding time dummies to the basic regression (this could also help to account for the apparent global business cycle effect apparent in Figure 7). As shown in Model 7a, adding time dummies does not alter the magnitude of other coefficient estimates substantially, although most variables are statistically insignificant (including the time dummies themselves). This is not so surprising since a time trend by itself leaves the PMR variable insignificant, and the individual time dummies will better match the behaviour of the monetary policy regime dummy variables.[17] While both the product market regulations and monetary policy regime variables tend to behave in a similar fashion across a number of countries over time, this happens not to be the case for days lost to labour market disputes, which is now significant. The point estimate suggests that the average decline in days lost to labour market disputes (from 252 to 47 days per thousand employed) implies a contribution to the decline in output volatility of 0.3 of a percentage point over the sample. Similarly, inflation volatility, which displays greater variation across countries than the monetary policy regime dummy variable, is significant in the presence of individual time dummies (Model 7b).

To the extent that the general decline in output volatility might be due to good luck, it is not clear that this is best captured by a linear trend, or by the time dummies. A third alternative is to include a dummy variable that could better capture the possibility of countries experiencing global good luck in the latter part of the sample period. Including a single step dummy (with a value of zero for 1983 and one thereafter) leaves all other coefficient estimates largely unchanged, with the PMR and monetary policy regime variables statistically significant. The 'good luck' dummy variable is itself statistically insignificant (Model 8).[18, 19]

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17. This matching of the time dummies and monetary policy is exaggerated with the use of five-year block data. Using annual data as per Model 5, but with time dummies added, leaves the monetary policy dummy variable significant (results not reported).

18. A similar result holds for a good luck dummy variable beginning instead in 1993. In this case the coefficient estimate on the good luck dummy is positive (though insignificant), apparently reflecting the fact that this captures two business cycle downturns in 1993 and 2003 and only one business cycle upturn in 1998.

19. It is not necessary to assume that the timing of this was coincident across all countries. We could allow for a once-off shift to a period of good luck for each country coinciding with the break dates estimated by Cecchetti, Flores-Lagunes and Krause earlier in this volume. Again, using this good luck dummy variable does not alter our basic results; the coefficient estimate on this dummy variable is positive (though insignificant).

It appears that the time trend, time dummies and the good luck dummy variable are not especially satisfactory means of modelling common innovations, κ_t. The problem is that while they may capture common innovations, they can also capture common trends in output volatility that are the result of common structural changes. An alternative is to attempt to remove trends in common innovations (unrelated to structural change) by examining relative changes in output volatility across countries – that is, by measuring both left- and right-hand-side variables relative to a control country or group of countries. One option is to use the average experience of the full sample of countries as the control. However, this is equivalent to using time dummies (as in Models 7a and 7b).

An alternative is to use a single country as a control for common innovations. The US has been consistently cited in the business cycle literature and elsewhere as acting as a 'locomotive' for the rest of the world (Canova and Dellas 1993, and Canova and Marrinan 1998).[20] In this case the specification would be:

$$\tilde{\sigma}_{it}^{Y} = \beta_1 \tilde{X}_{it-1} + \beta_2 \tilde{Z}_{it} + \tilde{\alpha}_i + \tilde{\varepsilon}_{it} \qquad \text{for } i = 1,2,\ldots,19 \tag{3}$$

where: 'tilde' represents the difference between country i's observation and the equivalent observation for the US, and $\tilde{\varepsilon}_{it} = \eta_{it} - \eta_{USt}$. Estimates for this equation are shown in Table 6 as Model 9. Both PMR and monetary policy regime variables are statistically significant even when controlling for common innovations in this way (results are robust to the exclusion of individual countries from the regression).[21] The significance of these coefficients (in contrast to the results for Models 7a and 7b, which use time dummies) derives from the fact that the pattern of behaviour for a number of variables for the US differed from the somewhat common pattern for many other countries. This is most obvious for the PMR variable, which in the US declined in a relatively consistent fashion throughout the sample period, whereas for many other countries the decline lagged the US initially, but subsequently declined more rapidly in the second half of the sample (Table 1 and Figure B1 in Appendix B). This difference is also mirrored in the path of output volatility, explaining why the PMR appears to be a better fit of the data than a linear time trend.

20. Other large economies, such as Germany and Japan, had significant idiosyncratic shocks affecting their output volatility in the 1990s (that is, the effect of re-unification for Germany, and bursting of the asset-price bubble in Japan) making them less appealing as controls.

21. Also, the coefficient on the measure of financial liberalisation is positive and statistically significant, though as before, this appears to be driven by a few countries that have experienced a period of substantial financial system instability, including Finland and Japan.

Table 6: Panel Regression Results for GDP Volatility
Fixed-effects estimation, five-year blocks,
the first ending in 1983, the last in 2003

		Model	
		Basic	US is the control
Variables	**Period**	1a	9
Direct structural measures			
Product market regulations	*t*–1	0.220 **	0.498 ***
Monetary policy regime	*t*–1	–0.370 *	–0.509 ***
Indirect structural measures			
Days lost to labour disputes	*t*	0.001	0.0005
Openness	*t*	0.007	0.008
Financial liberalisation	*t*	0.007	0.010 *
Other			
Oil price volatility	*t*	–0.001	
Number of observations		100	95
R^2 within		0.198	0.298

Note: ***, **, and * indicate that coefficients are significant at the 1, 5 and 10 per cent levels, respectively, using robust standard errors.

5. Conclusions

The decline in output volatility in a number of countries over the past few decades has been well-documented, though less agreement has been reached about the causes of this decline. In this paper we take an atheoretical approach to explain the general decline in output volatility across 20 OECD countries using various indicators of structural reform, including in the areas of monetary and fiscal policies, as well as in product and labour markets. We suggest that reforms in product and labour markets can reduce volatility of aggregate output by encouraging productive resources to shift more readily in response to differential shocks across firms and sectors.

In contrast to other studies, we include direct measures of product market regulations and monetary policy regimes as explanators for output volatility. We find that less product market regulation and stricter monetary policy regimes have played a role in reducing output volatility, with our estimates robust to a number of alternative specifications. We attempt to control for a possible trend in common (unexplained) innovations to output volatility, including a possible decline in the magnitude of global shocks. The coefficient estimates on the product market regulations and the monetary policy regime variables are robust to controlling for trends in common innovations by including a linear time trend, a 'good luck' dummy variable, or by examining the behaviour of output volatility across countries relative to the US.

These coefficient estimates are less robust to the inclusion of time dummies. This possibly reflects the fact that there is not a lot of variation across countries (other than for the US) for these explanatory variables. However, in the presence of time dummies, indirect measures of labour market regulations (days lost to labour disputes) and of monetary policy effectiveness (inflation volatility) are significant, reflecting greater cross-country variation in their behaviour over time. Other indirect measures of market reforms, such as trade openness and credit to GDP, are generally not statistically significant explanators of output volatility.

Studies that have used structural models to identify various demand and supply shocks find that most of the decline in output volatility is due to a decline in the magnitude of shocks, with a limited role for structural reforms and monetary policy. In comparison, our atheoretical approach accounts for the possibility that smaller shocks may themselves be the result of structural changes. The finding of a significant role for increased efficacy of monetary policy and less regulated markets in explaining the trend decline in output volatility across a wide range of developed economies has an important implication for future output volatility. Namely, while any decline in global shocks that has been driven solely by good fortune cannot (by definition) continue indefinitely, the benefit of significant structural reforms is likely to limit the extent of any future rise in output volatility.

Appendix A

This appendix outlines a simple model that illustrates how output volatility could fall in response to reforms that allow greater mobility of productive resources in response to differential shocks across sectors. The model has two sectors, labelled 1 and 2, and labour is the only factor of production. There are two (divisible) units worth of labour available. Production functions are identical for each sector:

$$y_i = A_i l_i^{\alpha} \tag{A1}$$

where y_i is output of sector i, l_i is labour employed in sector i and $0<\alpha\leq1$. Productivity shocks are embodied in A_i, which takes one of three possible values depending on three (equally likely) states of the world. In the steady state, A_i is assumed to be unity for both sectors, and demand is such that it is optimal to allocate one unit of labour to each sector, resulting in aggregate output, $Y = 2$. In the bad state of the world, sector 1 is assumed to suffer a negative productivity shock (with sector 2 unaffected), while in the good state of the world, sector 1 is assumed to benefit from a positive productivity shock (again with sector 2 unaffected). For the purposes of illustration, two parameterisations are considered, one with constant returns to labour ($\alpha = 1$), and one with diminishing returns to labour ($\alpha = 0.7$), broadly consistent with the labour share of income.

Consider two extreme cases of labour mobility. In one, regulations impede any transfer of labour across sectors and the allocation remains fixed according to steady state levels. In the other, these impediments are removed allowing labour to move freely so as to equate the marginal product of labour across sectors, which in competitive markets is equal to the economy-wide wage.[22] Results are summarised in Table A1.

The main results are as follows. With flexible labour, output is higher under both the bad and good states of the world (average output is higher for the case of both constant and decreasing returns to labour). However, the comparison of the variance of aggregate output across inflexible and flexible labour markets depends on the nature of the production function. Under constant returns to scale, the flexible labour market case results in a higher variance of output than in the inflexible labour market case. In contrast, under decreasing returns to labour, the variance of output is less under the flexible labour market case. The variance of output in the inflexible and flexible labour market regimes is equivalent at reasonably high levels of α (that is, α equal to about 0.86). For α less than this, the gains in output during the bad state arising from the ability to reallocate labour are larger than the gains in the good state of the world.

The magnitude of the decline in the variance of output implied by the model described in Table A1 under the case of $\alpha = 0.7$ appears relatively modest, especially considering that it compares the extreme cases of no flexibility and complete flexibility to reallocate resources across sectors. There are, however, likely to be other features

22. For simplicity, prices of outputs are assumed to be fixed to unity, which can occur if for example both outputs are tradable and the country in question is a small open economy.

Table A1: Results of Two-sector Model

	Productivity		Labour allocation		Total output	Average output	Variance of output
State of the world	A_1	A_2	l_1	l_2	Y	$\bar{Y}$	Var(Y)
Constant returns to labour, $\alpha = 1$							
No labour market flexibility						2.00	0.67
Positive shock	2	1	1	1	3.00		
Steady state	1	1	1	1	2.00		
Negative shock	0	1	1	1	1.00		
Full labour market flexibility						2.67	0.89
Positive shock	2	1	2	0	4.00		
Steady state	1	1	1	1	2.00		
Negative shock	0	1	0	2	2.00		
Decreasing returns to labour, $\alpha = 0.7$							
No labour market flexibility						2.00	0.67
Positive shock	2	1	1	1	3.00		
Steady state	1	1	1	1	2.00		
Negative shock	0	1	1	1	1.00		
Full labour market flexibility						2.32	0.54
Positive shock	2	1	1.82	0.18	3.34		
Steady state	1	1	1	1	2.00		
Negative shock	0	1	0	2	1.62		

Source: authors' calculations

of the real world that could act to amplify the impact of reforms that lead to more flexible and efficient reallocation of productive resources. For example, in reality, extended periods of unemployment can lead to a loss of human capital, thereby accentuating the impact of adverse shocks in a world where the unemployed are not as readily absorbed by those sectors faring relatively better during a downturn.

Appendix B: Data Descriptions, Sources and Summary Figures

Real GDP:

Real GDP non-seasonally adjusted, from Datastream (originally from national statistical offices). The exceptions are: Australia – National Income Expenditure and Product, ABS Cat No 5206.0; Austria – OECD *Main Economic Indicators* (*MEI*) sourced from Datastream; Belgium – Banque Nationale de Belgique sourced from Datastream; France – Eurostat; Japan – Cabinet Office sourced from Datastream, series prior to March 1980 spliced using the old SNA68 framework. The following countries' series are seasonally adjusted: Canada; Portugal; UK; US. All data for which historical data are not available were then spliced on real GDP, sourced from the World Bank *World Development Indicators* (*WDI*). The splice dates are: 1974 – Finland; 1976 – Netherlands; 1977 – France and Norway; 1979 – Belgium, Spain, Sweden and Switzerland; 1985 – Portugal; 1987 – Austria, Denmark and NZ; 1990 – Germany; 1994 – Ireland.

Product market regulations:

From Nicoletti *et al* (2001). Countries are classified on a 0–6 scale from least to most restrictive for each regulatory and market feature of each industry: airlines, railways, road, gas, electricity, post and telecommunications. Dependent on the industry, the features covered are: barriers to entry, public ownership, market structure, vertical integration and price controls. Aggregate indicators for each country are simple averages of indicators for the seven industries. These data are separate to the commonly cited economy-wide indicators, which are only available for 1998 and 2003 (Nicoletti *et al* 1999; Conway, Janod and Nicoletti 2005). Nicoletti and Scarpetta (2003) suggest that reforms in the seven industries are representative of economy-wide regulations.

Working days lost to labour disputes per thousand employed:

Constructed from the number of working days lost (from the International Labour Organisation) and the level of employment. The exceptions are: Australia – *MEI*; Belgium – Eurostat; Canada – *MEI*; France – Eurostat; Germany – data from 1993 from Eurostat; Netherlands – Eurostat; US – *MEI*. Employment data from OECD *Economic Outlook*, sourced from Datastream.

Monetary policy regime:

Dummy variable equal to 1 if strict(er) on inflation, 0 otherwise. Germany, Japan and Switzerland are assumed to have always been strict on inflation (Hyvonen 2004). For others, the strict regime is deemed to begin with entry to Exchange Rate Mechanism (ERM) (or other fixing to Deutschemark; Artis and Lee 1994; Eichengreen 1997; Hyvonen 2004; Kenen 1995; Liebscher 2005), euro-area membership (in 1999) or adoption of inflation targeting (IT): Australia – IT adopted in 1993 (Stevens 2003); Austria – in ERM 1995–1999; Belgium – in ERM 1979–1999; Canada – IT adopted 1992; Denmark – in ERM 1979–1992, 1992–1998 fixed exchange rate against Deutschemark (Andersen 2000); Finland – IT from 1994–1999; France – in ERM 1979–1999; Ireland – in ERM 1979–1999; Italy – in ERM 1979–1992;

Netherlands – in ERM 1979–1999; NZ – adopted IT in 1990; Norway – adopted IT in 2000; Portugal – in ERM 1992–1999; Spain – in ERM 1989–1994, adopted IT from 1995–1998; Sweden – adopted IT in 1995; UK – in ERM 1990–1992 (Nelson 2000 and Hyvonen 2004), adopted IT in 1993; US – 1979 Volcker disinflation (Bordo and Schwartz 1997).

Inflation:

Based on the Consumer Price Index (from the *WDI*). Exceptions are for Australia – CPI less interest charges prior to the September quarter 1998 and adjusted for the tax changes of 1999–2000 (RBA calculations) and Germany, which is sourced from the national statistics office via Datastream.

Oil price volatility:

From 1982, West Texas Intermediate (WTI) crude oil prices expressed in SDRs, sourced from Bloomberg. Earlier data reflect the IMF measure of oil prices (from the *International Financial Statistics*).

Financial liberalisation (ratio of credit to GDP):

Domestic credit, claims on private sector, from national sources and the *IFS*. Exceptions are: Australia – total credit, sourced from RBA; Canada – total household and business credit; France – loans to private sector; NZ – total private-sector credit; Norway – credit to households; UK – bank and building society lending; US – liabilities, credit market instruments. Domestic credit to private sector, sourced from the *WDI*, was spliced onto these when historical data were unavailable. Splice dates are: 1985 – Portugal; 1987 – Austria, Belgium and NZ. Nominal GDP data are from national statistics offices via Datastream. The exceptions are: Australia – National Income Expenditure and Product, ABS Cat No 5206.0; Belgium – Banque Nationale de Belgique sourced from Datastream; Finland – Eurostat, sourced from Datastream; Germany – Deutsche Bundesbank; Japan – Cabinet office, sourced from Datastream; Switzerland – Seco State Secretariat-Economic Affairs.

Openness (ratio of exports and imports to GDP):

Trade data, sourced from the OECD *Economic Outlook* (*EO*). Exceptions are: Australia – National Income Expenditure and Product, ABS Cat No 5206.0; France – national statistics office; Germany – Deutsche Bundesbank; UK – national statistics office; US – Bureau of Economic Analysis. Nominal GDP data sourced from *EO*. The exceptions are: Australia – National Income Expenditure and Product, ABS Cat No 5206.0; Austria – national statistics office; Canada – national statistics office; Germany – Deutsche Bundesbank; Portugal – national statistics office; Sweden – national statistics office; UK – national statistics office; US – Bureau of Economic Analysis.

Fiscal policy:

Cyclically-adjusted government primary balance as a percentage to GDP. Sourced from *EO*.

Figure B1: GDP and Inflation Volatility (in percentage points), Product Market Regulations Index, and Monetary Policy Regime Dummy, Five-year Block Data *(continued next page)*

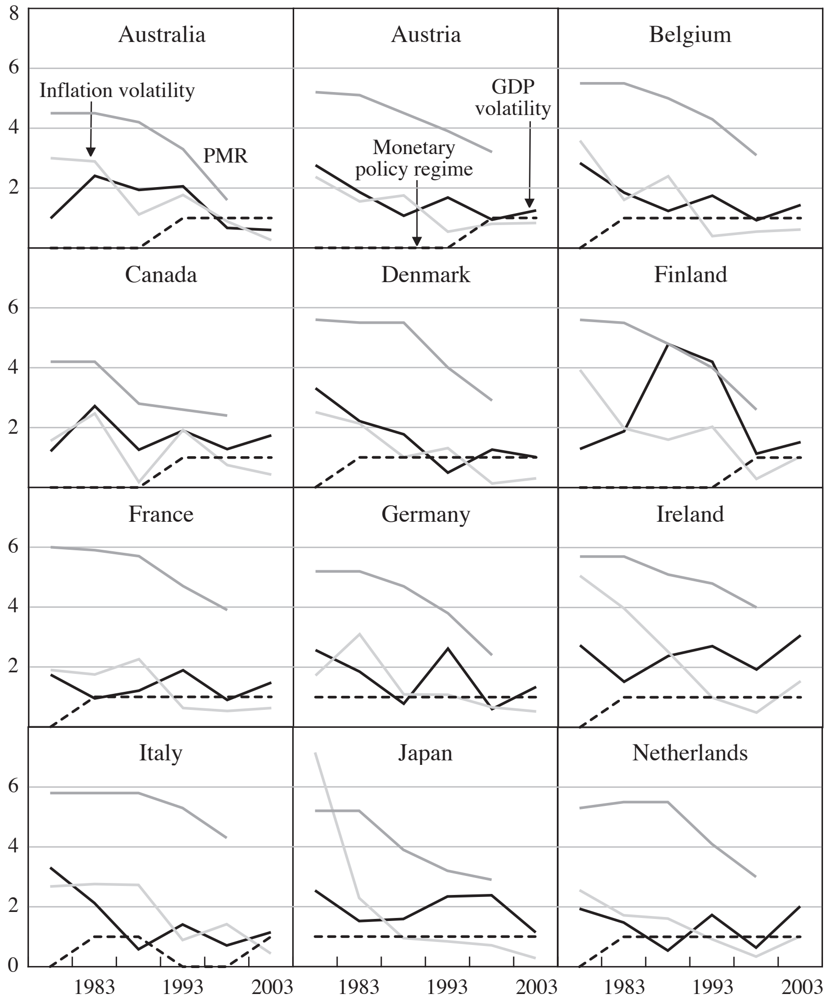
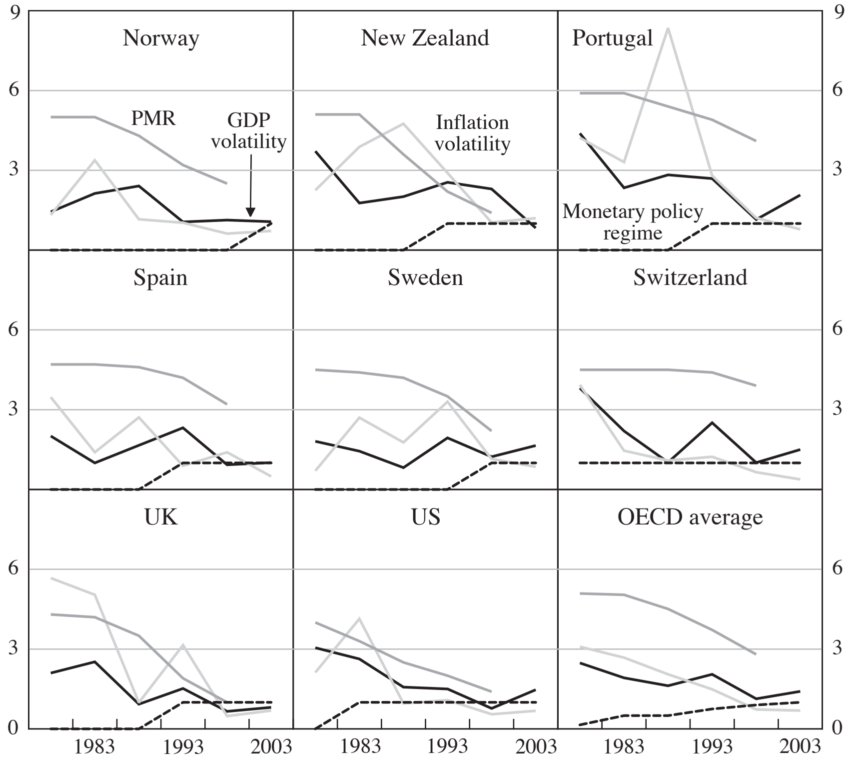


Figure B1: GDP and Inflation Volatility (in percentage points), Product Market Regulations Index, and Monetary Policy Regime Dummy, Five-year Block Data *(continued)*



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Discussion

David Gruen[1]

First, let me thank the organisers for inviting me to the Conference. I have rather a soft spot for these conferences, and this year's one is a worthy addition to the series of interesting annual conferences run by the RBA since 1989.

This paper by Christopher Kent, Kylie Smith and James Holloway is an interesting paper on an important topic: what explains the widespread fall in the volatility of output growth across the OECD over the past couple of decades? Since there are some overlaps between it and the earlier paper by Steve Cecchetti, Alfonso Flores-Lagunes and Stefan Krause, I will take the opportunity to also comment on some aspects of that paper, when it seems appropriate to do so.

The main contribution of the paper by Kent *et al* is to attempt to provide structural explanations for the decline in output volatility. The main candidates on which the authors focus their attention are: product and labour market regulations; the role of fiscal and monetary policies; trade openness; and financial deepening.

In my comments, I will play to my comparative advantage and primarily discuss the roles of fiscal and monetary policies in contributing to the reduction in output volatility. At the end of my comments, however, I will also have a few words to say about the role of financial deepening.

Fiscal policy

Let me start then with the role of fiscal policy. The authors conclude that fiscal policy has not made a significant contribution to the decline in output volatility across the OECD over the past 30 years or so. That result rings true to me, but there are some qualifications to that statement that I think are worth registering.

Of course, seriously inappropriate fiscal policy can lead to financial crises, with profound implications for output volatility, not to mention output growth. But this is primarily an issue for developing economies – at least it has been up until now. International capital markets, rightly or wrongly, are much more forgiving of developed countries with quite high ratios of government debt to GDP than they are of developing countries with similar ratios of debt to GDP.

In developed countries, governments can build up quite high levels of government debt without any obvious implications for the stability of their real economies. Of course, high levels of government debt do raise risk premia somewhat, which crowds out private investment and reduces the potential growth rate of the economy. But the implications for output stability appear to be minor.

Turning to the shorter-run implications of fiscal policy, the automatic stabilisers do undoubtedly stabilise the real economy to some extent. As the authors note,

1. Australian Treasury; the views expressed are those of the author and should not be attributed to the Australian Treasury.

however, the size of the automatic stabilisers has probably not risen significantly over the past 30 years, and so they have probably not contributed to the fall in output volatility over this time.

On discretionary fiscal policy, the authors make the point that it is difficult in practice for fiscal policy to move quickly enough to be genuinely counter-cyclical. That is the conventional wisdom on discretionary fiscal policy, and I agree with it up to a point. But I think it is also possible to overstate the argument.

There are, it seems to me, important examples where discretionary fiscal expansion plays a useful role in supporting monetary policy. The United States in 2001 comes to mind. There appeared to be a genuine threat of a quite severe recession at the time, as well as the possibility of deflation. Discretionary fiscal expansion – along with aggressive monetary easing – reduced the likelihood of a severe recession, and probably thereby reduced output volatility at that time.

Or, to give another contemporary example, when the zero lower bound on interest rates binds, as it has in Japan for many years now, discretionary fiscal expansion is likely to have some role in guiding the economy back to its potential level of output.[2]

I don't want to oversell the benefits of counter-cyclical fiscal policy. Among other things, unwinding fiscal expansions is often not as straightforward as unwinding monetary expansions – and again the US experience comes to mind. But my point is that, even within the existing institutional arrangements, discretionary counter-cyclical fiscal policy does sometimes have a useful role to play in reducing the volatility of the real economy.

Monetary policy

Let me turn now to monetary policy.

In their cross-country econometrics, the authors use two measures to allow for the effects of monetary policy on output volatility. Their preferred measure is a 'direct structural measure'. It is a dummy variable which takes a value of 1 when the monetary policy regime is deemed to be strict on inflation and 0 otherwise. And the authors show that, for many specifications, significantly lower output volatility has been generated by monetary policy regimes that were strict on inflation than by those that were not.

In this context, it is interesting to contrast this paper's results with those presented earlier by Cecchetti. There are some interesting, and perhaps revealing, differences between them. Both provide definitions of monetary policy regimes that are, according to the econometrics, stabilising for the real economy – that is, that generate significantly lower output volatility, other things unchanged. But the key features of these stabilising monetary policy regimes are somewhat different in the two papers.

2. See also O'Mara *et al* (1999) who provide evidence, for Australia and the OECD more generally, that discretionary fiscal policy was a net destabilising influence on the real economy over the period 1973–84, but a net stabilising influence over the period 1985–95.

In Kent *et al*, it is strict inflation control that defines membership of the stabilising monetary policy club, while in Cecchetti *et al*, it is inflation targeting.

So, for example, Kent *et al* classify Germany, Japan and Switzerland as having been members of the stabilising monetary policy club over the whole period since 1974, because all three of these countries are judged to have controlled inflation strictly over this time. By contrast, none of these countries are members of the stabilising monetary policy club as defined by Cecchetti *et al*, because none are, or ever have been, inflation targeters. (Cecchetti *et al* use the classification of Mishkin and Schmidt-Hebbel 2002 to determine membership of the inflation-targeting club.)

So it seems worth asking: which of these two characteristics of the monetary policy regime, strict inflation control or inflation targeting, should we expect to provide a better indication of the regime's capacity to stabilise the real economy in the future? In answering that question, I think I come down on the side of inflation targeting, rather than strict inflation control.

Let me explain how I come to that conclusion.

I have no doubt that, focusing on the decades since the great peacetime inflation of the 1970s, strict inflation control has been good policy. Countries that were stricter on controlling inflation over that whole period – (West) Germany obviously comes to mind – had better outcomes not only for inflation but also for the real economy, because they avoided entrenching expectations of high inflation in the community. And so countries that practiced strict inflation control over that period avoided both the worst excesses of those times as well as the savage recessions that re-established inflation control in those countries that had not been so strict on inflation in the first place.

Thinking to the future, however, the re-emergence of significant consumer price inflation is not the only undesirable possibility that central banks should seek to avoid. The possibility of inflation falling too low, or of outright deflation, also needs to be guarded against (both because of the zero lower bound on nominal interest rates, and because too-low inflation impedes relative real wage adjustment). Either of these possibilities, were they to eventuate, would likely be bad for the stability of the real economy, as well as for real growth.

Obviously, Japan has grappled with this problem over the past several years. But it may also be a problem for countries in the core of the euro area. These core countries are, after all, surrounded by a periphery of countries with faster trend productivity growth, and hence with higher trend inflation, courtesy of the single-currency area and the Balassa-Samuelson effect. An area-wide aim of achieving inflation rates below, but close to, 2 per cent over the medium term implies average inflation in the core countries of significantly below that. Along with their structural rigidities, it remains to be seen what are the implications of achieving such low average inflation rates for output stability in those core countries.

So, I would summarise this discussion as follows. With the benefit of hindsight – that most powerful of all our analytical tools – it is clear that strict inflation control served countries well when they were faced with the great peacetime inflation of the 1970s. The econometrics in Kent *et al*, which finds that those countries that strictly controlled inflation had lower output volatility over the past few decades, rings true to me. Looking to the future, however, it seems to me that central banks that respond vigourously both when inflation threatens to be too low as well as too high, and also include the volatility of the real economy in their loss functions, are likely to deliver more stable real economic outcomes than regimes that do not do so. Of course, that means flexible inflation targeting rather than simply strict inflation control.

Financial deepening

Finally, a few words on financial deepening. Both Kent *et al* and Cecchetti *et al* include a measure of financial deepening, the ratio of private credit to GDP, in their regressions seeking to explain output volatility. They do, however, come to different conclusions, with Cecchetti *et al* finding that financial deepening is associated with significantly lower output volatility, while Kent *et al* find a much less robust role for financial deepening, and when they find a significant relationship it is in the opposite direction.

I will leave to others the task of resolving this difference. There is, however, an observation about financial deepening that I think is worth making. The return of credible low-inflation regimes and the low interest rates that go with them, combined with financial deregulation, has encouraged households in many OECD countries to significantly raise their gearing ratios – that is, their ratios of household debt to income.

Higher levels of household gearing presumably raise the vulnerability of the household sector, at least to some extent. And yet, as we have seen, these continally rising household gearing ratios have coincided with a significant fall in the volatility of the real economies in which these households live. Presumably the fall in the volatility of the real economy has also convinced many households that the risks involved in gearing up are lower than they used to be, which has also contributed to their willingness to do so. If the results of Cecchetti *et al* are right, there is a positive feedback loop here, with more financial deepening enabling households to better smooth their consumption which feeds back to a more stable real economy, and in turn encourages households to gear up further.

And judging by the continuing rise in household gearing ratios in many OECD countries over many years, this process does not seem to have run its course – indeed, future rises in gearing ratios in many OECD countries seem the most likely outcome. The question I have been pondering is whether this positive feedback loop (presuming that it is genuine), and the associated rising gearing of the household sector, should be a cause for concern. Is the rising gearing of the household sector a relatively benign development given the increased stability of the real economy, or might it become a source of instability in its own right in the years ahead?

I don't know the answer to that question, but I think it is one that will repay further thought.

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General Discussion

An important issue raised in the discussion was the question of what form of volatility matters for welfare. Most economic analysis is conducted with seasonally adjusted data, suggesting that policy-makers are less concerned with quarterly volatility, and one participant therefore questioned whether volatility is only welfare-reducing over some time horizon. Related to this, another participant highlighted that the assessment of Bob Gordon's paper – that inventory changes were of secondary importance for the decline in volatility – conflicted with the results of Cecchetti *et al*. They argued that this is most likely due to the difference in the frequency each examine; while Gordon's paper looks at the contribution of inventories at an annual frequency, Cecchetti *et al* examine the volatility of quarterly contributions. Others suggested that the question of the appropriate time frame over which to examine volatility can be somewhat addressed by looking at the predictability of output, rather than volatility *per se*, in line with David Wilcox's earlier comments on Robert Gordon's paper. However, Stephen Cecchetti cautioned that such a focus would struggle to separate the issue of reduced volatility from reduced real-time data revisions; he argued that while volatility may have declined, predictability may have decreased due to growing difficulty in measuring GDP. In a similar vein, it was noted that despite the decline in aggregate output volatility, volatility has increased in many industries over the past decade. On this point, one participant argued that financial liberalisation could reduce aggregate volatility but also increase firm-level volatility. This follows from the fact that financial liberalisation enables investors to construct their own diversified portfolio of companies, thereby reducing the need to form large conglomerates to diversify risk.

Mardi Dungey's comment – that the difference in the timing of persistence and volatility breaks across countries argues against attributing a significant role to changes in inventory management – also provoked much discussion. One participant responded by suggesting that these changes in inventory practices did not occur sharply nor at the same time across countries, while another added that there appear to have been differences in the pace at which changes in inventory management technology have been reflected in the data. More generally, it was noted that the timing of breaks identified by Cecchetti *et al* could not be considered precise, as it is really only possible to test for the impact of structural changes in reducing volatility when sizeable shocks occur, which tends to be infrequent.

A number of participants also raised the issue of whether the interaction between structural reforms has been important in reducing volatility. For example, it was argued that recent Australian experience suggested that labour market deregulation and increased monetary policy credibility have been *jointly* responsible for dampening the transmission of shocks throughout the economy. While not rejecting this suggestion, Christopher Kent noted that an interaction between these two variables is statistically insignificant. Another participant also noted that it is very difficult to separate the effect of the labour and product market regulation variables, because they are collinear.

One participant questioned whether either paper had appropriately distinguished between demand and output volatility. It was noted that both papers focus on the reduction in output volatility, but include some variables which are likely to affect demand volatility (for example, financial liberalisation) and some which are likely to affect output volatility (for example, labour and product market regulations). Furthermore, it was argued that an increase in demand volatility will not necessarily correlate with an increase in output volatility, if inventory changes smooth production. This point was conceded by Christopher Kent, although he added that variables such as labour and product market regulation may be linked with both demand and output volatility.

The evidence in Cecchetti *et al* relating financial liberalisation (specifically, the debt-to-income ratio) to consumption smoothing also stimulated a discussion about the likely impact of leverage on volatility. Some thought that a better way to approach this would be to look at the correlation between changes in credit and changes in output volatility. There was also support for David Gruen's comments that higher credit may potentially be associated with increased volatility of output if the increase in the debt-to-income ratio reflects the 'bring-forward' of consumption, rather than consumption smoothing. Another participant also remarked that this could be assessed by looking directly at the savings ratio, arguing that consumption-smoothing behaviour would be consistent with an increase in the volatility of the saving ratio.

There was some discussion about the difference in the findings of the two papers with regard to the influence of financial liberalisation, with Cecchetti *et al* arguing that financial liberalisation reduces output volatility, while Kent *et al* find it increases volatility. One participant suggested this difference could relate to the former paper focusing on a longer horizon than the latter, with liberalisation almost certain to be beneficial in the long term, but perhaps inducing volatility in the medium term. This was supported by others who suggested that the effect of financial liberalisation can be to reduce volatility at some times and increase it at others, which may explain the sensitivity of Kent *et al*'s results to the inclusion of particular countries.

International Business Cycle Co-movements through Time

Dan Andrews and Marion Kohler[1]

1. Introduction

The increasing integration of the world economy in recent decades, through the liberalisation of trade and capital flows, has raised the possibility of a more rapid transmission of business cycle fluctuations across countries, especially those originating in large economies such as the United States. Indeed, over the past 40 years, the Australian and US business cycles have become highly correlated, a point well documented in the literature and exploited in a number of macroeconomic models for Australia.[2] Table 1 shows output correlations between Australia and a number of industrialised economies over the past 40 years.[3] It illustrates that the business cycle relationship between Australia and the US is not the only one which has changed over time.

Table 1: Output Correlations Between Australia and Selected Countries

Australia with:	Correlation of real GDP (year-ended growth rates)			Correlation of GDP cycles (band-pass filtered)		
	1961:Q1–2004:Q4[(a)]	1961:Q1–1982:Q4[(a)]	1983:Q1–2004:Q4	1963:Q1–2001:Q4[(b)]	1963:Q1–1982:Q4[(b)]	1983:Q1–2001:Q4
Canada	0.51	0.38	0.66	0.58	0.25	0.83
Euro area	0.23	0.40	0.16	0.32	0.46	0.21
Japan	0.28	0.41	0.00	0.30	0.49	0.07
New Zealand	0.29	–	0.21	0.38	–	0.32
UK	0.27	0.19	0.50	0.28	0.06	0.60
US	0.34	0.23	0.59	0.31	0.02	0.82

(a) Sample for Canada starts in 1962:Q1, for the euro area in 1971:Q1 and for New Zealand in 1978:Q1.

(b) Sample for Canada starts in 1964:Q1, for the euro area in 1973:Q1 and for New Zealand in 1980:Q1.

1. We would like to thank Anthony Rossiter, Amanda Armstrong, Bob Buckle, Graham Howard and Maximilian Layton for invaluable help with the data, and Luca Benati for sharing his Matlab code. Don Harding, Christopher Kent, Glenn Otto, Adrian Pagan, colleagues at the RBA and participants at the RBA annual conference 2005 provided valuable comments.

2. See, for example, de Brouwer and Romalis (1996), de Roos and Russell (1996), Debelle and Preston (1995), Dungey and Pagan (2000), Gruen and Shuetrim (1994) and Otto, Voss and Willard (2001).

3. Unless otherwise stated, sources for data underlying the tables or figures in this paper are authors' calculations. Details of the calculations and the source of the underlying data can be found in Appendix A.

While previous studies have sought to explain business cycle correlations in a cross-country context, less is known about the factors which have caused these relationships to change dramatically through time. This paper aims to analyse the extent to which cross-sectional explanations of business cycle co-movements can also explain changes in co-movements over time.

We find that the changes in cycle co-movement can – at least partly – be explained by factors similar to those highlighted in cross-sectional studies, such as trade and industrial structure. We also find a role for a measure of market flexibility and for monetary and fiscal policy for some economy pairs. However, the exact model and the sign of the effect of different factors on cycle co-movement varies across economy pairs.

In Section 2 we document the changes in the co-movements of Australia's business cycle with those of the economies in Table 1 in more detail. In Section 3 we analyse graphically how the explanatory factors proposed in the cross-sectional literature have evolved through time for our economy pairs and test the influence of these factors over time more formally. In Section 3.3, we briefly consider financial integration as an alternative explanation, before concluding in Section 4.

2. Business Cycle Co-movements through Time

In this section we document the changes in Australia's international business cycle co-movements in more detail. Figure 1 shows the growth cycles of real GDP for Australia and the US over the past 45 years.

A first glance confirms that the GDP cycle of Australia was less synchronised with that of the US in the earlier part of the sample, while it became highly synchronised after 1980. One way to measure this synchronisation and to capture co-movement over the entire cycle is to calculate correlation coefficients over some period, for instance 16 years, which captures on average roughly two cycles.[4] We calculate the bilateral correlation of these cycles using correlation coefficients over 16-year moving windows over the sample period. We use a slightly different definition of the business cycle based on the cyclical component of quarterly real GDP, isolated using the band-pass filter proposed by Baxter and King (1999).[5] The corresponding charts of the cycles for all economy pairs can be found in Appendix B.

4. Shortening the window tends to result in a more volatile measure of business cycle correlation, which in the extreme case of the length of one business cycle can move between 1 and –1, depending on the phase shift between the cycles of the two economies.

5. The band-pass filter of Baxter and King extracts the cyclical frequencies between 6 and 32 quarters, which coincides with the timing of cycles used in the seminal work on classical business cycles by Burns and Mitchell (1946). Since the filter incorporates a moving average, we lose three years of data at the beginning and at the end of the sample. The changes in co-movements through time are very similar if we use other filtering methods, such as the Hodrick-Prescott filter or the band-pass filter proposed by Christiano and Fitzgerald (2003), although the levels using the latter are lower for some of the country pairs. Gillitzer, Kearns and Richards (this volume) show that the change in the cycle co-movement between Australia and the US is also evident using cyclical measures other than GDP.

Figure 1: Business Cycles – Australia and the US
Real GDP, year-ended growth rates

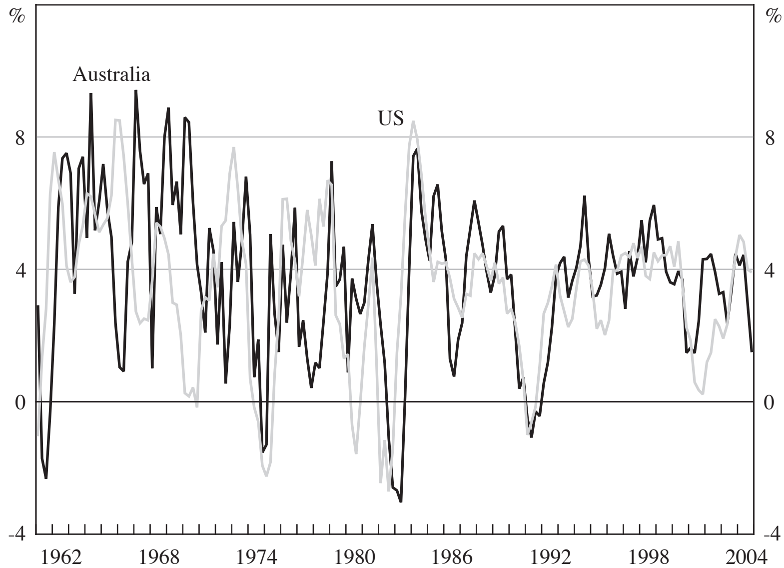


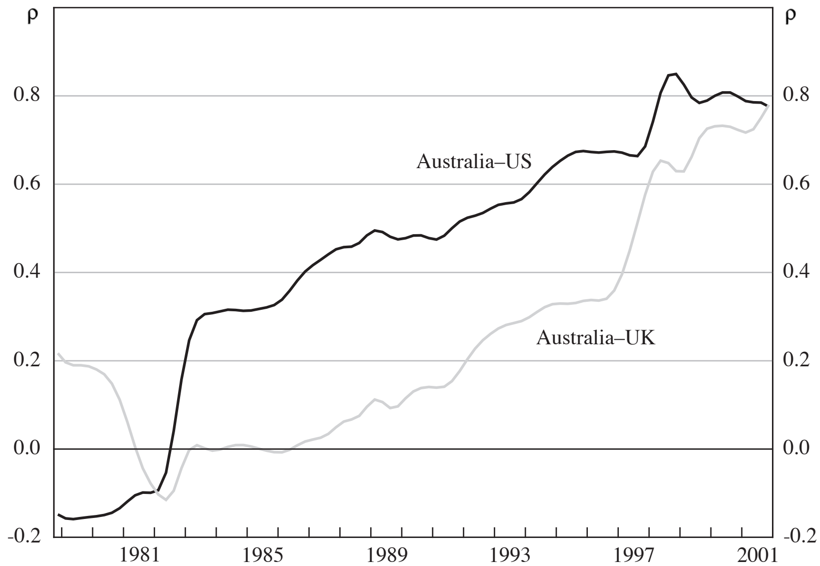
Figure 2 shows the change in business cycle co-movement between Australia and the US, and between Australia and the United Kingdom. The dates on the chart show the end-dates of the moving window, so that the first data point covers the correlation over the time period 1963:Q1 to 1978:Q4 and the last data point covers the time period 1986:Q1 to 2001:Q4.

Quite remarkably, the correlation with the US has increased from around zero (that is, uncorrelated) before 1980 to around 0.8 towards the end of the sample period. While the increase has mostly been gradual, a step increase can be observed in the mid 1980s, partly driven by the coincident recessions in the early 1980s in both countries. The business cycles of the two countries have been in close synchronisation for the following 20 years (though the US experienced a recession in 2001 while Australia did not). This suggests that structural changes might have occurred that increased the economic links between the two economies.

Figure 2 also documents the change in the co-movement of the Australian and the UK business cycles. Despite the close historical ties of the two economies, the cycles were uncorrelated throughout most of the 1960s, 1970s and 1980s. However, already in the early 1980s a gradual increase in the correlation of cycles is apparent, reaching 0.8 at the end of the sample. One reason for this increase could be the transmission of shocks via a third country, such as the US, rather than 'direct' transmission between Australia and the UK. This may partly reflect the fact that the correlation between the US and the UK cycles has always been at a high level. However, it has

Figure 2: Australia's Business Cycle Correlation with the US and the UK

1963–2001, 16-year moving window starting with 1963:Q1–1978:Q4



Notes: Correlation coefficients are based on band-pass-filtered GDP cycles. Dates refer to the end-point of the 16-year window.

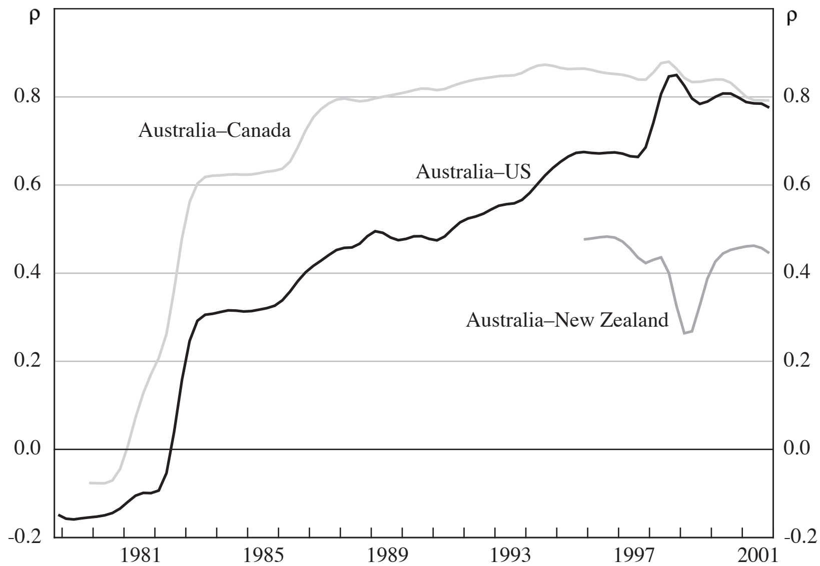
been decreasing between the 1970s and the mid 1990s from 0.75 to 0.5, while the Australia–UK correlation jumps up later in the sample period, suggesting that other factors may be driving the increase in the correlation with Australia.

Figure 3 depicts the correlation of the Australian cycle with that of Canada and New Zealand (plus, for comparison, that with the US). Canada is an interesting case for several reasons. First, its economy is known to have close ties with the US economy, with a correlation at or above 0.8 for the past 40 years, one of the highest among OECD countries. Second, like Australia, Canada is a small open economy with a large share of commodity exports. Interestingly, Australia's correlation with the Canadian cycle is even higher than it is with the US. Similar to the US cycle correlation, it has increased over the sample period, but it did so earlier and remained flat at a high level for the past two decades.

One might suspect that the high correlation of the Australian and Canadian cycles is due to their common exposure to world commodity cycles. However, the correlation with New Zealand, another small open economy with significant commodity exports and one that trades more intensively with Australia, is much lower. Unfortunately, data limitations do not allow us to investigate whether this correlation changed at the same time that the correlation with Canada changed. Surprisingly, despite the

Figure 3: Australia's Business Cycle Correlation with Canada and New Zealand

1963–2001, 16-year moving window starting with 1963:Q1–1978:Q4



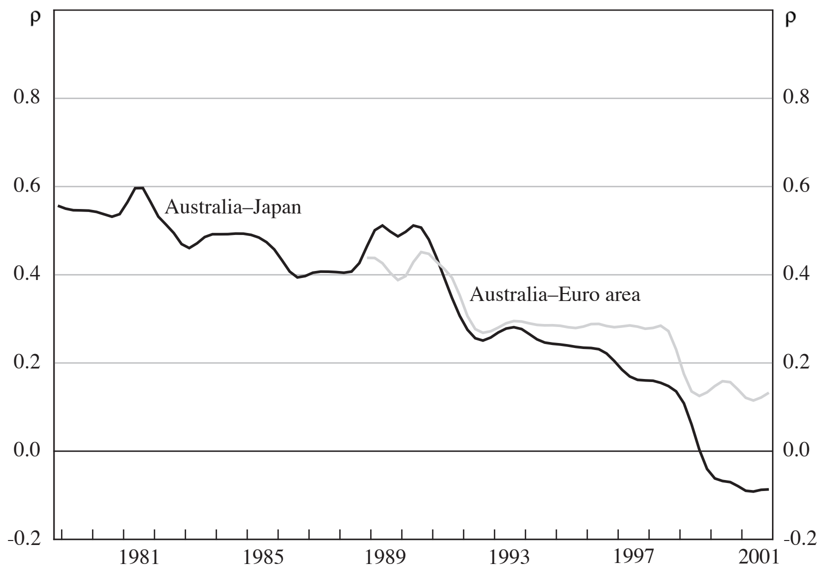
Notes: Correlation coefficients are based on band-pass-filtered GDP cycles. Dates refer to the end-point of the 16-year window.

shorter sample period and the overlapping windows used for the rolling correlations, the correlation drops significantly around the Asian financial crisis in 1997–98, indicating how disruptive this event was for New Zealand relative to Australia.

Finally, Figure 4 shows the correlation of Australia's cycle with that of two major industrialised trading partners, Japan and the euro area. Both are relatively low in the second half of the sample, consistent with the existence of an Anglo-Saxon effect in business cycle correlations identified by Otto *et al* (2001). However, the correlation with Australia used to be higher in the earlier part of the sample, especially in the case of Japan. This fall in correlations could be due, in part, to the idiosyncratic shocks experienced by Japan and the euro area over the 1990s.[6] However, we will analyse in the next section whether other, structural, factors may also have been at work.

6. Interestingly, the cycle correlation between Japan and the euro area has been between 0.6 and 0.8 over most of the sample, with the higher values of 0.8 being reached in the earlier part of the sample.

Figure 4: Australia's Business Cycle Correlation with Japan and the Euro Area
1963–2001, 16-year moving window starting with 1963:Q1–1978:Q4



Notes: Correlation coefficients are based on band-pass-filtered GDP cycles. Dates refer to the end-point of the 16-year window.

3. Explaining Business Cycle Co-movements

3.1 Evidence from cross-sectional studies

As the previous section demonstrates, Australia's business cycle has become more correlated with some countries, and less so with others. Business cycles, and their synchronisation across countries, are determined by the interaction of common shocks, country-specific or idiosyncratic shocks, and the transmission of these shocks within countries. By themselves, common shocks will tend to lead to synchronisation of business cycles across countries. Even in the presence of significant common shocks, however, business cycles may diverge due to differences in the (domestic) transmission of shocks. Differences in transmission are in turn likely to reflect structural differences, including the structure of industry, labour and product markets, and of the financial system. Country-specific shocks, which are essentially the result of border effects, such as differences in the stance of fiscal and monetary policies, will tend to reduce synchronisation of business cycles. Finally, in the open-economy context, business cycles can be correlated if country-specific shocks are transmitted across borders, thus acting like a common shock. One key vehicle for this international transmission is trade. Consequently, the cross-sectional studies that aim at explaining business cycle co-movement have focused on these structural factors: trade; industrial structure; adjustment mechanisms to shocks; and monetary or fiscal policy reactions. More recently, a number of studies have sought to exploit financial market integration to explain business cycle co-movement, a point we will return to in Section 3.3. We will now discuss each of the structural factors in turn.

3.1.1 Trade

Trade has become an important theme in the literature, especially since Frankel and Rose (1998) found that countries with closer trade links tend to have more closely correlated business cycles. Theoretically, however, the effect of trade on synchronicity is ambiguous. Krugman (1993) argues that a pair of countries that trade more may specialise more in order to reap the gains from trade. This would lead to even greater differences between each country's industrial structure, and in the presence of sector-specific shocks (even if these are common across countries) it can lead to more idiosyncratic business cycles. The importance of this effect depends upon the degree of specialisation induced by trade integration, which tends to rise with the ratio of inter-industry to intra-industry trade. Furthermore, the net effect on business cycles depends upon the relative importance of aggregate and sector-specific shocks. If the relative variance of aggregate shocks is greater than that of sector-specific shocks, closer trade integration could be expected to lead to more synchronised business cycles (Frankel and Rose 1998).

Much of the recent literature can be defined in terms of its efforts to establish a more robust relationship between trade and synchronicity (Clark and van Wincoop 2001, Imbs 2000, Otto *et al* 2001). After controlling for other factors, especially industrial structure, these studies generally find that the effect of trade is small and positive (Imbs 2000), or in some cases, insignificantly different from zero (Otto *et al* 2001). In recent work, Baxter and Kouparitsas (2005) argue that only bilateral trade has a robust (and positive) coefficient in explaining business cycle co-movements across countries.[7]

Following much of the literature we use a number of different measures for bilateral trade exposure.[8] The first measure, following Frankel and Rose (1998), is the bilateral trade share, that is, total bilateral trade relative to total trade of the two economies *i* and *j*:

$$TradeFR_{ij,t} = \frac{Exports_{ij,t} + Imports_{ij,t}}{Exports_{i\,world,t} + Imports_{i\,world,t} + Exports_{j\,world,t} + Imports_{j\,world,t}} \quad (1)$$

The second measure, used by Frankel and Rose (1998) and Clark and van Wincoop (2001), is bilateral openness, which takes into account the possibility that bilateral trade exposure may matter more for GDP fluctuations in relatively open economies, which tend to be small, than in relatively closed economies, which tend to be large. Bilateral openness is defined as the ratio of bilateral trade to the sum of nominal GDP in the two economies *i* and *j*:

7. However, as Kehoe (2005) notes, trade can only explain a very small fraction of cycle co-movement in their model, possibly a result of the large, heterogeneous sample of countries used.

8. All our bilateral trade data are based on goods trade only, as bilateral services trade data are only available for a shorter period.

$$TradeCW_{ij,t} = \frac{Exports_{ij,t} + Imports_{ij,t}}{GDP^{nom}_{i,t} + GDP^{nom}_{j,t}} \tag{2}$$

The trade measures so far are symmetric for the two economies. However, we could imagine that there is a one-way interdependence in the case of a small economy, such as Australia's, trading intensively with a very large economy, such as that of the US. Then the trade share from the perspective of Australia might matter more than some average of both trade shares. Measures that capture such an asymmetry have been used by Kose, Prasad and Terrones (2003) and Otto *et al* (2001). Therefore, we also consider a trade share measure, which is defined as bilateral trade over total Australian trade.[9]

$$TradeSH_{AUS\,j,t} = \frac{Exports_{AUS\,j,t} + Imports_{AUS\,j,t}}{Exports_{AUS\,world,t} + Imports_{AUS\,world,t}} \tag{3}$$

A number of studies address the potential endogeneity of trade and cyclical correlation by including elements of the gravity model to instrument for trade. Unfortunately, this is difficult to do in our study, since variables such as the distance of two economies are time-invariant, and therefore unsuitable for our time-series model.

3.1.2 Industrial structure

Industry-specific shocks account for a considerable share of global shocks (see, for example, Clark and Shin 2000, Funke, Hall and Ruhwedel 1999, and Kwark 1999). Economies with a similar industrial structure will tend to transmit and receive these common shocks in a similar fashion, and consequently experience co-movements of their business cycles. Not surprisingly, a number of authors have included measures of industrial structure in their cross-sectional studies. Clark and van Wincoop (2001), Imbs (1999) and Kalemli-Ozcan, Sørensen and Yosha (2001) all argue that more similar production structures lead to higher correlation, and Imbs (1999) finds that the effect of industry similarity on cycle co-movement is larger than that of trade.

To measure dissimilarity in industry specialisation, we adopt Krugman's (1991) index, which aggregates the absolute difference of sectoral output shares, $S^{real}_{ik,t}$, across all sectors. Sectoral output shares are defined as the value-added share of sector k, $Y^{real}_{ik,t}$, in total value added, $Y^{real}_{i,t}$. The index of dissimilarity in industry specialisation is:

$$IS_{ij,t} = \Sigma^{M}_{k=1} \left| S_{ik,t} - S_{jk,t} \right| \tag{4}$$

9. Since, in the econometric section of the paper, we investigate only country pairings which involve Australia and larger trading partners, we can restrict ourselves to this simple choice. In a more systematic analysis, a decision rule that chooses the larger share would have to be applied, similar to that used by Otto *et al* (2001).

This takes values between zero and two, with higher values indicating sectoral dissimilarity. We choose a broad sectoral breakdown, which covers the 10 one-digit industries in the International Standard Industrial Classification (ISIC).[10]

3.1.3 Market flexibility

Differences in market structure – particularly with regard to the flexibility of markets – might be an important factor in explaining the degree of cyclical co-movement, since it can measure the adjustment of an economy to a shock. Countries with similar market structures could be expected to react similarly to a common shock. Of course, the effect of relative market flexibility on business cycle co-movement is not unambiguous, but it will also depend on the level of market flexibility. More flexible economies could be expected to adjust more rapidly to large idiosyncratic shocks, thereby dampening their impact on the business cycle. This would tend to lead to greater co-movement of business cycles. Therefore, the overall effect of changes in market flexibility will depend not only on relative market flexibility, but also on the prevalence of different types of shocks.

The aspect of adjustment to shocks within economies has been relatively neglected in the cross-sectional literature. Otto *et al* (2001) use indices of market structure that capture accounting standards and concentration of firm ownership. They find evidence of an 'Anglo-Saxon effect' which they explain by factors such as common legal institutions, accounting standards and technology take-up. However, these are likely to change little over time, and are therefore probably more suitable to explain cross-sectional differences, than those over time. An economy's ability to adjust to idiosyncratic shocks has received more prominence in the context of cyclical co-movements within the European Monetary Union, starting with the influential work by Bayoumi and Eichengreen (1993). However, few studies have explicitly modelled structural factors that explain adjustment, possibly because of a lack of suitable data.

Measuring market flexibility, especially over time, is an even more difficult task. Following Blanchard and Wolfers (2000), we have chosen a measure of net union density to proxy labour market flexibility. While this cannot capture all aspects of labour market flexibility, or market flexibility, we will show below that its time profile lines up reasonably well with the index of product market flexibility developed by Nicoletti *et al* (2001) and used by Kent, Smith and Holloway (this volume). In order to capture the difference in labour market flexibility (LMF) between two economies, we use two measures. The ratio of net union density (NUD) is used for the graphical analysis, where 'similarity' implies a value of one:[11]

10. For Figures 5 to 10 we have scaled the industrial dissimilarity index to lie between 0 and 200. More detailed sectoral breakdowns than ISIC1 have been used in the literature, but we are constrained by the requirement of data comparability across countries and over time.

11. The ratio of the two indices can capture not only whether two economies have become more similar, but also which economy has become more flexible relative to the other. This allows us to compare it with other measures of flexibility. The absolute difference is used for the regressions. In our country pairings, these two measures give somewhat different profiles for Australia–UK, Australia–New Zealand and, to a lesser extent, Australia–Canada, where the indices cross each other over time.

$$LMF\_ratio_{ij,t} = \frac{NUD_{i,t}}{NUD_{j,t}} \tag{5}$$

Following the definition of dissimilarity for other variables in our model, we use the absolute difference in net union density in the regressions, where 'similarity' implies a value of zero:

$$LMF_{ij,t} = \left| NUD_{i,t} - NUD_{j,t} \right| \tag{6}$$

3.1.4 *Monetary and fiscal policy*

In the context of monetary unions, much attention has been paid to the effect of the co-ordination of monetary and fiscal policies on business cycle synchronisation. To the extent that monetary and fiscal policy shocks in an individual economy are a source of business cycle movements, a common policy across countries would lead to higher business cycle co-movement. More similar policy reactions lead also to higher cycle synchronisation if economies are affected by a common, or rapidly transmitted, shock. On the other hand, an idiosyncratic response in policy can lead to more synchronisation by dampening country-specific shocks.

The empirical success of including policy differences to systematically explain differences in cycle co-movements across country-pairs has been mixed. Clark and van Wincoop (2001) cannot find a significant effect of policy on cycle synchronisation, but argue that this might be a result of policy being both a source of shocks and a stabiliser. On the other hand, Otto, Voss and Willard (2003) argue that similar monetary policy can be an important factor in business cycle synchronisation. Since changes in the similarity of fiscal or monetary policy may play a role in explaining changes in cycle synchronisation for a specific economy pair, we include such measures as possible controls in our considerations.

Similar to Clark and van Wincoop (2001) we measure monetary policy differences by taking the absolute difference of the nominal short interest rate (in our case, an interest rate with 3-month maturity):[12]

$$MP_{ij,t} = \left| Short\,rate_{i,t} - Short\,rate_{j,t} \right| \tag{7}$$

Fiscal policy similarity is measured by taking the absolute difference of the ratios of the primary budget balance to GDP:

$$FP_{ij,t} = \left| \frac{Primary\,budget\,balance_{i,t}}{GDP^{nom}_{i,t}} - \frac{Primary\,budget\,balance_{j,t}}{GDP^{nom}_{j,t}} \right| \tag{8}$$

3.2 Empirical evidence through time

In this section we analyse how the factors described in Section 3.1 have evolved over time for the economy pairs presented in Section 2. We will start with a graphical

12. Initially we also considered a similar measure for 10-year bond interest rates, but we found that the profile over time did not differ substantially from that of 3-month interest rate differences.

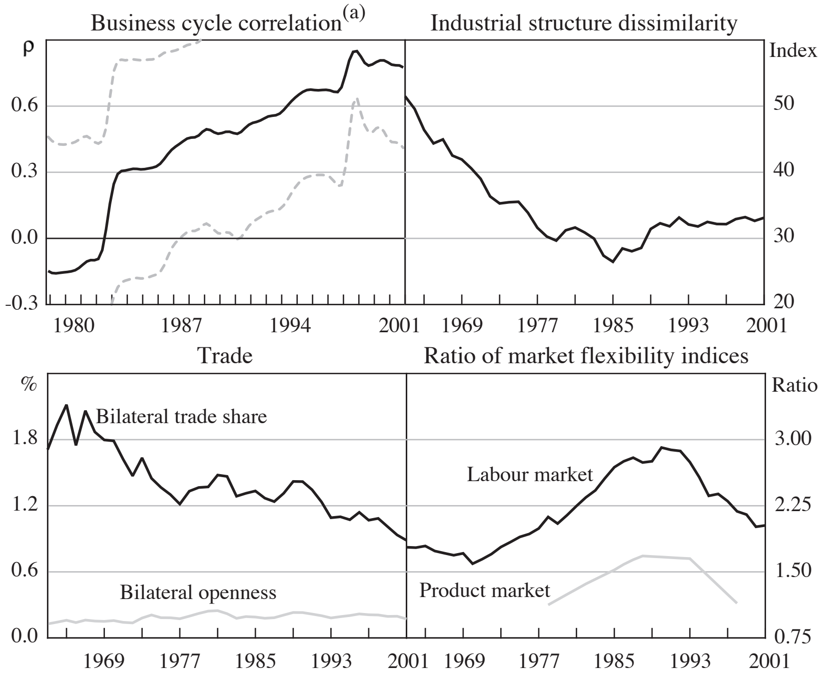
analysis, which allows us to gauge in which direction each of these factors may have affected business cycle synchronisation, if at all. We then proceed to a more formal test of whether these cross-sectional explanators can account for changes in cycle synchronisation over time.

3.2.1 Trends in factors through time

We use time-series data starting in 1963, or as far back as available, for our economies to construct the structural variables discussed in Section 3.1.[13] Details of the underlying data sources can be found in Appendix A.

The first economy pair under consideration is Australia and the US. Figure 5 shows the change in cycle synchronisation over time, and how the three factors, trade exposure, similarity of industrial structure and relative market flexibility have evolved through time.

Figure 5: Australia and the US



(a) The dates refer to end-point of 16-year moving window. Dashed lines denote Newey-West-corrected 95 per cent (asymptotic) confidence intervals.

13. Due to limited data availability, we had to proxy some of the euro area data with data from Germany and France. Data are quarterly or annual, except for the product market index which is only available on a five-yearly basis and for a much shorter time period. It is therefore only included to allow for an approximate comparison.

As noted above, the business cycle correlation between Australia and the US has increased strongly over the past 40 years. At the same time, however, the bilateral openness measure has increased only slightly and the bilateral trade share has fallen considerably. This implies, if anything, a negative relationship between cycle co-movement and trade, the opposite of what is suggested by cross-sectional studies. One explanation for this could be the dominance of Krugman-type effects, by which less bilateral trade can be a result of more similar industrial structures. In fact, this is supported by our industrial structure index which shows that the dissimilarity index has halved over the last 40 years, driven by the retail, manufacturing and government sectors.[14] Finally, labour market rigidities in Australia relative to the US have increased over the 1970s and 1980s, before falling to a level slightly above that in the 1960s. This hump-shaped profile hides falling labour market rigidities (as measured by net union density) in both countries: net union density fell in the US over the entire time period, while in Australia the trend decline in net union density began in the mid 1980s.

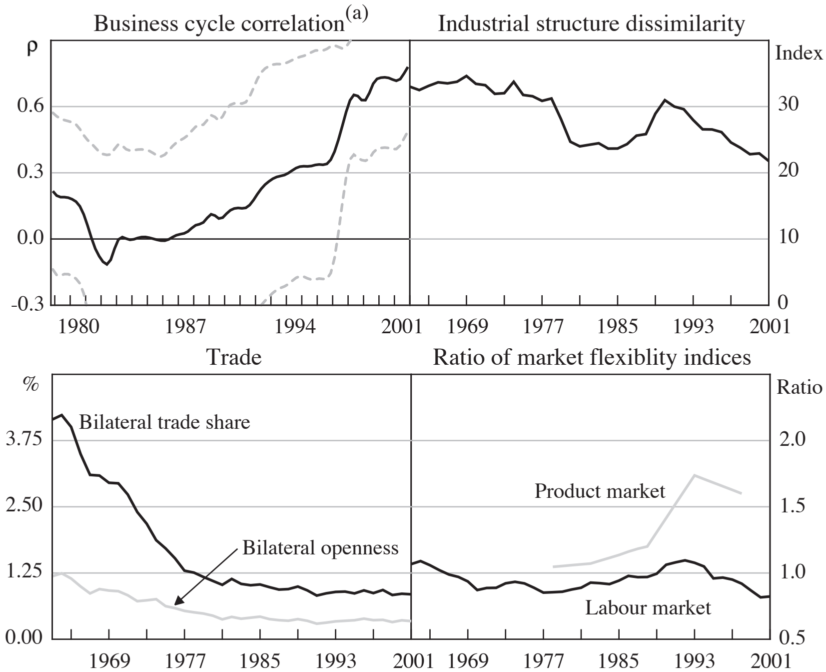
Of course, another possible explanation for the changes in cycle co-movement could be that the nature of the shocks to which both economies were exposed has changed. One example is the conduct of monetary and fiscal policy: both Australia and the US have changed the conduct of monetary policy considerably over the 1980s and the early 1990s. For Australia and the US, business cycles became more synchronised during the 1980s. However, this was also a period when monetary policy became – if anything – more idiosyncratic in the two economies with inflation falling earlier and remaining more stable much earlier in the US (detailed charts of the monetary policy and fiscal policy variables can be found in Appendix B). While monetary policy is an unlikely explanator for the changes in cycle co-movement between Australia and the US, we will see below that the conduct of policy may have played some role for other economy pairs.

Australian business cycle co-movements with the UK have also increased over the last 40 years, although somewhat later than with the US. Both the bilateral trade share and bilateral openness have fallen sharply over the same period, again suggesting a negative relationship between trade and synchronicity (Figure 6). While the sectoral composition of the two economies has become more similar, the change is less dramatic than for the Australia–US pair, partly because the UK and Australia started at a more similar level. This suggests that a Krugman-type effect cannot be the entire explanation for the strong negative relationship between bilateral trade exposure and cycle co-movement. Also, market flexibility cannot shed more light on this, with the relative ratio of flexibility roughly flat around 1 over the period, which indicates that market flexibility has always been similar in the two economies through time.

The increase in business cycle co-movements with Canada is one of the most striking, with much of the increase happening before the mid 1980s (Figure 7).

14. In fact, sectoral shares for Australia and the US have become more similar for most industries. One notable exception is the share of 'financial services', which increased markedly in both economies but by much more in Australia.

Figure 6: Australia and the UK



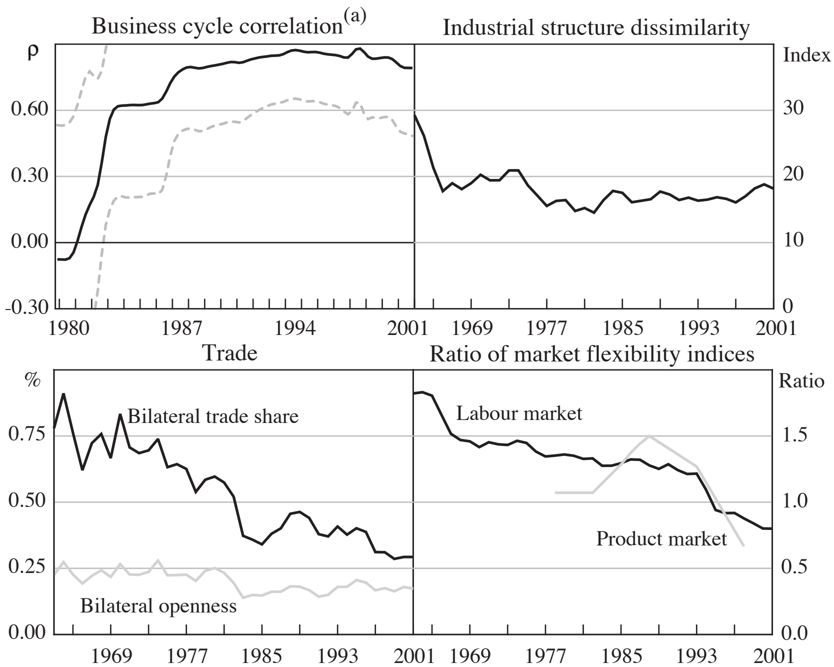
(a) The dates refer to end-point of 16-year moving window. Dashed lines denote Newey-West-corrected 95 per cent (asymptotic) confidence intervals.

Again, both measures of bilateral trade exposure have fallen over the period, although not to the extent seen in the previous two cases. Industrial structures became more similar early in our sample period and remained flat thereafter. In fact, Canada's industrial structure is the most similar to Australia in our selection of economies, partly providing an explanation for the high business cycle synchronicity. Relative labour market flexibility has also become more similar in the two economies, with Canada's net union density flat or slightly rising over the sample period, while that of Australia halved between the mid 1980s and 2002.

New Zealand's cyclical co-movement with Australia was broadly unchanged over the (much shorter) sample period. This contrasts with trend changes in our three explanatory factors (Figure 8). New Zealand is the only economy in our sample with a significant increase in bilateral trade exposure with Australia.[15] Similar to our previous cases, changes in trade exposure are accompanied by opposite changes in industrial similarity. In New Zealand's case, the sectoral composition has become

15. It is not surprising that most of our economies had falling trade exposure with Australia, since over the last 20 to 30 years industrialised countries' trade has been increasingly oriented towards east-Asian economies and China.

Figure 7: Australia and Canada



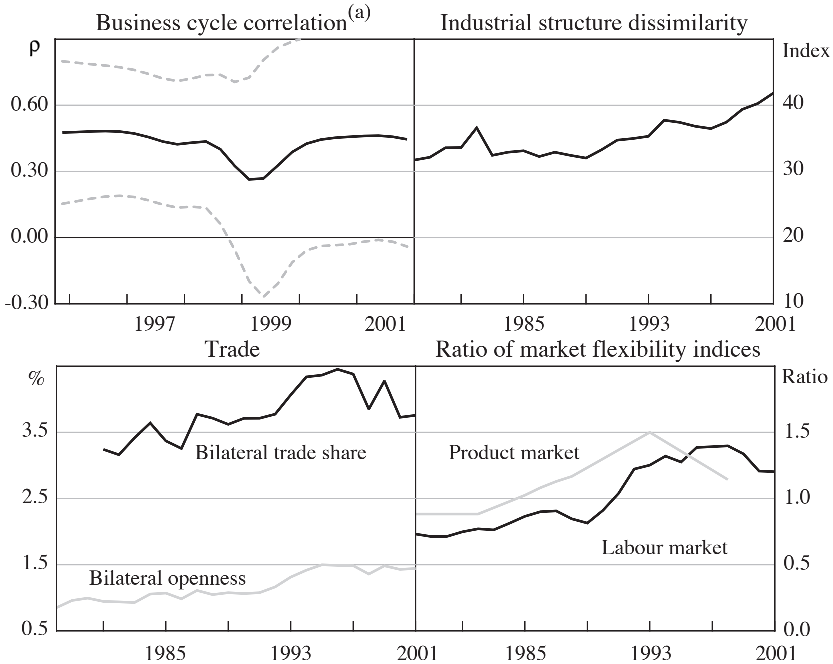
(a) The dates refer to end-point of 16-year moving window. Dashed lines denote Newey-West-corrected 95 per cent (asymptotic) confidence intervals.

more dissimilar to that of Australia, driven by the financial services, mining and manufacturing sectors. Labour market flexibility, as measured by net union density, is now very similar in the two economies, with the relative index increasing over time, driven by New Zealand's strong fall in net union density.

The cyclical correlation between Japan and Australia has fallen over the past 40 years (Figure 9). While part of this development, especially over the 1990s, is undoubtedly linked to strong adverse idiosyncratic shocks in Japan, it could also be partly explained by the underlying factors analysed here. More specifically, the fall in cycle correlation has been accompanied by a fall in bilateral trade exposure since the 1980s. Unlike the previous cases, the link between trade exposure and cycle correlation is positive in the case of Japan, as suggested by cross-sectional studies. Changes in industrial structure (dis-)similarity and relative labour market flexibility provide a less convincing explanation. Both have been roughly flat over the sample period, with relative labour market flexibility undergoing some swings.

Similar to the case of Japan, the business cycle correlation between the euro area and Australia has fallen over the sample period (Figure 10). This is consistent with a fall in bilateral trade exposure, again suggesting a positive relationship between trade and synchronicity. Industrial structure has remained broadly unchanged,

Figure 8: Australia and New Zealand

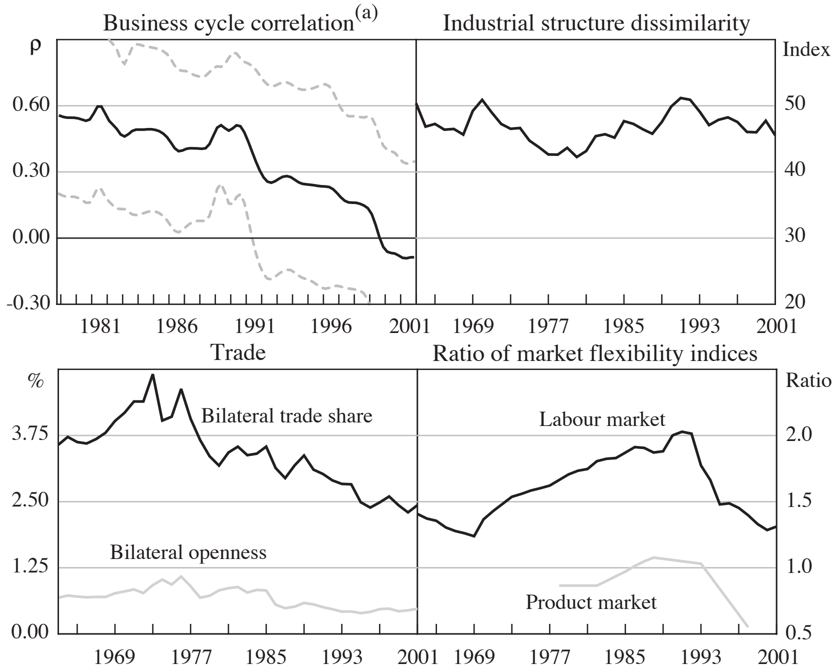


(a) The dates refer to end-point of 16-year moving window. Dashed lines denote Newey-West-corrected 95 per cent (asymptotic) confidence intervals.

though the two economies have surprisingly similar structures when compared to Japan. Relative labour market flexibility changed significantly over the second half of the sample, with net union density broadly flat in the euro area while that of Australia halved over the same time. The level of net union density might be a somewhat misleading indicator of the level of market flexibility for the euro area. The product market indicator and other indicators of labour market flexibility by Nickell and Nunziata (2001) suggest that the economies of the euro area and Japan are more regulated than other economies in our sample. This implies a slower process of adjustment to shocks and might have contributed to the prolonged response to the idiosyncratic shocks these economies experienced in the 1990s (see Ebell and Haefke 2003).

Our analysis so far suggests that, while trade, industrial structure and market flexibility could explain changes in business cycle co-movements, the sign of these effects can differ widely across economy pairs. This is especially evident for trade exposure, which has a strongly negative correlation with cycle synchronicity for some countries, while it has a positive correlation for others. Interestingly, the first group, which includes the Anglo-Saxon countries, except for New Zealand, has had strongly increasing synchronicity with Australia despite falling bilateral trade

Figure 9: Australia and Japan



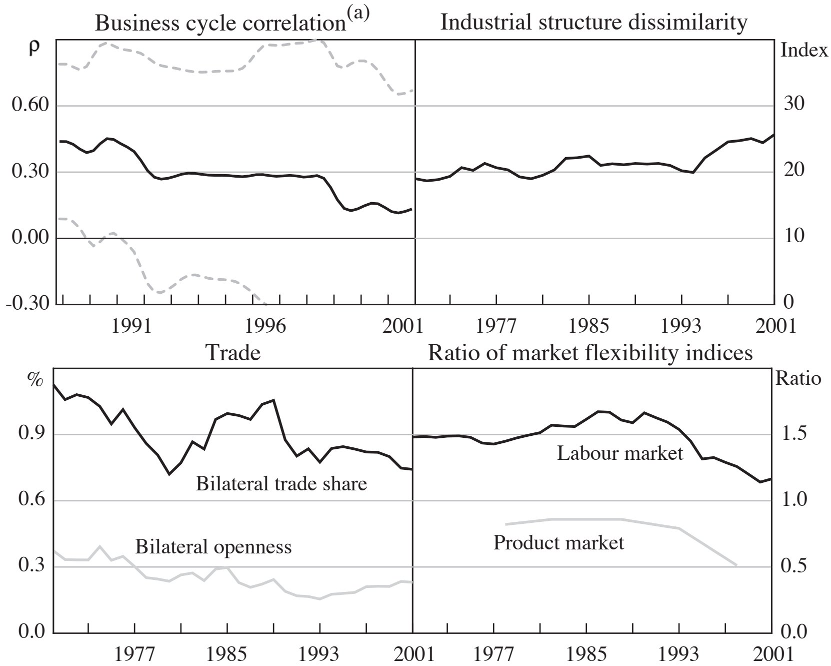
(a) The dates refer to end-point of 16-year moving window. Dashed lines denote Newey-West-corrected 95 per cent (asymptotic) confidence intervals.

exposure. For the UK and the US, we also find that industrial structure has become more similar, which may partly explain both the decreasing trade exposure and the increasing cycle co-movements. On the other hand, Canada's industrial structure has always been very similar, and therefore the strong increase in cycle co-movements is more difficult to explain.

The second group, Japan and the euro area, have experienced falling synchronisation of business cycles with Australia. This coincides with falling bilateral trade exposure, and a fall in relative labour market flexibility towards more similarity in the case of the euro area. Industrial structure similarity is an unlikely explanation for this group, as it has been roughly constant through time.

Ultimately, the relative importance of these factors for each economy pair needs to be established in an estimation which includes all factors jointly. However, our sample period is rather short (especially since we need to measure cycle correlation over more than one cycle) and the estimation is affected by a number of econometric problems which need to be addressed for such an exercise to be conclusive. With these caveats in mind, we now turn to more formal estimates.

Figure 10: Australia and the Euro Area



(a) The dates refer to end-point of 16-year moving window. Dashed lines denote Newey-West-corrected 95 per cent (asymptotic) confidence intervals.

3.2.2 Econometric evidence

In this section, we formally test the relevance of the factors in explaining changes in business cycle co-movements for specific economy pairs discussed in Section 3.2.1. Due to the short time series available, we do not estimate a model for Australia–New Zealand. Figures 2 to 4 indicate clearly that the business cycle correlation coefficient is not stationary over time for the remaining five economy pairs.[16] Since a number of our explanators are also trending, they might form a co-integrating relationship with the business cycle correlations, our dependent variable. Our first step is therefore to test for co-integration. If we are unable to find co-integration between the cycle correlations and the right-hand-side variables

16. Integration tests confirm that all variables are I(0) or I(1). One could argue that, strictly speaking, a correlation coefficient is a summary statistic of a distribution, and therefore statistical concepts such as non-stationarity are misplaced. Moreover rolling correlation coefficients imply changing distributions. We share some of these conceptual problems with studies using rolling standard deviations of output, such as Barrell and Gottschalk (2004). An entirely different approach to our empirical problem would be to model the covariance and variance of two GDP cycles, conditional on exogenous factors. These could then be combined to estimate the impact on the correlation coefficient. We would like to thank Adrian Pagan for suggesting this alternative approach which we aim to evaluate in future research.

(or a subset thereof), this can be interpreted as a rejection of the hypothesis that these factors are able to explain changes in cycle correlation. A moving window of correlation coefficients introduces serial correlation in our model by construction (see Barrell and Gottschalk 2004). In order to account for this, we use a DOLS regression as the basis for our co-integration test. We also allow for several lags in the ADF co-integration test on the residuals from the DOLS regression.[17] We regress the cycle correlations on bilateral trade, industrial similarity (IS), and the (absolute) difference in labour market flexibility (LMF):

$$BCS_{t-64,t} = \alpha + \beta Trade_{t-64} + \gamma\, IS_{t-64} + \delta LMF_{t-64} + \left(dynamics\right) + \varepsilon_t \quad (9)$$

Model 1 uses the bilateral trade share (*TradeFR*) to model bilateral trade exposure, model 2 uses bilateral trade openness (*TradeCW*), and model 3 uses bilateral trade as a share of Australia's total trade (*TradeSH*). The explanatory variables relate to the beginning of the time period covered by each correlation coefficient. Table 2 shows the results of the co-integration test.

Table 2: Testing for a Co-integrating Relationship
ADF test statistics on the residuals from the Dynamic Ordinary Least Squares (DOLS) model

Australia with:	Canada	Euro area	Japan	UK	US
Model 1 (*TradeFR*)	–2.82	–5.35***	–3.89*	–3.59	–4.86***
Model 2 (*TradeCW*)	–2.76	–5.50***	–3.80	–3.48	–2.84
Model 3 (*TradeSH*)	–2.48	–3.38	–2.76	–3.79	–4.88***
Number of observations	87	53	87	87	87

Notes: ***, ** and * refer to significance at the 1, 5 and 10 per cent levels, respectively, using MacKinnon (1991) critical values. DOLS is modelled with 4 lags and leads. The number of observations is the number available for estimation, after adjusting for the 64-quarter lag resulting from the 16-year moving window and after adjusting for the 4 leads and lags of the DOLS model.

Using only our three structural variables, we can find a co-integrating relationship for the US and the euro area, but not for the UK, Canada and Japan. However, we may have to control for other factors, such as fiscal and monetary policy changes. In fact, as Table 3 shows, we can find co-integration for all country pairs, once we control for differences in fiscal policy for the UK and Canada, and for differences

17. Unfortunately, we do not have enough data to account explicitly for a full lag structure of 16 years, the length of our moving window. We have checked the robustness of our results by estimating a long-run model that explicitly takes account of an MA-error structure with 16 lags (that is, four years). For all models the results are very close to our DOLS regressions, and for almost all models only the first 6 to 8 lags are significant.

in monetary policy for Japan.[18] Unlike in the basic model for Table 3, all three trade measures appear to perform equally well in the expanded model in most cases.

In the next step, for those models that are valid, we tested whether we can reduce the number of right-hand side variables while still maintaining co-integration. We took care to note where the reduction did affect other coefficients materially. Table 3 reports the results of our preferred models, focusing on the coefficients of the long-run variables.[19]

Interestingly, trade is part of the co-integrating relationship for all economy pairings and the coefficient on trade is positive, except for the UK. Once we control for policy influences, all measures of bilateral trade exposure can be used to form a valid model for most country pairs. A notable exception is the bilateral openness measure, which is not, or only at the margin, part of a valid model for either the US or Japan, both large closed economies.

For the US, we find that once we control for industry dissimilarity, the remaining role for trade on cycle co-movement is positive, in line with cross-sectional evidence presented by Kose *et al* (2003). Similarly, for Canada, once we control for industrial structure and fiscal policy, not only is the relationship a co-integrating one, the trade coefficient also becomes positive.[20] For the UK, however, the trade coefficient remains negative, even once we control for changes in industrial structure, which is contrary to the predictions from theory.

Industrial structure dissimilarity enters the co-integrating relationship for Canada, Japan, the UK and the US, and has the expected negative sign in all these cases. Changes in industrial structure are the most important factor in explaining changes in synchronicity with the US, Canada and the euro area.[21] The Canadian result is somewhat surprising, since the dissimilarity index between Australia and Canada has

18. We should point out that the inclusion of these variables implies also a shortening of the estimation period for these three economy pairs, since the fiscal policy variable is only available from 1970:Q1 and the monetary policy variable for Japan is only available from 1969:Q1. For the UK and Japan, this shortening is not material: over the shorter estimation period the policy variables are required to obtain co-integration. For Canada, however, we can obtain co-integration (at a 5 per cent significance level) over the shorter period without including fiscal policy. This is because our model has difficulties explaining the steep increase in correlation between 1963 and 1970. The coefficient estimates are only slightly affected by the inclusion of fiscal policy.

19. The significance level of these coefficients should be treated with caution, as we may not have fully corrected for serial correlation in our model.

20. We should note that for Canada, if fiscal policy and labour market flexibility are included, we have a co-integrating relationship where trade has a negative coefficient. However, the coefficient on labour market flexibility is not significant, and, once dropped, trade becomes positive, pointing to a problem of multicollinearity between trade and labour market flexibility.

21. In our models, trade appears to be the most important factor in explaining the synchronicity changes with Japan and the UK (the latter with a negative sign), while industrial structure plays a larger role for Canada, the euro area and the US. The exact contribution varies with the model estimated. The results in Table 3 allow us to gauge the contributions from various factors to the estimated long-run changes in business cycle changes, but not for the actual changes since our model has a dynamic specification. Moreover, a variable which moves cyclically might be an important variable for the model although its overall contribution in explaining a (monotonic) trend might be small.

Table 3: Long-run Coefficients of Preferred Models

Australia with:	*TradeFR*	*TradeCW*	*TradeSH*	IS	LMF	MP	FP	*Co-integration*
Canada	14.98***			–0.01***			0.96	–5.44***
	(4.42)			(0.00)`			(0.64)	obs = 59
		30.48*		–0.01***			0.67	–5.16***
		(16.07)		(0.00)			(0.61)	obs = 59
			3.82**	–0.02***			1.25*	–5.15***
			(1.41)	(0.00)			(0.69)	obs = 59
Euro area	33.84***				–0.11***			–4.00**
	(6.16)				(0.01)			obs = 53
	41.29***				–0.08***	–0.02***		–5.79***
	(3.04)				(0.01)	(0.00)		obs = 53
		73.87***			–0.05***	–0.01***		–4.74*
		(9.02)			(0.01)	(0.00)		obs = 53
			1.15		–0.07***	–0.02***		–5.91***
			(0.92)		(0.01)	(0.00)		obs = 53
Japan	19.17***			–0.03***	–0.04***			–3.89*
	(6.54)			(0.01)	(0.00)			obs = 87
	48.72**			–0.04***		–0.03***		–4.67**
	(6.48)			(0.01)		(0.00)		obs = 63
		113.38**		–0.04***	0.02	–0.00		–4.53*
		(46.26)		(0.01)	(0.04)	(0.01)		obs = 63
			2.34	–0.02**	–0.06**	–0.01		–6.19***
			(2.08)	(0.01)	(0.02)	(–0.01)		obs = 63
UK	–36.07***			–0.02**			9.93***	–5.26***
	(4.25)			(0.01)			(1.31)	obs = 59
		–141.51***		–0.01			10.75***	–5.12***
		(16.31)		(0.01)			(2.89)	obs = 59
			–4.02***	–0.02***			9.47***	–4.76**
			(0.95)	(0.00)			(1.65)	obs = 59
US	59.79***			–0.06***				–3.88**
	(12.38)			(0.00)				obs = 87
			3.57***	–0.05***				–4.37**
			(0.72)	(0.00)				obs = 87

Notes: All models are estimated as DOLS models with 4 leads and lags. Co-integration reports the ADF test statistic. ***, ** and * refer to significance at the 1, 5 and 10 per cent levels, respectively, using MacKinnon (1991) critical values for the co-integration tests and Newey-West corrected standard errors (shown in parantheses) for the coefficients. The number of observations, 'obs', is the number available for estimation, after adjusting for the 64-quarter lag resulting from the 16-year moving window and after adjusting for the 4 leads and lags of the DOLS model. Note that the trade variables, *TradeFR* and *TradeCW*, are shares and therefore smaller by a magnitude of 100 compared with the lines drawn in Figures 5 to 10, which are percentages. Accordingly, the coefficients are larger by the same factor.

been flat after 1980, with a moderate fall prior to that. However, this coincides with the increase in business cycle correlation between the two economies, which also occurred largely before 1980. While an increase in industrial similarity might be part of the explanation, our model cannot explain the very rapid increase in correlation before 1970 very well. Other factors are likely to have played an important role, such as, perhaps, a change in the type of shocks occurring globally. Canada and Australia are likely to experience similar shocks, such as commodity price shocks, due to their similar economic structure, and if the relative importance of these had increased, they would create more cyclical co-movement. However, it is beyond the scope of this paper to extend our analysis from changes in transmission to changes in shocks.

The variable measuring differences in labour market flexibility enters the models for the euro area and Japan, and with a negative effect. As outlined earlier, the expected sign of this coefficient is ambiguous, since it will also depend on the type of shock – common or idiosyncratic – that prevails over the sample period. A negative sign is consistent with a world where adjustment to common shocks has become more similar, and therefore the resulting business cycles become more similar.

As noted above, for three of our economy pairs we need to control for monetary or fiscal monetary policy in order to obtain a valid model. Changes in differences in fiscal policy appear to play some role in explaining business cycle episodes over the past 40 years for the UK and Canada. Interestingly, the coefficient for Canada is not significant, but including the variable strengthens the case for co-integration. For the UK, our finding would suggest that there was at least one, if not several, episodes where differences in fiscal policy produced more similar business cycles for Australia *vis-à-vis* the UK. Changes in monetary policy need to be controlled for in the models for Japan and in some of the models for the euro area. For the euro area, we do not need to control for monetary policy in order to obtain a valid model, but inclusion of the variable leads to valid models for all trade measures. The role for monetary policy in these two economy pairs is not surprising, since both economies have been subject to large idiosyncratic shocks in the 1990s which prompted idiosyncratic policy responses. Finally, for the US, neither differences in monetary nor fiscal policy appear to play a role. Their inclusion does not alter any of our findings, and the coefficients are insignificant.[22]

Overall, the results of our model are more supportive of the cross-sectional evidence than our graphical evidence. Changes in business cycle co-movement can be explained by a combination of factors for all economy pairs. Higher trade integration has – with one exception – a positive effect on business cycle co-movement, once we control for the effects of other factors such as changes

22. We have also checked whether there is a role for fiscal or monetary policy, or both, in the other models. For Canada, the addition of monetary policy does not alter any of our results, and co-integration is somewhat less likely. For the euro area, we can include either policy variable or both, but the monetary policy variable affects other coefficients more strongly. For the UK, the inclusion of monetary policy does not alter anything. For Japan, we cannot find co-integration when we include fiscal policy.

in the similarity of industrial structures, changes in differences in labour market flexibility, which may proxy for a range of market flexibility measures, or changes in differences in fiscal and monetary policy. More similar industrial structures can explain some of the increase in business cycle co-movement between Australia and the US, the UK and Canada, while the decrease in industrial similarity is found to contribute to the decrease in cycle co-movement between Australia and Japan. A decrease in the difference in labour market flexibility has, if anything, a positive effect on cycle co-movement in our models. Finally, there is some role for fiscal and monetary policy in explaining trend changes in business cycle co-movement for specific country pairs. For example, for individual economy pairs where one economy has experienced a large idiosyncratic shock, such as for Japan and the euro area, measures of divergences in fiscal and monetary policy can capture some of this shock.

Of course, our econometric model is likely to overstate the importance of some explanations, for example similarity in industrial structure, if they are correlated or even only coincide with changes in other factors which we have not modelled. One example is, as mentioned above, a change in the nature of the shocks to which the economies were exposed. One approach would be to control for shocks caused by oil price movements or terms-of-trade shocks. However, these can increase or decrease business cycle co-movements depending on whether the countries under consideration are affected by them in similar or in idiosyncratic ways. It is beyond the scope of this paper to build a model which takes these differences into account, and which also can control for other sources of shocks. We have also neglected some channels of transmission of shocks that may have changed. One example is financial market linkages, which are likely to have increased as a result of increased global financial market integration.

3.3 A missing link: financial market integration

So far we have neglected one channel of transmission of shocks across economies: financial integration. Linkages between financial markets and financial contagion have received much attention in the literature (for an overview, see Forbes and Chinn 2003). Share market and asset return channels are well-documented, however, it has been more difficult to establish the real effects of these linkages (with the exception of extreme cases, such as stock market collapses or severe financial crises).

Heathcote and Perri (2002) analyse a theoretical model of the effect of financial globalisation on international correlations of GDP. They argue that financial integration should be associated with lower correlation of business cycles for two reasons. First, two economies that have less correlated cycles have more to gain through financial integration, since they can diversify their consumption risk. Second, since financial integration allows diversification of risk, it allows economies to become even more specialised in production so as to reap economies of scale. On the other hand, anecdotal evidence suggests that there could be an increase in correlation, for example through foreign direct investment (FDI), if companies make decisions about spending and cost-cutting based on the location of headquarters that have flow-on effects to their foreign subsidiaries.[23]

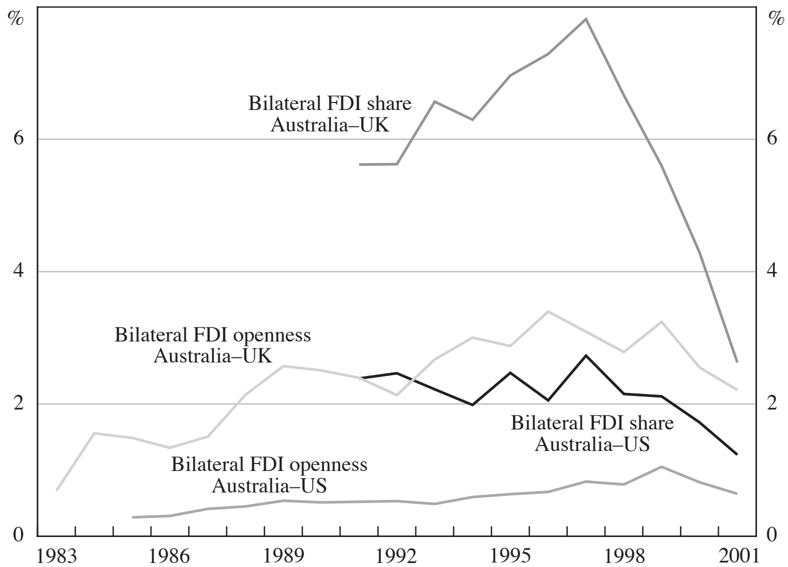
Kalemli-Ozcan, Sørensen and Yosha (2003) analyse the indirect link via industrial specialisation, and present evidence that financially integrated regions are indeed more specialised in their production structure. However, the empirical literature has had problems confirming a direct link between financial integration and real business cycle correlation. Kose *et al* (2003) find at best limited support for the hypothesis that globalisation led to an increase in the degree of cycle synchronisation. They note that consumption correlations have not increased in the 1990s, precisely when financial integration would have been expected to result in better opportunities to share the risks arising from idiosyncratic shocks. On the other hand, Imbs (2004) argues that financial integration has a role in explaining higher cycle correlations using data on effective asset cross-holdings, rather than an index of restrictions to capital flows, which is used by Kose *et al* (2003) and Bordo and Helbling (2003).

Attempts to measure the effect of financial integration in cross-sections have been hampered by a lack of suitable data. This problem is exacerbated in a study such as ours, where time-series data are required. One possibility would be to use share market indices (or share market returns), as employed by Otto *et al* (2003). Existing studies have found time-series evidence that US asset price shocks have an important impact on Australian economic activity (de Roos and Russell 1996; Dungey and Pagan 2000). However, share market indices are highly correlated globally, and Australia's share market is no exception. Over the past 20 years Australia's share market index has had a correlation of more than 0.8 with the share markets in all the economies in our sample, except for Japan. Such a uniform correlation is unlikely to explain the different experiences in cycle correlation both across economy pairs and over time.

A different avenue might be to use bilateral FDI, however, reliable data are at best available only from the mid 1980s. Figure 11 shows bilateral indices for FDI similar to those we constructed for trade exposure for the UK and the US. Bilateral FDI openness measures the stock of bilateral FDI (inward and outward) as a share of GDP of both economies. The bilateral FDI share measures bilateral direct investment as a share of total FDI of both economies. Even though these are very short time series, the two measures do not necessarily give the same picture since the 1980s. FDI openness has risen overall, suggesting that bilateral FDI has grown at a faster pace than GDP. However, for these country pairings, total FDI has grown at an even faster pace than bilateral FDI, leading to falling bilateral FDI shares. This is not surprising since these economies are likely to have taken up other FDI opportunities, for example in China or east Asia. This is likely to dampen any measurable effect of bilateral FDI on the business cycle, since at the same time there would be spillovers from financial investments in these other (Asian) economies. Ultimately, more data and longer time series are required to assess any such effect.

23. Of course, optimal portfolio allocation theory would suggest that, if one market has a low or negative return, investment should be shifted to the market with the higher return, rather than spending reigned in on all investments.

Figure 11: Australia's FDI Exposure with the US and the UK



4. Conclusions

Over the past 40 years, the Australian business cycle has become highly correlated with that of Canada, the UK, and the US. On the other hand, Australia's business cycle has become less correlated with that of Japan and the euro area. While previous studies have sought to explain business cycle correlations in a cross-country context, less is known about the factors which have caused these relationships to change so dramatically through time.

The results from this paper suggest that there is no single model that can explain changes in cycle co-movements across all the five economy pairs considered. However, many of the cross-sectional explanations for business cycle co-movements are also useful for explaining changes through time. For instance, the well-documented increase in Australia's business cycle correlation with the US could be at least partly explained by more similar industrial structures, which – in the presence of global industry-specific shocks – leads to more cyclical co-movement. Once we control for this effect, we find that the falling trade share with the US is likely to have had a dampening effect on cycle correlation.

For other economy pairings, however, the explanation suggested by our models is somewhat different. While the two most prominent variables from the cross-section literature – trade and industrial structure – are necessary to obtain a valid model, they are not sufficient. A move towards more similar degrees of labour market flexibility has a positive effect on cycle co-movement for our economy pairs, though the direction of this relationship is theoretically ambiguous, and is contingent on the nature of the shocks that prevail over the sample period. We also find evidence that for individual economy pairs where one economy has experienced a large idiosyncratic shock, such as for Japan and the euro area, measures of divergences in fiscal and monetary policy matter, possibly because they can capture some of this shock.

However, our models are likely to overstate the importance of individual factors, such as industrial structure, if these coincide with other factors omitted in our analysis. Monetary and fiscal policy are only one example where changes in shocks can affect cyclical co-movement. More generally, change in the nature of shocks that an economy pair is exposed to can alter business cycle co-movements. A thorough analysis of this is, unfortunately, beyond the scope of this paper.

Finally, we have also neglected some possible channels of transmission of shocks across countries. Despite our findings *vis-à-vis* trade, which has reduced business cycle co-movement across our economy pairs, we have not discounted the significance of increasing international economic interdependence. One would expect that closer financial market integration also plays a role, although the theoretical link is less clear. Limited data availability makes this a difficult hypothesis to test.

Appendix A: Data

Real GDP:

Quarterly real GDP data for Australia come from the Australian Bureau of Statistics (ABS), Cat No. 5206.0 for 1960:Q1 to 2004:Q4; for the euro area from Fagan, Henry and Mestre (2001) for 1970:Q1 to 1990:Q4, spliced to data from Eurostat (EMU-11 plus Greece) for 1991:Q1 to 2004:Q4; for New Zealand from Buckle, Haugh and Thomson (2001) for 1977:Q1:1987:Q1, spliced to data from Thomson Financial for 1987:Q2 to 2004:Q4; for all other countries from Thomson Financial for 1960:Q1 to 2004:Q4 (1961:Q1 to 2004:Q4 for Canada).

Trade measures:

Annual bilateral trade data (exports plus imports) for goods come from the *Direction of Trade Statistics* (IMF) for all countries from 1963, or earliest available. Data for the euro area were obtained by adding EMU member country figures and splicing backwards with average growth rates where individual smaller countries are unavailable. Since exports from country *i* to country *j* do not always equal imports recorded by country *j*, we have averaged these. Where only data from one country are available, we spliced backwards for the partner country using that series. Annual data were converted into quarterly data by linear interpolation.

Annual trade data *vis-à-vis* the world come from the same source as the bilateral trade data. Euro area data were calculated net of intra-EMU trade.

Quarterly nominal GDP comes from the same sources as real nominal GDP, except for New Zealand where data on GDP(P) for 1970:Q1 to 1987:Q1 were obtained from the RBNZ, spliced to data from Thomson Financial thereafter. These were converted into US$ using quarterly average exchange rates from the RBA.

Industrial structure:

Annual data for gross value added at constant prices by industry classification (ISIC) were compiled using a number of sources: the OECD International Sectoral Database (ISDB) and the OECD National Accounts II formed the basis. Updates for Australia used ABS data (Cat No 5204.0), prior to 1969 we used growth rates of employment by industry from the ISDB; for the UK we used O'Mahony (1999) to provide data for earlier years, and shares to calculate the weights (UK data are only available as index series) were obtained using current price series for the base year 1995, with updates from Thomson Financial; the euro area data were proxied with data from Germany and France for which earlier observations were provided by O'Mahony (1999), weighted using all industries gross value added; for the US we used data by the Bureau of Economic Analysis from 1987, which we matched with ISIC1 categories, and OECD and O'Mahony for data prior to 1987; data for New Zealand come from Buckle *et al* (2001); data for Canada come from Thomson Financial from 1981 and the Bank of Canada prior to 1981. Quarterly frequency for the dissimilarity index was obtained by linear interpolation.

Labour market flexibility:

Annual data on net union density come from Nickell and Nunziata (2001). Updates come from national sources and the ILO. The euro area data comprise Belgium, Finland, France, Germany, Italy, Netherlands, and Spain, weighted by euro-area weights as documented in Fagan *et al* (2001). Quarterly frequency for the dissimilarity index was obtained by linear interpolation.

Product market flexibility:

Index compiled by Nicoletti *et al* (2001) from a range of underlying indicators. Data are available every four to five years from 1978 to 1998. The euro-area data comprise Belgium, Finland, France, Germany, Italy, Netherlands, and Spain, and were aggregated using the euro-area weights of the individual countries employed by Fagan *et al* (2001).

Monetary policy:

Quarterly short-term interest rates (3-month maturity) come from Global Financial Data and Thomson Financial.

Fiscal policy:

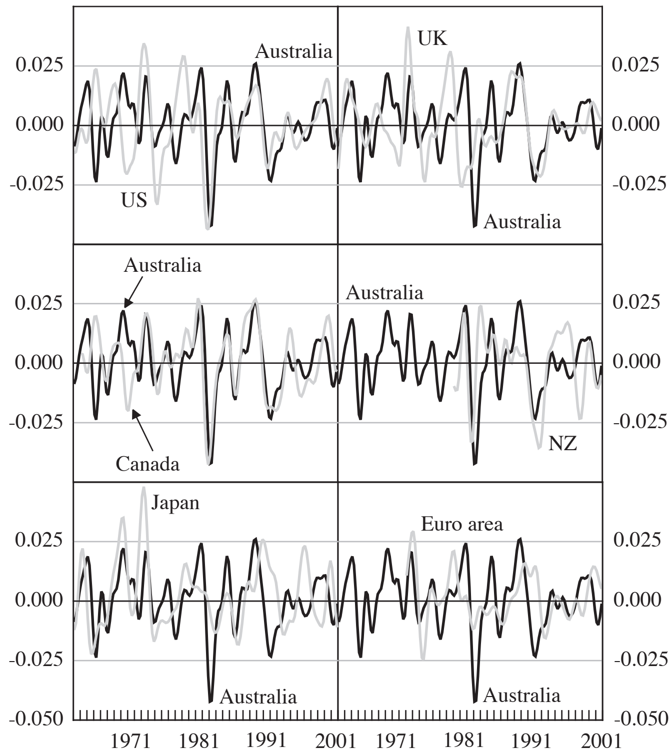
Quarterly data on primary budget deficits for 1965:Q1 (or earliest available) to 2004:Q4, cyclically unadjusted as calculated by the OECD, come from Thomson Financial. For the euro area we sum the OECD data for Austria, Finland, France, Germany, Ireland, Italy and the Netherlands after 1996:Q1, and splice this to the data from Fagan *et al* (2001). Nominal GDP data are the same as for the trade measures.

Bilateral FDI:

Data on bilateral FDI stocks (inwards and outwards) come from the ABS Cat No 5302.0 (since 1990) and from the OECD foreign direct investment database (prior to 1990). Data on total FDI (assets and liabilities outstanding), as calculated in the *International Financial Statistics*, come from Thomson Financial.

Appendix B: Additional Figures

Figure B1: Band-pass-filtered GDP Cycles[(a)]



(a) Business cycle extracted using the band-pass filter by Baxter and King (1999), which extracts frequencies between 6 and 32 quarters.

Figure B2: Monetary Policy Variables

Nominal short-term interest rates (3-month maturity)

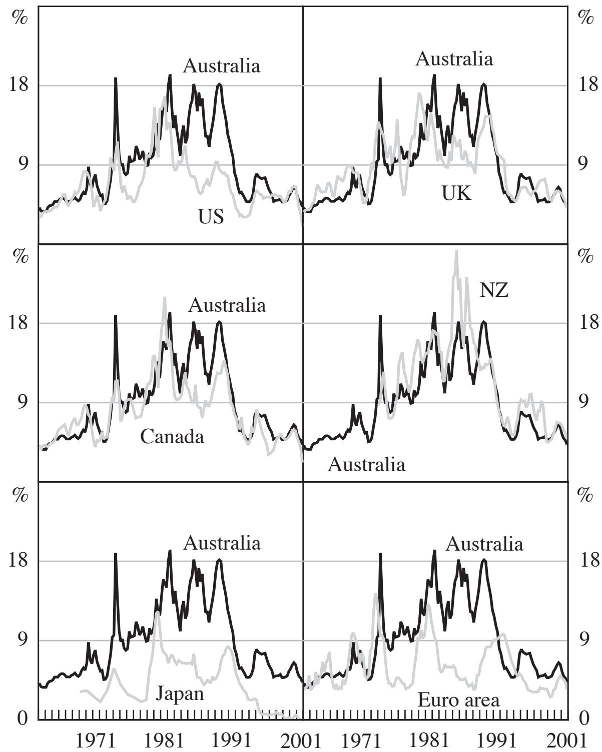
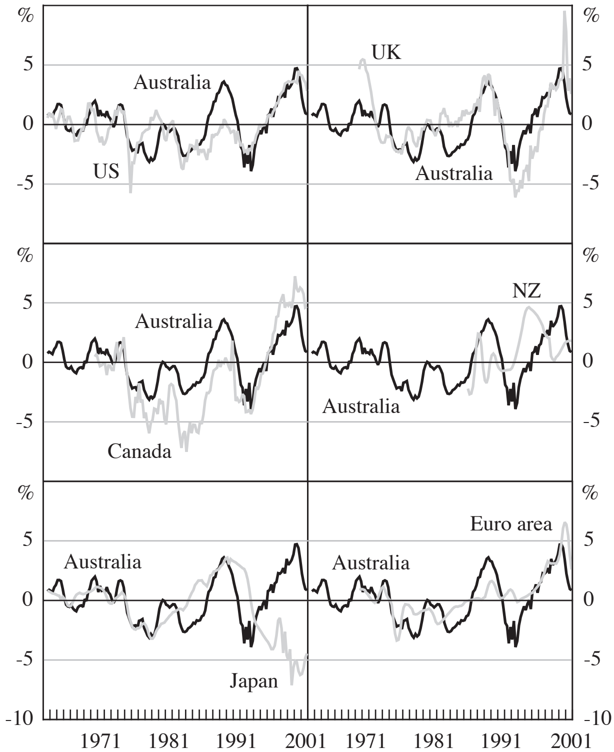


Figure B3: Fiscal Policy Variables
Primary budget deficit as per cent to GDP



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Discussion

1. Glenn Otto

The paper by Dan Andrews and Marion Kohler provides an interesting and very useful contribution to the empirical literature that seeks to explain the factors influencing bilateral output correlations. While there are a number of papers that have developed empirical models of the cross-section distribution of bilateral (de-trended) output correlations (Baxter and Kouparitsas 2005, Imbs 2004 and Otto, Voss and Willard 2001), the key innovation of Dan and Marion's paper is to focus on the time-series dimension of bilateral output correlations. Specifically, the authors examine whether factors such as trade intensity and similarity of industry structure, which appear to explain the cross-section behaviour of output correlations, also explain trends in bilateral sample correlations over time.

In their paper the bilateral correlations of interest are between Australian output and that of a number of other industrialised economies – Canada, the euro area, Japan, the United Kingdom and the United States. A time series for the bilateral correlation coefficients is constructed by using a 16-year (one-sided) moving window. Based on the time-series plots of these correlations in Figures 2 to 4 of the paper, it certainly appears that the strength of these bilateral correlations has changed over time. In the case of Canada, the UK and the US, the size of bilateral correlations with Australia has risen over time, whereas it has fallen with Japan and the euro area. To explain the trends in the bilateral correlations the authors construct bilateral time-series measures of a number of potential explanatory variables – trade intensity, trade openness, similarity of industry structure, market flexibility, monetary policy and fiscal policy. Since all of the time series variables appear to be non-stationary, Dan and Marion test for the existence of cointegrating relationships and, where cointegration is found, use dynamic ordinary least squares (Stock and Watson 1993) to estimate the long-run relationships for Australia's bilateral correlations.

In general the methodology used in the paper appears to yield quite plausible results. Table 1, below, presents a representative summary of the results reported by the authors in Table 3 of their paper. To make the estimates comparable I have used bilateral trade shares (*TradeFR*) as a common measure for trade intensity. What is clear from Table 1 is that bilateral trade in goods and similarity of industry structure are the most robust of the potential explanatory variables in explaining the long-run trends in Australia's bilateral correlations over time. Greater bilateral trade in goods is typically associated with a higher (positive) correlation, with the results for the Australia–UK relationship the only exception, while larger differences in industry structure lead to smaller (positive) correlations. A standard interpretation of these findings is that the trade variable captures the transmission of idiosyncratic shocks between countries, whereas the industry structure variable measures the susceptibility of a pair of economies to a common shock (that is, a shock that does not originate in either economy). One interesting and positive aspect of Dan and Marion's findings for time-series data is that they are broadly consistent with the results obtained from cross-section data.

Table 1: Comparison of Long-run Models for Bilateral Correlation with Australia

	Trade share	Industrial structure	Market flexibility	Monetary policy	Fiscal policy
US	59.79	–0.06	–	–	–
Canada	14.98	–0.01	–	–	0.96
UK	–36.07	–0.02	–	–	9.93
Euro area	41.29	–	–0.08	–0.02	–
Japan	48.72	–0.04	–	–0.03	–

Source: Andrews and Kohler (this volume)

One additional piece of information that could be usefully reported in the paper is an indication of how well the estimated models fit the data. For example, although trade and industrial structure are found to have a statistically significant effect on the long-run behaviour of the Australia–US correlation, it is not clear from the reported results exactly how well these variables explain the major shifts in this variable. Some plots of the predicted correlation from the long-run models (excluding the leads and lags) against the actual correlation would clarify this issue.

Despite the relatively plausible nature of Dan and Marion's findings, there are two issues that I believe it would be useful to address in more detail. Given the focus on time-series data in the paper, a crucial assumption is that the bivariate population correlation coefficient is time-varying. In the paper, the unobserved correlation coefficient is proxied by using a 16-year moving window to construct a time series. An important question is how well the moving window estimates the population correlation coefficient. One way to answer this question is through a Monte Carlo analysis. For example, it would be a relatively straightforward exercise to ensure that the type of trends in the estimated correlation coefficient observed in Figures 2 to 4 are not likely to arise with data that are generated from a model where the population correlation coefficient is actually constant over time.

The second issue is more general and concerns the role that changes in the variances of output growth rates might have on the correlation coefficient. This is an important issue because variables that might influence these variances are typically not included in models of the correlation coefficient. Consider the definition of the correlation coefficient between the growth rates of output in Australia (x_t^{AU}) and the US (x_t^{US}),

$$\rho\left(x_t^{AU}, x_t^{US}\right) = \frac{Cov\left(x_t^{AU}, x_t^{US}\right)}{\sqrt{Var\left(x_t^{AU}\right)Var\left(x_t^{US}\right)}} \qquad (1)$$

It is clear that the magnitude of the correlation coefficient is influenced not only by the covariance between the Australian and US growth rates, but also by the variances of the Australian and US growth rates. Since a number of papers at this conference have argued that output volatility in Australia and the US has declined over time, it seems a reasonable conjecture that this may have been an important source of the variation in the bilateral correlation coefficient. However some caution is required since changes in the variance of the growth rates are unlikely to occur independently of changes in the covariance.

To clarify this point, it is helpful to consider a simple model for Australian and US growth rates:

$$x_t^{AU} = \alpha^{AU} f_t + \beta^{AU} \varepsilon_t^{US} + \varepsilon_t^{AU} \quad (2)$$

$$x_t^{US} = \alpha^{US} f_t + \beta^{US} \varepsilon_t^{AU} + \varepsilon_t^{US} \quad (3)$$

In this model, Australian output growth depends on idiosyncratic Australian shocks, ε_t^{AU}, US shocks (ε_t^{US}) that are transmitted to Australian growth via the parameter, β^{AU}, and a shock, f_t, that is common to both Australia and the US. The impact of the common shock depends on the size of the parameter α^{AU}. The equation for US growth has a similar form, although in practice it is appropriate to set $\beta^{US} = 0$ so that Australian-specific shocks are not transmitted to the US economy. Finally, I assume that all of the three shocks have mean zero and are independently distributed.

If we substitute (2) and (3) into (1) then the correlation coefficient becomes

$$\rho\left(x_t^{AU}, x_t^{US}\right) = \frac{\alpha^{AU}\alpha^{US} E\left(f_t\right)^2 + \beta^{AU} E\left(\varepsilon_t^{US}\right)^2 + \beta^{US} E\left(\varepsilon_t^{AU}\right)^2}{\sqrt{Var\left(x_t^{AU}\right) Var\left(x_t^{US}\right)}} \quad (4)$$

where $Var(x_t^{AU}) = (\alpha^{AU})^2 E(f_t)^2 + (\beta^{AU})^2 E(\varepsilon_t^{US})^2 + E(\varepsilon_t^{AU})^2$; and $Var(x_t^{US}) = (\alpha^{US})^2 E(f_t)^2 + (\beta^{US})^2 E(\varepsilon_t^{AU})^2 + E(\varepsilon_t^{US})^2$.

Equation (4) provides a simple framework for evaluating the various empirical models for bilateral correlation coefficients, including the results presented by Dan and Marion. To begin with, we can identify all of the influences on the magnitude of the Australia–US output correlation coefficient. According to Equation (4), it depends on:

- the variances of each country's own idiosyncratic shocks;
- the variance of the common shock; and
- the magnitudes of the transmission mechanism coefficients and the common shock parameters.

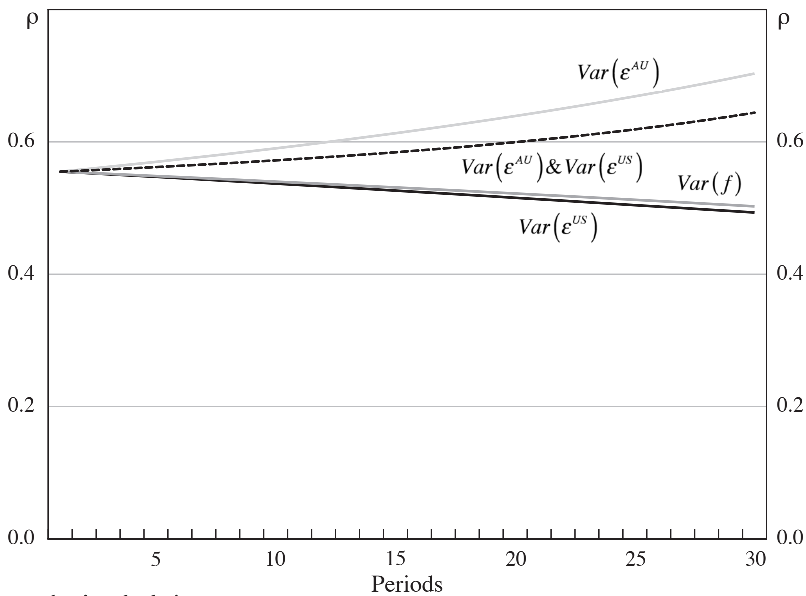
In empirical models of the correlation coefficient it is standard to include as potential explanatory variables factors that might either influence the transmission of shocks between countries or affect the susceptibility of a pair of countries to common shocks. However it is less evident that possible changes in the variances of the three shocks that enter Equation (4) are captured in existing models of the correlation coefficient. Ideally, we would like to augment Dan and Marion's model for the Australia–US correlation with time-series measures of the variance of common Australia–US shocks, the variance of Australian-specific shocks and the variance of US-specific shocks. In practice, such series are difficult to construct; a simpler strategy would be to include observable proxies for these variances. Some possible candidates include the variance of the terms of trade, the variance of oil prices or even a time trend, where the latter is a proxy for the recent decline in output growth volatility.

Finally, it is possible to use Equation (4) to indicate how important changes in the variances are likely to be for the correlation coefficient (even in the absence of good measures of the variances of the shocks). For example, consider a decline in $E(\varepsilon_t^{US})^2$. From Equation (4) this variable shows up in the numerator and twice in the denominator. Thus a fall in $E(\varepsilon_t^{US})^2$ will reduce the covariance, but also the variances of US and Australian output growth. What is the overall effect? Table 2 shows a parameterised version of Equations (2) and (3). With this choice of parameters, the Australia–US correlation coefficient is 0.56. Now consider the effect on the size of the correlation coefficient of the following changes in the variances:

1. $E(\varepsilon_t^{US})^2$ declines from 1.0 to 0.5 in a linear fashion over 26 periods;
2. $E(\varepsilon_t^{AU})^2$ declines from 1.0 to 0.5 over 26 periods;
3. $E(f_t)^2$ declines from 1.0 to 0.5 over 26 periods; and
4. $E(\varepsilon_t^{US})^2$ and $E(\varepsilon_t^{AU})^2$ both decline from 1.0 to 0.5 over 26 periods.

Figure 1 shows a plot of how the Australia–US correlation coefficient would change over time. Three interesting results emerge. When the variance of the US-

Figure 1: Effect on Correlation Coefficient of a Decline in Variance of Shocks



Source: author's calculations

Table 2: A Parameterised Model for Australian and US Growth Rates

$$x_t^{AU} = \alpha^{AU} f_t + \beta^{AU} \varepsilon_t^{US} + \varepsilon_t^{AU}$$
$$x_t^{US} = \alpha^{US} f_t + \beta^{US} \varepsilon_t^{AU} + \varepsilon_t^{US}$$
$$\alpha^{AU} = \alpha^{US} = \beta^{AU} = 0.50$$
$$\beta^{US} = 0.01$$
$$E(f)^2 = E(\varepsilon_t^{AU})^2 = E(\varepsilon_t^{US})^2 = 1$$

specific shock alone, or the common shock alone, is reduced, then the size of the Australia–US correlation actually falls over time. To increase the size of the correlation it is necessary to either reduce the variance of the Australian specific shock or to simultaneously lower the variance of both the Australian- and US- specific shocks. Thirdly, although the variances of the shocks are reduced by 50 per cent, this does not produce a particularly large change in the size of the bilateral correlation coefficient. This suggests that it may not be the declining variances of growth rates that are the primary source of change in bilateral correlations over time. Of course one cannot draw particularly strong conclusions from this simple exercise, but the results do suggest that it would be worthwhile considering a version of the model in Table 2 that is more closely calibrated to the Australian and US economies.

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2. General Discussion

Presaging the paper by Crosby and Bodman, a number of participants raised the issue of whether high business cycle correlations stem from the joint experience of recessions, particularly in English-speaking countries. One participant noted that this appears true in the data used by Andrews and Kohler, while another suggested that this should push researchers of business cycle synchronisation to focus on the question of what causes recessions. To this end, some participants speculated that with financial and credit market shocks playing a key role in recent recessions, especially in English-speaking countries, and with more closely integrated financial markets in recent years, it would not be too surprising to find an important role for financial variables in driving trends in correlation coefficients. In response to these points, the authors agreed that recessions have increased the correlation between countries, but argued that high correlations are not solely due to the joint occurrence of recessions. Furthermore, they maintained that recessions are an important part of the business cycle and, therefore, there is no theoretical basis for excluding them from an analysis of business cycle synchronisation. And while financial sector shocks are an important consideration, testing their significance requires a structural model in order to distinguish financial shocks from an endogenous response of financial variables to other developments.

Another participant questioned the absence of capital flows from the list of explanatory variables used in the paper by arguing that capital flows appear to have had a particularly strong influence on business cycle synchronicity in Asia and could be expected to have played an important role in other countries. Marion Kohler largely agreed with this hypothesis, but noted that the time series data are not sufficiently long to test the theory. Furthermore, she suggested that theoretical arguments regarding the effect of greater capital flows are ambiguous; 'headquarter effects' (where firms adjust both headquarter- and affiliate-investment in response to an idiosyncratic shock to one economy) suggest increased synchronisation, while capital transfers would be likely to reduce synchronicity (as capital may flow away from a country experiencing an adverse idiosyncratic shock towards another).

There was also some discussion about the characterisation of shocks as either common or idiosyncratic, with one participant arguing that shocks traditionally characterised as common have very different implications based on industrial structure (for example, an oil price shock will affect energy importers differently to energy exporters). In a similar vein, another participant noted that the speed with which shocks are transmitted across countries appears to be a crucial factor underpinning the size of correlation coefficients in Monte Carlo studies, indicating that the transmission mechanism can be as important as the relative magnitude of common and idiosyncratic shocks.

Finally, there were some suggestions about alternative proxies and estimation techniques. For example, one participant thought that it would be preferable to use price synchronisation as a proxy for industrial similarity, while another raised concerns about the use of trade shares, rather than absolute levels, when examining trade channels of transmission, given the increasing importance of developing countries in international trade.

When the US Sneezes, Do We Need to Catch a Cold? Historical and Future Linkages between the Australian and US Business Cycles

Mark Crosby and Philip Bodman

Abstract

Many observers worry that when the economy of the United States sneezes, the rest of the world catches a cold. In the case of Australia, the linkage is usually seen to be particularly strong, with Australia's business cycle being much more correlated with the US cycle than most other OECD economies. In this paper we examine the relationship between the Australian and the US economy for the last 130 years. We argue that the very high post-war correlation between the Australian and US cycles is driven largely by the early 1980s and early 1990s recessions, and the associated high interest rates of these periods. With monetary policy now expected to achieve low inflation into the foreseeable future, we see no reason for the high correlation between the Australian and the US economies evident from 1980 to 2000 to continue into the next 20 years.

1. Introduction

In this paper we examine the linkages between the Australian and United States economies since 1870. It is common to hear the expression, 'when the US sneezes, Australia catches a cold'.[1] From a policy-maker's perspective, understanding the historically high correlation between Australian and US cycles is critical. Is this correlation unavoidable, or is it avoidable through the right policy choices? Has policy caused this high correlation? Is this correlation simply coincidental? In this paper we argue that the historically high correlation between the two cycles is particular to the period from 1980 to 2000, and is driven largely by the similarity of monetary policy during this period. Looking into the future we do not anticipate the two cycles to be as highly synchronised as in the 1980s and 1990s.

The structure of our paper is as follows. In the next section we briefly discuss related literature, and review the evidence on the high degree of synchronisation between Australian and US cycles. Section 3 of the paper examines the evidence on the lack of synchronisation between the Australian and the US economies between 1870 and 1939, while Section 4 examines the post-war evidence on synchronisation patterns. In Section 5 we provide some tentative explanations for the changing

1. Using a Google search we were able to find 110 such quotes in the press or on radio transcripts in Australia over the last 5 years.

correlation between Australian and US cycles in the post-war period, and the final section of the paper offers concluding comments.

2. Related Literature

The recent surge of research in the field of optimal currency areas has led to a number of papers that seek to describe and explain cross-country business cycle correlations, particularly among OECD countries. The desirability of a currency union depends in part on the extent to which participating countries' economies are synchronised. As a result, much effort has gone into trying to explain synchronisation, and also into trying to predict the impact that changes such as the formation of a currency union and greater trade integration have on business cycle synchronisation. Frankel and Rose (1998) argue that countries that have closer trade linkages tend to have more closely synchronised business cycles. On this basis they argue that steps that enhance economic and trade integration between countries are likely to lead to more synchronised cycles and therefore make currency unions more desirable. Similarly, Clark and van Wincoop (2001) find that states within the US are much more closely synchronised than countries within Europe, a result which they attribute mostly to closer trade linkages within the US as compared with European countries. Rose and Engel (2000) also find that countries in currency unions trade more, and have more highly synchronised business cycles than countries not in currency unions.

While the above papers suggest that trade is an important determinant of business cycle synchronisation, a number of authors have suggested that, once other determinants of synchronisation are properly controlled for, this effect is quite small. Imbs (2000, 2004) finds that this literature ignores structural similarity and financial specialisation, which he argues to be important factors in explaining synchronisation. Using a measure of similarity that depends on the shares of employment in each sector of the economy in each country, Imbs (2000) finds that structural similarity is able to explain much more of the cross-country variation in business cycle synchronisation within the OECD than trade. He also estimates that the rise in trade between 1963 and 1990 has caused a small increase in synchronisation, but that this has been more than offset by an increase in specialisation that has reduced synchronisation. In Imbs (2004) it is found that intra-industry trade has a sizeable effect on business cycle synchronisation, while inter-industry trade has only a small impact on synchronisation. Kose, Prasad and Terrones (2003) also find only limited evidence of trade increasing business cycle synchronisation. In addition, they find that business cycle co-movements have not changed significantly between the period from 1960 to 1980, and the period from 1981 to 1999. Heathcote and Perri (2003) also document changes in business cycle correlations with the US, and find that over the last 40 years the rest of the world has become less synchronised with the US.

Otto, Voss and Willard (2001) include measures of trade, similarity of economic structure, and financial and monetary policy linkages in their model of business cycle synchronisation for 17 OECD countries. They argue that most of the alternative transmission channels captured by structural variables act as proxies for trade, though there is some evidence that similar exchange rate behaviour can help explain synchronisation. They also argue that there is evidence that their basic model is misspecified (and the same is likely to be true of the models discussed above). In addition to trade, they find that country characteristics such as similarity of technological development, language and legal structures are important explanators of synchronisation. Crosby (2003) examines business cycle correlations in the Asia-Pacific region and finds that trade is a poor predictor of synchronisation, and synchronisation patterns are, in general, difficult to explain using any of the variables used to explain OECD correlations.

While there is debate over the statistical significance of trade and other factors in explaining synchronisation, it should be said that all of these studies find that trade is able to explain very little of the variability in business cycle correlations – R-squared values are typically around 0.2, and never above 0.4 in the many regressions estimated in the above papers.

The papers outlined above tend to take a cross-section approach to the examination of business cycle correlations. In this paper we narrow the focus to just the Australia–US correlation. Our approach is non-structural, but rather aims to document the facts regarding the Australia–US cycle correlation over time. In the penultimate section of the paper we provide some discussion on what has been driving the changing correlation patterns over time, and predict where these correlations may go in the future.

3. Historical Evidence on Australian–United States Synchronisation

In this section we examine the correlations between Australian and US GDP in the period 1870 to 1939. While there have no doubt been many fundamental changes in both economies subsequent to 1939, there are two reasons to examine the pre-war synchronisation patterns. Firstly, this period allows us to make some interesting observations relevant to the debate over whether structural similarities, trade intensity, or other factors are most important in synchronising business cycles. Secondly, there is little existing evidence on pre-war synchronisation, and documenting the facts regarding Australia's correlation patterns with other economies is of interest in its own sake.

We should note that there are some obvious difficulties in comparing pre-war economies given that the quality of the data and the methods used in its construction are not as consistent across countries as in the post-war era. It is also impossible to find data as detailed as those available today, and so we are forced to take a somewhat superficial approach when examining issues such as the structural similarity of the Australian and US economies. The data that we have used come from a variety of sources, including Maddison's (1995) estimates of real GDP, Meredith and Dyster (1999) for the Australian data, and Lee and Passell (1979) for the US data.

3.1 Basic features of the Australian and US economies prior to 1939

In Table 1 we document some basic facts about Australia, the US and the UK in the pre-1939 period. In 1870, agriculture's share of GDP was very similar in Australia and in the US, while the UK was much more reliant on mining and manufacturing. Over the next 60 years the US gradually shifted towards a greater reliance on mining and manufacturing, while Australia's share of agriculture, and mining and manufacturing in GDP remained remarkably stable. By 1930 agriculture was only 4.1 per cent of UK GDP, while the mining and manufacturing share was still significantly larger than in the US. These trends would lead us to expect that the Australian and US economies were somewhat synchronised in 1870, but became less so by 1930.

Table 1: **Features of Pre-1939 Economies**

		1870s	1890s	1910s	1930s
Structural variables (per cent of GDP)					
Australia[(a)]	Agriculture	23.9	22.5	29.3	21.0
	Mining & manufacturing	18.1	15.0	17.9	20.9
US[(b)]	Agriculture	21.6	15.2	17.0	10.4
	Mining & manufacturing	17.5	24.7	22.2	26.2
UK[(c)]	Agriculture	14.2	8.6	6.0	4.1
	Mining & manufacturing	38.1	38.4	37.0	40.2
Trade variables					
Exports	Australia[(d)]	22.5	13.7	25.2	13.8
(per cent of GDP)	US[(e)]	6.2	6.5	4.8	4.2
Per cent of	Australia (wool)[(f)]	37.0	65.2	38.0	33.0
total exports	US (cotton)[(g)]	47.8	28.3	24.2	14.9
Per cent of	Australia[(f)]	60.9	68.8	47.0	46.2
exports to UK	US[(h)]	52.7	52.2	29.0	17.6
Terms of trade	Australia[(i)]	90.2	101.9	100.0	76.1
(1910 = 100)	US[(j)]	79.7	91.4	100.0	123.0

(a) Butlin (1985). Agriculture includes pastoral and dairying.
(b) Lee and Passell (1979, p 273). Data for the 1870s are the average for 1869–79; for the 1890s they are the 1889–99 average, while in the final column they are the 1919–40 average. The 1910s data are the 1904–13 average from United States Bureau of the Census (1975, p 238).
(c) Mitchell (1988). Data are for 1871, 1891, 1907 and 1924.
(d) Butlin (1962) and EconData DX database
(e) United States Bureau of the Census (1975, p 887)
(f) Butlin (1962, p 410), and Meredith and Dyster (1999, pp 63 and 137)
(g) United States Bureau of the Census (1975, chapter U)
(h) United States Bureau of the Census (1975, p 903)
(i) Bambrick (1970)
(j) Williamson (1964, p 262)

A significant difference between the Australian and the US economies was in respect to the relative openness of the two countries. Australia's ratio of exports to GDP was quite variable, but was always much larger than the US equivalent. Interestingly, both countries were very exposed to a single export commodity in the early part of the period documented – wool in the case of Australia and cotton in the case of the US. Australia, however, remained reliant on wool throughout the period, while the US reliance on cotton fell from almost 50 per cent of exports to under 15 per cent. Both countries were also very reliant on the UK as a major trading partner. Once again, however, Australia's reliance persisted while US exports to the UK fell from 53 per cent of total exports to 18 per cent in 1930. The table also shows movements in the terms of trade – particularly notable is the dramatic fall in the terms of trade from 1910 to 1930 in Australia, illustrating the fact that the prices of the two countries' exports diverged during the inter-war period.

Overall, the data paint a picture of two economies that were quite similar in 1870 – economies with large agricultural sectors, reliant on the UK for trade concentrated around a small number of important exports. By 1930 these structural features remained intact for the Australian economy, while the US saw a halving of agriculture's share of GDP, along with a fall in the reliance on cotton and the UK in regard to exports.

3.2 Correlation patterns in the pre-war period

We use two basic approaches to examine synchronisation between the Australian and US economies pre-1939. Firstly, we document the correlation between GDP growth rates of the G7 countries plus Australia and NZ over different sub-periods prior to 1939. We also use the historical business cycle dating scheme from the National Bureau of Economic Research, along with some existing dates for business cycles in Australia, to compare cycles in the two countries.

Table 2 presents correlations between GDP growth rates in Australia and those in eight other countries between 1870 and 1939. The first era of globalisation, prior to World War I, was characterised by movements in Australia's GDP that were not closely related to any G7 country.[2] The highest contemporaneous correlation was 0.23 with NZ, and the correlations with the US and Canada were negative. Australia's similarity in structure to the US did not lead to synchronised cycles in this period, but it is also true that the strong trade linkages with the UK did not lead to synchronisation with that country.

The inter-war pattern of correlations with Australia is a story of two correlation structures. In the 1920s, the Australian economy was again uncorrelated with the major economies and uncorrelated with NZ, so that the correlations for 1919–39 were only significantly different from zero in the case of Germany. The correlation with the US was positive but small, while the correlation with NZ was similar to that found prior to 1913. The correlations during the 1930s were positive and significantly

2. The correlation patterns between lags of Australian GDP and the other countries' GDP are similar.

Table 2: Correlations Between Australian and Selected Countries' GDP
1870–1939

	Canada	France	Germany	Italy	Japan	NZ	UK	US
1870–1913	–0.09	0.08	0.22	0.08	0.19	0.23	0.17	–0.16
1919–1939	0.02	0.13	0.52	0.07	0.20	0.26	0.07	0.17
1930–1939	0.51	0.47	0.63	0.47	0.48	0.70	0.81	0.49

Sources: authors' calculations, using Maddison (1995)

different from zero for all countries, as they moved into recession together. For this period, there was a high correlation between Australian and US GDP growth, but the highest correlations were with NZ and the UK. (Later we examine the post-1945 data and also find that recessions tend to synchronise business cycles.) A small number of recessions experienced coincidentally across a large number of countries seems to be an important factor in understanding the cross-section data on business cycle correlations.

3.3 Recession dates prior to 1939

As well as utilising GDP data, it is informative to examine business cycle chronologies. These chronologies provide evidence on whether the timing of recessions is similar across countries – it is possible, for example, that GDP growth rates are correlated (or uncorrelated) but recessions are experienced at dissimilar (similar) times. The NBER chronology for the US provides dates for peaks and troughs beginning in 1857. We use this chronology for the US, and compare it to the Australian business cycle dates presented in Pagan (1996). (There is no official organisation that provides widely recognised business cycle dates in Australia prior to 1939, and Pagan simply provides a table of peak and trough dates for the classical cycle as gleaned from a variety of sources. The lack of consistency arising from taking dates from different sources is an issue here, but there is no other dating scheme available.) We also graph the years in which Australia's GDP growth was negative, along with negative growth years for the US.

Figure 1 shades each year for which the relevant country was in recession for any part of that year, using the NBER and Pagan dates (the dates provided for Australia are not as precise as the dates for the US in documenting which month or quarter was a peak or trough date, so this is a fair way to compare the available data). The figure illustrates two points very clearly. First, the US experienced a lot of years during which at least some time was spent in recession. If one takes the actual NBER dates, then for the period 1870 to 1900, 49 per cent of months are spent in the contraction phase of the business cycle. From 1900 to 1939 this percentage falls, but only to 42 per cent. Pagan (1996) lists only one recession in Australia in the 1870 to 1900 period, the severe recession of the 1890s, while there were seven recessions in the period from 1900 to 1939.

Figure 1: Recessions – NBER Methodology

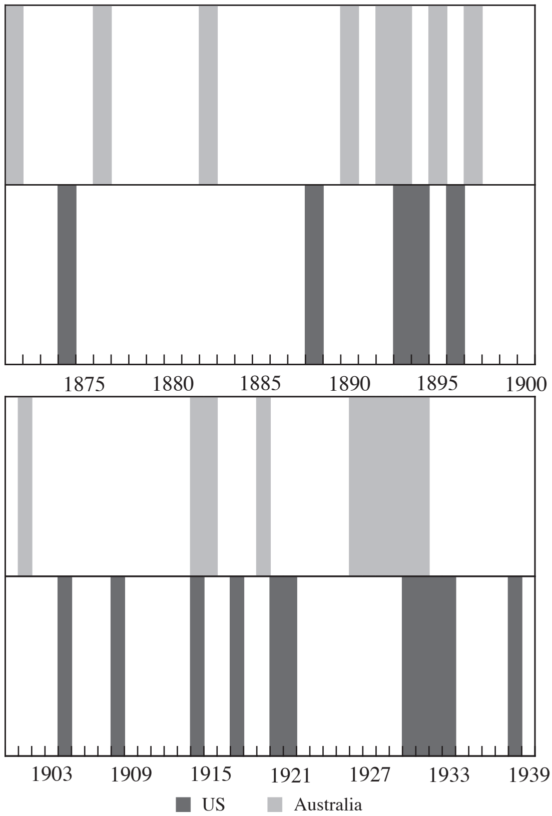
Sources: NBER; Pagan (1996)

The second point is that the timing of recessions appears to be quite different, except that both countries are in recession in the 1890s and the 1930s.

Figure 2 shows the years for which GDP growth was negative in Australia and in the US. Australia experienced more years of negative growth than the US from 1870 to 1900, with both countries having the worst of it in the 1890s. The post-1900 period was dominated by the Depression, though overall the US had more years of negative growth from 1900 to 1939. The conclusion regarding synchronisation remains as above. Aside from the severe downturns of the 1890s and the 1930s, recessions in Australia and the US were generally not coincident.

Overall this section illustrates quite clearly a couple of points. First, the Australian business cycle prior to 1939 was not particularly synchronised with the US (despite structural similarities that were quite evident in 1870) nor with other G7 economies. Second, Australia's connection with the economies of the rest of the world was restricted to the joint experience of two serious recessions.

Figure 2: Recessions – Negative Growth Methodology



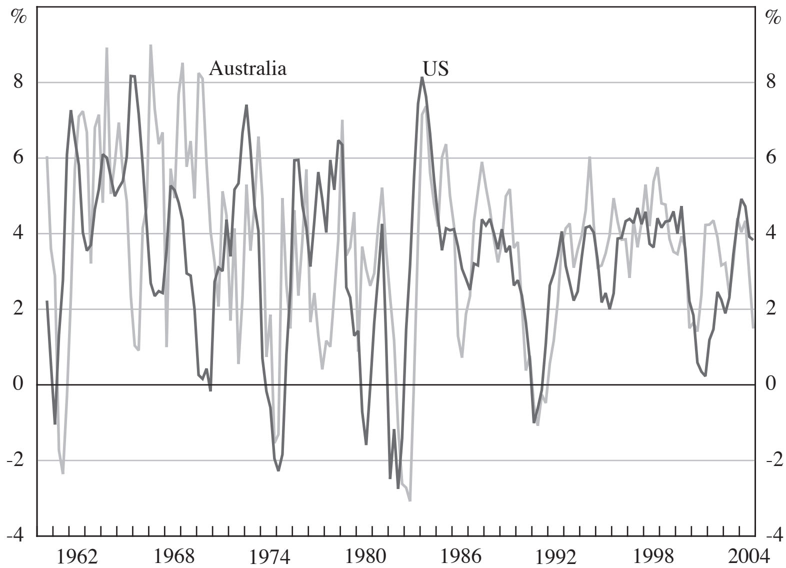
Sources: Lee and Passell (1979); Maddison (1995); authors' calculations

4. The Post-war Experience

In this section we analyse the post-war relationship between Australian and US business cycles. We begin by examining the correlation between Australian cycles and cycles in G7 countries, using methods similar to those employed in the papers described in Section 2. We then characterise both the changing nature of Australian output growth and its evolving relationship with US output growth since the early 1960s. We find that the high correlation between Australian and US GDP appears from around the time of the first oil shock in the early 1970s.

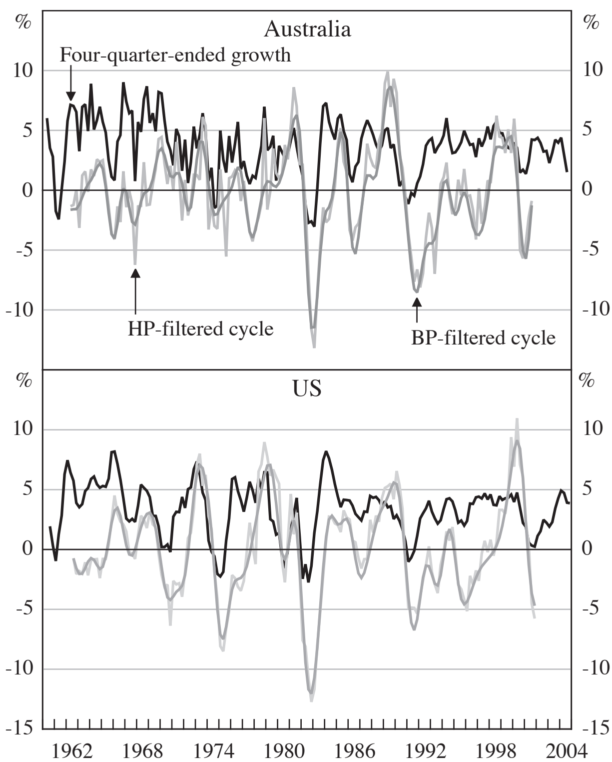
We focus our analysis in this section primarily on four-quarter-ended GDP growth rates for Australia and the US. Figure 3 provide a comparison between the two countries' growth rates, while Figure 4 compares the four-quarter-ended GDP growth rates to the levels data filtered using the Hodrick-Prescott filter and the Baxter-King band-pass filter. It can be seen that the filtered data are highly correlated with the four-quarter-ended data and we do not find any significant difference in our conclusions regarding synchronisation when we use the filtered data instead of the growth rate data.

Figure 3: Four-quarter-ended Growth Rates



Sources: ABS; Bureau of Economic Analysis (BEA)

Figure 4: Cycle Measures



Sources: ABS; BEA; authors'calculations

4.1 Correlations between Australian cycles and G7 cycles

In this sub-section we provide some simple comparative evidence on the correlation of the Australian cycle with all of the G7 countries. Table 3 suggests that the Australian economy has become much more highly correlated with the English-speaking countries of the G7 in the 1980s and 1990s and more decoupled from the economies of Germany and Japan. In the table we also compute the correlations with Australia when dates in which Australia is in recession are excluded. We date recessions using either one of two rules; at least two quarters of negative growth, or by taking dates from the Economic Cycle Research Institute (ECRI), which dates recessions using a methodology similar to that employed by the NBER to date US cycles (see Tables 4 and 5 for the actual dates). Correlations between Australia and the other English-speaking countries are lower in the expansion phase of the business cycle than in the full sample. This is particularly true when the ECRI dated recessions are excluded. In particular, the Australia–US correlation drops from 0.34 to 0.12 when one examines only the dates when Australia is not in recession.

Tables 4 and 5 provide the business cycle chronologies for Australia and the G7 countries when the NBER/ECRI dating scheme and the simple 'two quarters' rule for dating recessions are employed. Also included is summary information regarding the incidence of recessions, including the amount of time that recessions overlapped with Australia since 1948. The ECRI dating scheme finds that Australia spent 9.9 per cent of the time in recession, while the US was in recession more than 15 per cent of the time (Table 4). Germany and Japan spent more time in recessions, though the US had more recessions than any of the other countries in the table. Australia spent 68 months in recession, and the US was also in recession during 22 of these 68 months. It is true that Australia's recessions coincided more with those of the US than any other country. However, the most obvious feature of the table is that the recessions of the mid 1970s, early 1980s and early 1990s were shared by all countries (with the exception of Japan, which avoided a recession in the early 1980s).

When consecutive quarters of negative growth are used to date recessions it is again found that Australia spent roughly 10 per cent of the sample in recession (Table 5). Interestingly, Australia had more episodes of falling GDP than other countries in the table (other than Germany). It is also apparent that falls in GDP coincided more for Australia and Canada and Australia and the UK, than Australia and the US.

Both the correlations and the cycle dates suggest that Australia is closely tied to the US cycle, though this relationship is clear only since the early 1970s. It is notable that since the 1970s Australia has suffered from three global recessions and in general these recessions raised the cross-country correlations.

Table 3: Correlations with Australian Real GDP Growth
1961–2004

Sample	US	Canada	Germany	France[(a)]	UK	Italy	Japan
1961:Q1–1969:Q4	–0.05	–0.37	0.05	–	0.13	–0.36	0.00
1970:Q1–1979:Q4	0.08	0.26	0.45	–	0.19	0.56	0.40
1980:Q1–1989:Q4	0.57	0.72	0.46	0.14	0.11	0.60	0.42
1990:Q1–1999:Q4	0.80	0.79	–0.80	0.19	0.88	0.06	–0.49
2000:Q1–2004:Q4	0.28	0.07	–0.08	–0.20	0.07	–0.38	–0.22
1961:Q1–1982:Q4	0.24	0.39	0.34	–	0.19	0.28	0.38
1983:Q1–2004:Q4	0.59	0.66	–0.37	0.16	0.50	0.30	–0.02
1992:Q1–2004:Q4	0.39	0.34	–0.12	0.05	0.52	–0.03	–0.22
1961:Q1–2004:Q4	0.34	0.51	0.05	0.14	0.27	0.26	0.26
Expansions only[(b)]	0.12	0.30	0.21	0.05	0.19	0.25	0.31
Expansions only[(c)]	0.30	0.42	0.18	0.09	0.23	0.29	0.38

(a) Correlations with France begin in 1980:Q1.
(b) Correlations over the full sample excluding recessions, where recession dates are taken from ECRI.
(c) Correlations over the full sample excluding recessions, where recessions are defined as two or more quarters of negative growth.

Sources: ECRI; NBER; authors' calculations

Table 4: Business Cycle Chronology – NBER/ECRI Method
Monthly data

Period	Peak (P)/ trough (T)	Australia 1948–	US 1948–	Canada 1948–	Germany 1950–	France 1951–	UK 1952–	Italy 1956–	Japan 1953–
1948–50	P		11/48						
	T		10/49						
1951–52	P	6/51							
	T	9/52					8/52		
1953–55	P		7/53	5/53					
	T		5/54	6/54					12/54
1956–59	P	12/55	8/57	10/56		11/57			
	T	8/56	4/58	2/58		4/59			
1960–61	P	12/60	4/60						
	T	9/61	2/61						
1962–66	P				3/66			1/64	
	T							3/65	
1967–68	P								
	T				5/67				
1969–72	P		12/69					10/70	
	T		11/70					8/71	
1973–76	P	6/74	11/73		8/73	7/74	9/74	4/74	11/73
	T	1/75	3/75		7/75	6/75	8/75	4/75	2/75
1976–80	P		1/80			8/79	6/79		
	T		7/80			6/80			
1980–83	P	6/82	7/81	4/81	1/80	4/82		5/80	
	T	5/83	11/82	11/82	10/82		5/81	5/83	
1984–86	P								
	T					12/84			
1987–89	P								
	T								
1990–91	P	6/90	7/90	3/90	1/91		5/90		
	T	12/91	3/91						
1992–94	P					2/92		2/92	4/92
	T			3/92	4/94	8/93	3/92	10/93	2/94
1995–99	P								3/97
	T								7/99
2000–04	P		3/01		1/01				8/00
	T		11/01		8/03				4/03
Months in recession		68	104	72	140	88	63	92	121
Fraction of time in recession		0.099	0.152	0.105	0.212	0.136	0.099	0.156	0.194
No of recessions		6	10	4	5	5	4	5	5
No of months jointly in recession with Australia		–	22	11	21	17	18	18	7

Sources: ECRI; NBER

Table 5: Business Cycle Chronology – 'Two Quarters' Method
Quarterly data

Period	Peak (P)/ trough (T)	Australia 1960–	US 1956–	Canada 1956–	Germany 1960–	France 1970–	UK 1956–	Italy 1960–	Japan 1956–
1956–59	P						1/56		
	T						3/56		
	P		3/57	3/57			1/57		
	T		1/58	1/58			4/57		
1960–63	P	1/61			2/63		2/61		
	T	4/61			1/63		4/61		
1964–68	P	2/65			3/66			1/64	
	T	1/66			2/67			4/64	
1969–75	P	3/71	3/69				2/73	3/69	
	T	1/72	1/70				1/74	1/70	
	P	2/75	2/74		1/74	3/74	1/75	2/74	
	T	4/75	1/75		2/75	1/75	3/75	2/75	
1976–78	P	2/77						1/77	
	T	4/77						3/77	
1979–80	P		1/80	1/80	1/80	1/80	4/79		
	T		3/80	3/80	4/80	4/80			
1981–86	P	3/81	3/81	2/81	1/82			1/82	
	T	1/82	1/82	4/82	3/82		1/81	4/82	
	P	2/82							
	T	1/83							
1987–91	P	4/90	3/90	1/90			2/90		
	T	3/91	1/91	1/91			3/91		
1992–96	P				3/92	3/92		1/92	1/92
	T				2/93	3/93		4/92	3/92
	P								3/93
	T								1/94
	P								3/94
	T								1/95
1997–99	P								3/97
	T								4/98
	P								2/99
	T								4/99
2000–04	P				1/01				1/01
	T				4/01				1/02
	P				3/02			4/02	
	T				2/03			2/03	
Quarters in recession		19	13	14	25	9	22	19	17
Fraction of time in recession		0.106	0.066	0.071	0.138	0.064	0.112	0.106	0.087
No of recessions		8	6	4	8	3	4	7	6
No of quarters jointly in recession with Australia		–	3	5	1	0	6	3	0

Sources: authors' calculations, using ABS and BEA

4.2 Properties of Australian and US GDP

In this sub-section we carefully examine the time-series properties of GDP growth rates in Australia and the US. Table 6 provides some summary statistics for mean growth rates and their volatility for the two countries, as well as the contemporaneous correlation. It also provides the statistics by decade and for different sub-samples, and divides the data into the pre- and post-1974 periods. When we use formal tests for a break in the correlation relationship we find that this is the most likely break date in the sample. We also provide the summary statistics for the period since the end of the recession of the early 1990s, a period characterised by strong, stable growth in both countries.

These simple summary statistics are suggestive of a permanent slowdown in growth (a decline in potential GDP) in the late 1960s or early 1970s and a marked decline in volatility sometime in the 1980s or early 1990s for both countries. Over the whole sample period, the contemporaneous correlation of 0.34 is only slightly above the average correlation of 0.33 reported by Otto *et al* (2001) for bilateral correlations between 22 OECD economies. The simple correlations indicate that the close relationship between US and Australian GDP is one that only emerged somewhere in the middle of the sample period. In fact, the two countries' growth rates were negatively correlated prior to the first oil price shock, and strongly positively correlated thereafter. This pattern is illustrated in Figure 5, which shows 5-year and 10-year rolling correlations between the series over the sample.

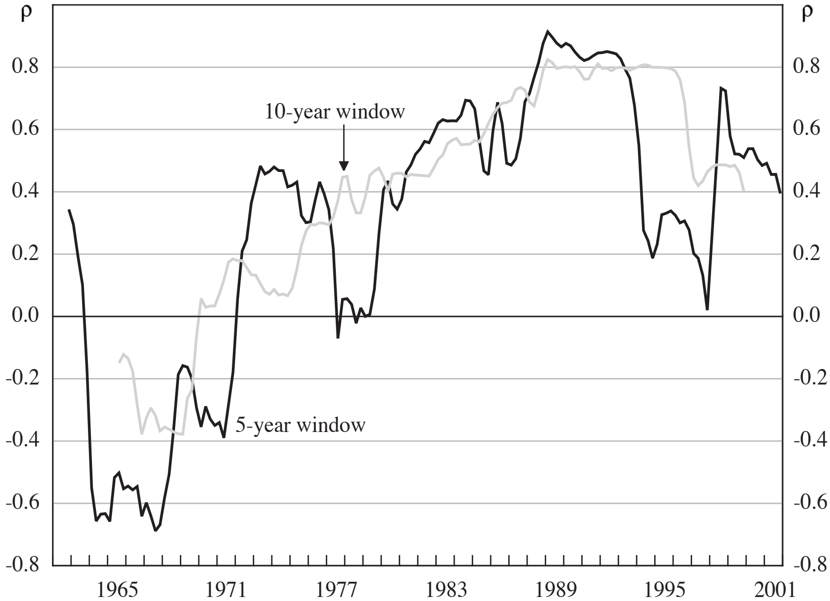
Table 7 presents dynamic correlations between leads and lags of US and Australian growth rates over the whole sample and across the main sub-samples of Table 3. The dynamic correlations suggest a substantially stronger correlation between lags of US GDP and Australian GDP than the reverse, consistent with the US economy leading the Australian economy – once again it is clear that this relationship has strengthened significantly since the mid 1970s.

Table 6: Summary Statistics for Four-quarter-ended Growth in Real GDP
1960–2004

Sample period	**Mean** (per cent)		**Standard deviation** (percentage points)		**Contemporaneous correlation**
	Australia	US	Australia	US	
1960:Q1–2004:Q4	3.59	3.33	2.35	2.23	0.34
1960:Q1–1969:Q4	4.84	4.54	2.87	1.98	–0.05
1970:Q1–1979:Q4	3.33	3.18	2.28	2.66	0.08
1980:Q1–1989:Q4	3.28	3.00	2.56	2.60	0.57
1990:Q1–1999:Q4	3.24	3.05	1.83	1.46	0.80
2000:Q1–2004:Q4	3.19	2.71	1.05	1.51	0.28
1960:Q1–1973:Q4	4.70	4.24	2.66	2.15	–0.15
1974:Q1–2004:Q4	3.13	2.95	2.05	2.17	0.52
1992:Q1–2004:Q4	3.63	3.26	1.16	1.21	0.39

Sources: authors' calculations, using ABS and BEA

Figure 5: Rolling Correlation Between US and Australian GDP Growth



Sources: ABS; BEA; authors' calculations

Table 7: Dynamic Correlations Between Four-quarter-ended Growth Rates

Correlations	1960:Q1–2004:Q4	1960:Q1–1982:Q4	1983:Q1–2004:Q4	1960:Q1–1973:Q4	1974:Q1–2004:Q4
$\rho(Aus_t, US_{t-4})$	0.32	0.19	0.47	0.27	0.26
$\rho(Aus_t, US_{t-3})$	0.44	0.30	0.56	0.22	0.46
$\rho(Aus_t, US_{t-2})$	0.47	0.28	0.64	0.10	0.54
$\rho(Aus_t, US_{t-1})$	0.43	0.19	0.65	–0.17	0.57
$\rho(Aus_t, US_t)$	0.33	0.23	0.59	–0.15	0.53
$\rho(Aus_t, US_{t+1})$	0.22	0.01	0.44	–0.40	0.35
$\rho(Aus_t, US_{t+2})$	0.09	–0.04	0.23	–0.32	0.14
$\rho(Aus_t, US_{t+3})$	0.01	0.01	0.04	–0.11	–0.05
$\rho(Aus_t, US_{t+4})$	–0.06	0.00	–0.08	0.02	–0.23

Sources: authors' calculations, using ABS and BEA

4.3 Allowing for time-varying GDP growth and volatility

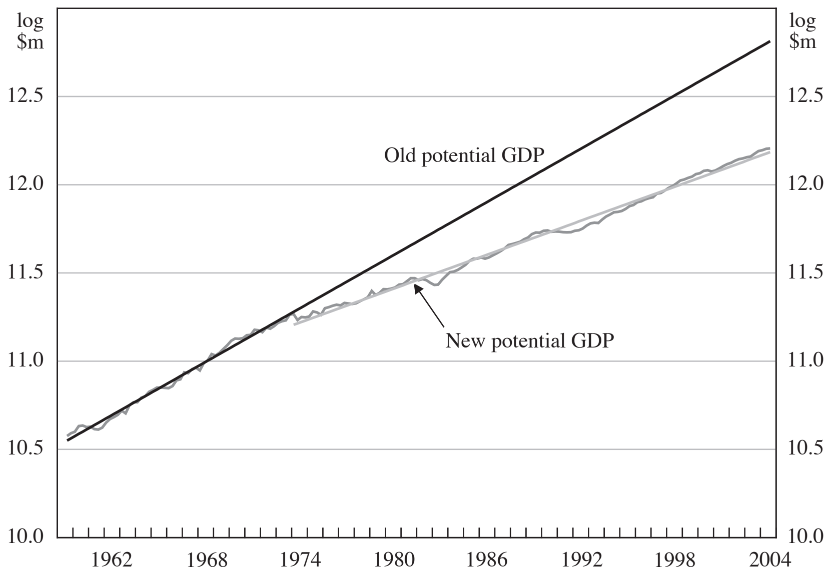
One possible explanation for the increase in the correlation between Australian and US GDP is that structural breaks in the mean or variance of GDP growth in one or both countries have affected the correlation over certain sub-samples. In both countries a decline in the volatility of GDP growth has been documented, and there is also some evidence of a fall in the mean GDP growth rate, at least in the case of Australia.

Many papers have documented the decline in volatility in the US economy starting in the mid 1980s, although there has been some debate over whether the decline has been smooth or due to a one-off shift, as well as potential causes of the decline (see Blanchard and Simon 2001, and McConnell and Perez-Quiros 2000). These papers find no apparent break in the mean growth rate of GDP (no shift in potential GDP) for the US, despite the much discussed productivity slowdown in the 1980s and the 'IT revolution' beginning in the mid to late 1990s.

In Australia, however, there is evidence of a break in mean GDP growth in the early 1970s as well as a similar decline in volatility to the US in the mid 1980s. The permanent fall in average GDP growth in the early 1970s in Australia, from around 5 per cent per annum to just over 3 per cent per annum, is fairly similar in timing and magnitude to the fall experienced in Canada (see Debs 2001 and Voss 2004), although Canada seems to have experienced increasing volatility in GDP growth in the 1980s and 1990s – the opposite of the Australian and US experience. Figure 6 illustrates the permanent slowdown in Australian growth around the time of the first oil shock.

Figure 6: The Break in Australian GDP

Millions of 2002/03 dollars in logarithms



Source: ABS

The Australian data do not show any evidence of a pick-up in productivity and GDP growth since the mid 1990s. Whilst trend growth has increased in Australia after 1995, from around 3 per cent per annum to over 4 per cent per annum (still well below the 5 per cent-plus average growth rates of the 1960s), this spurt in economic growth was not sustained into the new millenium. Average growth rates since 2000 have been, at best, similar to those experienced since 1971.

More formal evidence regarding the instability in the conditional moments of Australian and US GDP is provided in Table 8. Following Stock and Watson (2002), we conduct Andrews-Quandt-type break tests on the coefficients of an autoregressive model that allows either the conditional mean or the conditional variance, or both, to break, possibly at different dates. The estimated model is of the form,

$$y_t = \alpha_t + \phi_t(L)y_{t-1} + \varepsilon_t$$

where

$$\alpha_t + \phi_t(L) = \begin{cases} \alpha_1 + \phi_1(L) \text{ for } t \le \kappa \\ \alpha_2 + \phi_2(L) \text{ for } t > \kappa \end{cases} \quad \text{and} \quad Var(\varepsilon_t) = \begin{cases} \sigma_1^2 \text{ for } t \le \tau \\ \sigma_2^2 \text{ for } t > \tau \end{cases},$$

$\phi_1(L)$ and $\phi_2(L)$ are lag polynomials, and κ and τ are the break dates for the conditional mean and conditional variance respectively. The sup-Wald statistics (see Andrews 1993) used to test the stability of the conditional mean are computed for all possible break dates in the central 70 per cent of the sample. To test the stability of the conditional variance, the growth rate series was first demeaned, allowing for any break in mean found for the series, and the sup-Wald test statistics calculated for the residuals from the estimated regression run on the demeaned data.

Table 8 suggests that there is no significant break in the conditional mean of the US GDP growth series but there is strong evidence of a structural break in 1971:Q3 for Australia, somewhat before the occurrence of the first oil price shock. Filtering

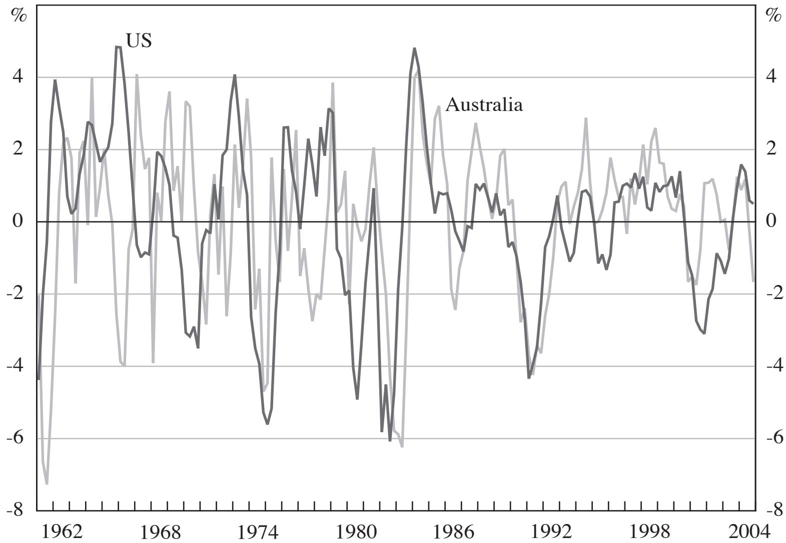
Table 8: Andrews-Quandt Tests for Structural Change in Moments of Real GDP Growth

Real GDP growth	Sup-Wald test	p-value	Break date
US conditional mean	10.79	0.47	–
Australian conditional mean	**26.88**	**0.00**	**1971:Q3**
US conditional standard deviation (constant mean)	**27.60**	**0.00**	**1984:Q4**
Australian conditional standard deviation (break in mean: 1971:Q3)	**34.88**	**0.00**	**1982:Q1**
Correlation of demeaned growth rates	**27.01**	**0.00**	**1973:Q4**

Note: Bold type indicates significance at the 5 per cent level.

the GDP growth rates on the basis of these results gave the demeaned growth rates as depicted in Figure 7.

Figure 7: Demeaned Real GDP Growth Rates



Notes: US constant mean = 3.33; Australian non-constant mean: pre-1971:Q3 = 4.91, post-1971:Q3 = 3.16

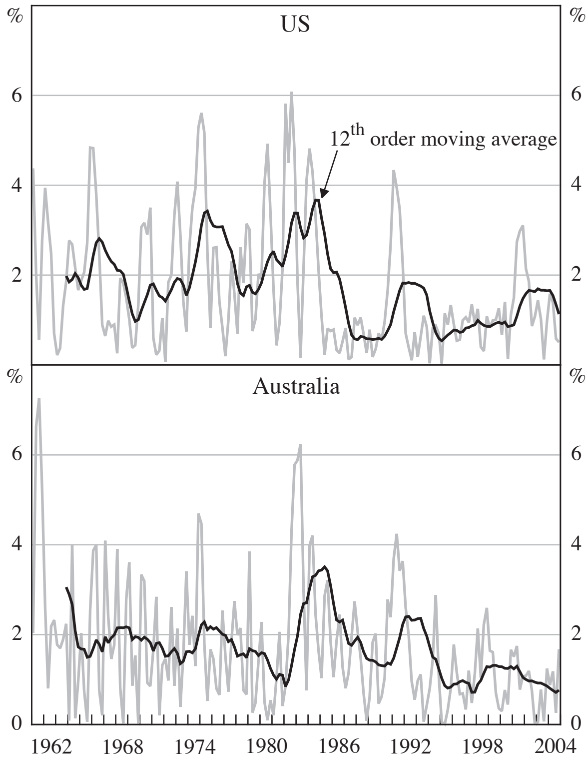
Sources: ABS; BEA; authors' calculations

Using these demeaned growth rates in the time-varying autoregressive models, tests were then performed on the stability of the conditional variances. The sup-Wald test statistics provide strong evidence of significant breaks in volatility for both economies. The evidence suggests a break in the US series towards the end of 1984, consistent with the date suggested by McConnell and Perez-Quiros (2000), Stock and Watson (2002) and Voss (2004).[3] The sup-Wald test statistic suggests that the break date for Australia is 1982:Q1. Time-varying measures of volatility – the absolute value of the demeaned four-quarter growth rates for each country and a simple 12th order moving average – are depicted in Figure 8. This provides further visual evidence of the decline in volatility in both countries.

Finally, to test the stability of the correlation between US and Australian growth rates, the sup-Wald test statistic was calculated for the coefficient on the US GDP growth rate in a simple regression of the demeaned Australian growth rate on the US growth rate. The test provides strong evidence of a significant shift in the correlation between Australian and US growth rates in 1973:Q4 after the recession caused by the first oil shock, thus formalising the break date suggested by the correlations in Table 6 and by Figure 5.

3. Voss suggests a break date for volatility for the US of 1985:Q1 whilst Stock and Watson provide a confidence interval for their US break date of 1982:Q4–1985:Q3.

Figure 8: GDP Volatility
Absolute value of demeaned four-quarter growth rates



Note: Australian volatility is filtered for broken mean (break = 1971:Q3)
Sources: ABS; BEA; authors' calculations

5. Understanding the Changing Correlation

In the previous section we provided evidence that both the US and Australian economies have undergone shifts in either mean growth rates, volatility, or both, and that the two economies moved towards a much higher degree of correlation with each other after the recession of the early 1970s. We now present some evidence as to why the Australian economy might have moved so much closer in terms of its cyclical variation to that of the US. In turn this will allow us to ask whether such changes are likely to persist into the future. We begin by examining the components of Australian GDP. This allows us to answer questions such as whether Australia's exports respond to US GDP growth in the same manner as Australia's GDP. We then examine some other macroeconomic variables, such as interest rates and employment growth. To fully understand changes in the correlation patterns a more structural approach would be preferable, but we think that the findings in this section are useful pointers for further research.

5.1 Correlations with Australian GDP components

Tables 9 and 10 present detail on the components of Australian GDP along similar lines to the evidence on GDP in Section 4. Table 9 shows that the mean and variance profiles of the Australian components are similar to the equivalent US components. The correlations with US components and with US GDP suggest that investment is the component of Australia's GDP that most closely tracks US GDP. In the 1970s and 1990s, Australian investment was highly correlated with US investment and US GDP. Interestingly the correlation dropped away in the 1980s. However, the overall pattern in Table 9 is suggestive that supply or productivity shocks in the 1990s were similar in Australia and the US, driving the high correlation between Australian and US investment and GDP.

Table 10 tests for constancy of the means and variances of the GDP components, as well as the stability of correlations. When considering the different components it appears from the break dates that the correlations rise at a later date than those of GDP itself.

5.2 Monetary policy

Table 11 details the behaviour of some other Australian macroeconomic variables. Nominal interest rates are highly correlated with US interest rates, except in the 1980s, while real interest rates show a pattern similar to GDP correlations – real rates were negatively correlated in the 1960s, but the correlation then increases in the 1970s and 1980s. However, the correlation between real rates is not evident beyond 1990. Interestingly, the graph of rolling 10-year correlations shown in Figure 9 clearly illustrates the similarity of monetary policy during the 1980 and 1990 recessions. In both countries these recessions were periods of very tight monetary policy as inflation was brought under control. It may be that the structural break tests (Table 12) and the correlation patterns decade by decade are not picking up similarity in monetary policy that was specific to a very small number of years over the sample.

Table 9: **Summary Statistics for Australian Real GDP Growth and its Components**
1961–2004

	1961–2004	1960s	1970s	1980s	1990s	2000s	1961–1982	1983–2004
Mean								
GDP	3.59	4.84	3.33	3.28	3.24	3.19	3.79	3.39
Consumption	3.55	4.51	3.55	3.10	3.19	3.36	3.95	3.11
Investment	3.96	5.27	2.26	4.69	3.46	4.81	3.90	4.02
Δ inventories/GDP	0.31	–	0.64	0.33	0.16	0.13	0.53	0.21
Exports	5.87	7.30	5.47	4.69	7.16	3.03	5.63	6.13
Imports	5.45	5.72	3.65	6.61	5.78	5.63	4.88	6.06
Standard deviation								
GDP	2.35	2.87	2.28	2.56	1.83	1.05	2.68	1.96
Consumption	1.74	2.14	1.68	1.55	1.55	0.67	1.87	1.48
Investment	6.25	3.14	4.33	7.42	7.26	9.19	4.52	7.71
Δ inventories/GDP	0.82	–	1.01	0.84	0.76	0.34	0.91	0.76
Exports	7.03	9.16	6.67	7.65	4.11	5.69	7.98	5.88
Imports	10.50	12.12	12.69	10.94	6.33	7.73	11.80	8.92
Standard deviation relative to US equivalent component								
Consumption	0.94	1.33	0.76	0.78	1.07	0.76	0.84	0.94
Investment	1.10	0.89	0.61	1.13	1.54	2.34	0.74	1.10
Δ inventories/GDP	1.54	–	2.05	1.40	1.96	0.58	1.53	1.50
Exports	1.08	1.54	0.92	1.06	1.14	0.74	1.12	1.08
Imports	1.45	1.96	1.42	1.31	1.48	1.05	1.46	1.45
Correlation with US equivalent component								
GDP	0.34	–0.05	0.08	0.57	0.80	0.28	0.24	0.59
Consumption	0.17	0.24	–0.06	–0.34	0.73	0.33	0.15	0.22
Investment	0.36	0.35	0.51	0.19	0.87	–0.20	0.33	0.41
Δ inventories/GDP	0.30	–	0.11	0.47	0.24	0.07	0.23	0.35
Exports	0.05	–0.22	–0.29	0.21	0.46	0.80	–0.22	0.54
Imports	0.21	–0.06	0.27	0.11	0.81	0.55	0.12	0.37
Correlation with US GDP growth								
Consumption	0.16	0.14	–0.07	–0.16	0.70	0.33	0.14	0.21
Investment	0.37	0.35	0.54	0.21	0.86	0.03	0.39	0.48
Exports	–0.04	–0.40	–0.26	0.28	–0.37	0.74	–0.14	0.16
Imports	0.13	–0.12	0.05	0.20	0.76	0.59	–0.02	0.50

Note: The change in inventories is measured in similar fashion to Stock and Watson (2002) as *100* x (*Δ inventories*/*GDP*) and is over the sample of 1974:Q3–2003:Q4 only.

Sources: authors' calculations, using ABS and BEA

Table 10: Structural Break Tests – Australian GDP Components and Correlations with the US

Australian GDP component	Sup-Wald test	*p*-value	Likely break date
Conditional mean			
Output (GDP_t)	**26.88**	**0.00**	**1971:Q3**
Consumption (C_t)	**23.16**	**0.01**	**1978:Q2**
Investment (I_t)	13.02	0.26	1967:Q4
Δ inventories/GDP	8.85	0.68	1979:Q3
Exports (Exp_t)	3.57	0.45	1969:Q3
Imports (Imp_t)	**17.29**	**0.07**	**1979:Q1**
Unconditional standard deviation			
Output (GDP_t)	**17.33**	**0.00**	**1992:Q2**
Consumption (C_t)	**11.27**	**0.02**	**1991:Q4**
Investment (I_t)	**28.54**	**0.00**	**1980:Q2**
Δ inventories/GDP	**7.32**	**0.09**	**1979:Q3**
Exports (Exp_t)	**18.66**	**0.00**	**1967:Q2**
Imports (Imp_t)	**20.55**	**0.00**	**1991:Q3**
Conditional standard deviation			
Output (GDP_t)	**34.88**	**0.00**	**1982:Q1**
Consumption (C_t)	7.64	0.81	1994:Q3
Investment (I_t)	13.11	0.25	1982:Q2
Δ inventories/GDP	9.17	0.64	1979:Q3
Exports (Exp_t)	7.53	0.82	1973:Q4
Imports (Imp_t)	9.05	0.65	1991:Q1
Correlation with US equivalent			
$\rho(AusC_t, USC_t)$	**14.68**	**0.00**	**1990:Q2**
$\rho(AusI_t, USI_t)$	**9.39**	**0.04**	**1984:Q4**
$\rho(AusInventories_t, USInventories_t)$	4.10	0.36	1993:Q3
$\rho(AusExp_t, USExp_t)$	**24.68**	**0.00**	**1982:Q4**
$\rho(AusImp_t, USImp_t)$	**11.42**	**0.01**	**1974:Q4**
Correlation with demeaned US GDP			
$\rho(AusC_t, USGDP_t)$	**12.64**	**0.01**	**1985:Q2**
$\rho(AusI_t, USGDP_t)$	**21.02**	**0.00**	**1984:Q4**
$\rho(AusExp_t, USGDP_t)$	5.78	0.18	1979:Q4
$\rho(AusImp_t, USGDP_t)$	**16.20**	**0.00**	**1974:Q4**

Note: Bold type indicates significance at the 10 per cent level.
Source: authors' calculations

Table 11: Summary Statistics – Other Australian Macroeconomic Variables

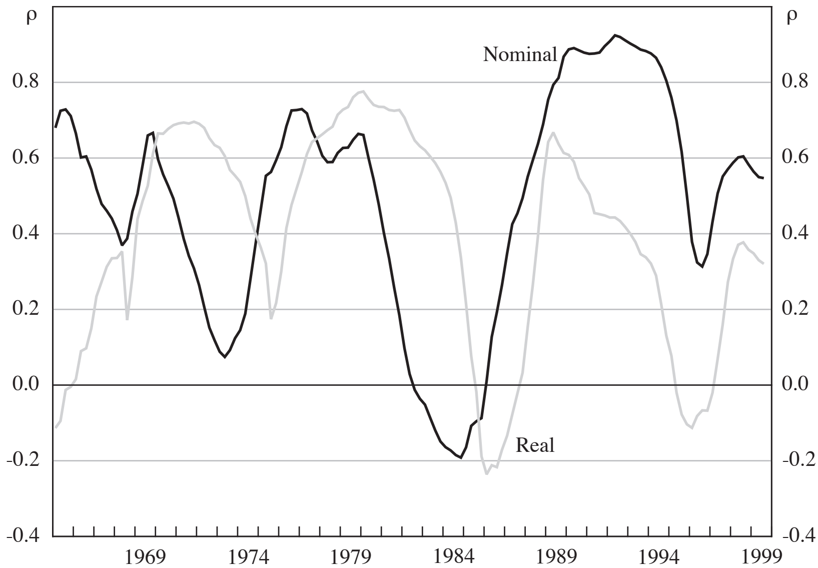
	Full sample	1960s	1970s	1980s	1990s	2000s
Mean						
Cash rate	6.18	3.85	6.85	14.03	7.24	5.11
Cash rate (real)	2.13	1.35	–3.16	5.66	4.88	1.68
M3 growth	10.74	–	11.82	13.17	8.12	8.93
Inflation	5.31	2.44	9.29	8.06	2.46	3.33
Δ inflation	0.00	0.00	0.17	–0.05	–0.14	0.02
Employment	2.05	2.89	1.63	2.40	1.23	2.18
Standard deviation						
Cash rate	4.20	0.70	2.92	2.99	1.01	0.42
Cash rate (real)	4.14	1.36	4.41	2.30	1.71	1.23
M3 growth	4.41	–	5.24	3.97	2.84	2.17
Inflation	3.87	1.51	3.77	2.08	2.07	1.32
Δ inflation	0.99	0.82	1.26	1.02	0.76	1.10
Employment	1.68	1.10	5.75	2.04	1.86	0.90
Correlation with US equivalent						
Cash rate	0.64	0.66	0.41	–0.15	0.77	0.74
Cash rate (real)	0.59	–0.11	0.36	0.23	0.08	–0.72
M3 growth	0.14	–	–0.09	–0.74	0.16	0.20
Inflation	0.71	0.29	0.57	0.33	0.76	0.58
Δ inflation	0.13	–0.23	0.30	–0.10	0.30	0.45
Employment	0.43	0.57	0.06	0.61	0.81	0.23

Notes: Variables are levels of 10-year, 90-day interest rates and annualised inflation rates, period-by-period change in annualised inflation, and four-quarter growth rates of seasonally adjusted M3 and non-farm employment.

Sources: authors' calculations, using ABS and RBA

Figure 9: Correlation between Short-term Interest Rates – Australia and the US

10-year backward-looking window



Source: authors' calculations

Table 12: Structural Break Tests – Other Australian Macroeconomic Variables and Correlations with the US

Australian variable	Sup-Wald test	*p*-value	Likely break date
Conditional mean			
Cash rate	**22.37**	**0.01**	**1986:Q3**
Cash rate (real)	14.02	0.19	1976:Q4
M3 growth rate ($M3_t$)	**18.82**	**0.04**	**1990:Q4**
Inflation (π_t)	12.02	0.33	1990:Q4
Δ inflation ($\Delta\pi_t$)	7.28	0.85	1975:Q1
Employment growth (Emp_t)	8.48	0.72	1997:Q3
Unconditional standard deviation			
Cash rate	**24.06**	**0.00**	**1991:Q2**
Cash rate (real)	**23.57**	**0.00**	**1992:Q3**
M3 growth rate ($M3_t$)	**30.13**	**0.00**	**1976:Q1**
Inflation (π_t)	**12.55**	**0.01**	**1983:Q3**
Δ inflation ($\Delta\pi_t$)	4.05	0.37	1985:Q3
Employment growth (Emp_t)	**17.93**	**0.00**	**1995:Q4**
Conditional standard deviation			
Cash rate	**24.67**	**0.00**	**1983:Q1**
Cash rate (real)	10.17	0.52	1974:Q4
M3 growth rate ($M3_t$)	**25.58**	**0.00**	**1975:Q3**
Inflation (π_t)	11.37	0.40	1975:Q2
Δ inflation ($\Delta\pi_t$)	8.55	0.71	1991:Q4
Employment growth (Emp_t)	12.54	0.29	1997:Q3
Correlation with US equivalent			
$\rho(cash_t, fedfunds_t)$	**82.24**	**0.00**	**1982:Q1**
$\rho(realcash_t, realfunds_t)$	**28.71**	**0.00**	**1983:Q4**
$\rho(AusM3_t, USM3_t)$	9.60	0.11	1990:Q2
$\rho(Aus\pi_t, US\pi_t)$	**19.44**	**0.00**	**1991:Q3**
$\rho(Aus\Delta\pi_t, US\Delta\pi_t)$	6.06	0.16	1990:Q3
$\rho(AusEmp_t, USEmp_t)$	**19.45**	**0.00**	**1982:Q2**

Note: Bold type indicates significance at the 5 per cent level.
Source: authors' calculations

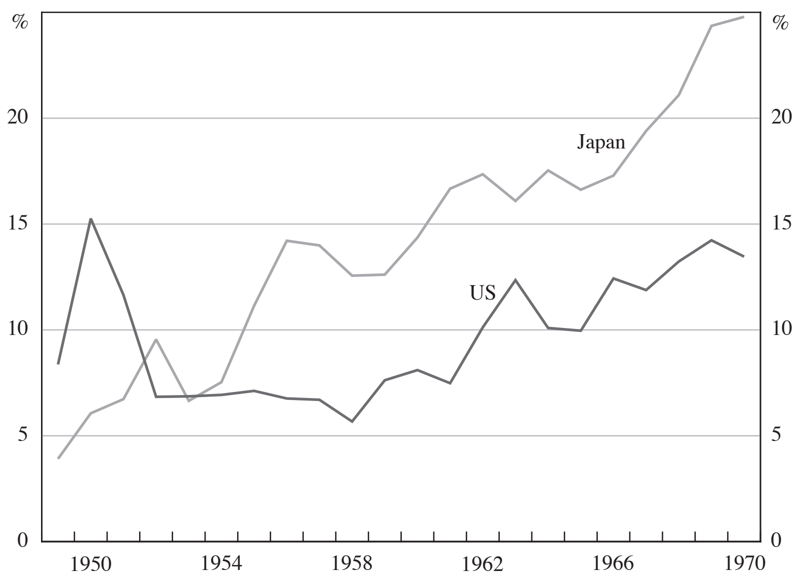
5.3 Looking ahead – will a growing China affect Australia?

Thus far in this section we have suggested that the Australian economy has been synchronised with the US and other economies in the post-war period mainly through synchronisation of monetary policy in the early 1980s and early 1990s, and the oil shock that affected global economies in the early 1970s. Currently, however, there is a debate in Australia about how closely the Australian economy is tied to the growth of the Chinese economy. One suggestion is that with the Australian resources sector and terms of trade heavily affected by China's growth, a slowdown in China will have serious negative consequences for the Australian economy.

We do not see risks associated with Australia's stronger trade relationships with China for two reasons. First, as discussed in Crosby (2004), we see it as unlikely that China's medium- to longer-term outlook will deteriorate, so that trade between Australia and China will continue to grow steadily. Second, we do not expect that any hiccup to China's growth will cause recession in Australia. In Figure 10 we show Japan's share of Australian trade from 1949 to 1970. During this period Japan's share of Australia's exports rose from around 4 per cent to almost 25 per cent. Despite this rise, the correlation between Australian and Japanese GDP growth in the 1960s is zero, as shown in Table 3. Japan remains Australia's major trading partner, but the poor performance of the Japanese economy since 1990 has not stopped Australia from achieving strong rates of economic growth since this time.

Figure 10: Australian Exports to Various Destinations

Per cent of total exports



Note: Prior to 1960, data are in financial years

Source: ABS

6. Conclusions

In this paper we examine the issue of whether or not the Australian economy is inexorably linked to the US economy. We argue that the pattern of a strong post-war correlation between Australian and US GDP is largely explained through the experience of three deep recessions with very similar timing. The latter two recessions were associated with very high real interest rates in both countries, and are commonly described as recessions in which monetary policy played a very prominent role. This high level of policy synchronisation can explain why the Australian economy has become more synchronised with the US since 1980, a pattern which is the opposite of that for other OECD economies studied in Heathcote and Perri (2003).

Prior to World War II the Australian and the US economies were not at all synchronised, despite economic structures that appeared quite similar. The only years during this period when the two economies were synchronised were during the 1890s recession and during the Depression years. Looking ahead, with both countries likely to achieve low inflation into the foreseeable future, one cannot see a high probability of monetary policy-induced recessions that occurred in the 1980s and 1990s. If the global economy catches a cold then Australia will no doubt be affected, but Australia has less to fear from idiosyncratic recessions in any particular major economy.

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Discussion

1. Andrew Stone

This paper by Mark Crosby and Philip Bodman focuses primarily on links between the Australian and United States business cycles. However, in so doing it aims to shed light more generally on the factors which might account for either actual correlation between the business cycles of different economies or the mistaken impression of correlation where, in fact, little exists.

The paper advances three main theses, drawn from a study of the Australian and US economies as far back as 1870. The first is that two of the popular channels for explaining the degree of co-movement between economies, trade and structural similarity, would seem to be of little help in accounting for the extent of correlation between Australia and the US, or how this has changed over time. On this issue, Crosby and Bodman contribute interesting new evidence through their examination of the period from the aftermath of the Civil War in the US to the start of World War II.

The paper's second main thesis is that caution should be exercised before reading too much into the strong increase since the early 1970s in the 10-year rolling correlation between Australian and US real GDP growth rates (see Figure 5 of the paper). Crosby and Bodman argue that much of this increase, as well as its high absolute level during the 1980s and 1990s, was driven by the common experience of sharp recessions in the early to mid 1970s, the early 1980s and the early 1990s – and thus may not reflect strong intrinsic coupling between the two economies. Rather, it could reflect a handful of episodes of economic downturn which merely happened to coincide despite being the result of independent shocks or policy actions in each country.

Finally, further developing this latter theme, Crosby and Bodman advance tight monetary policy in both the US and Australia as a key cause of the co-incident recessions experienced by both countries in the early 1980s and 1990s. Given that they see little reason for monetary policy in the two countries to move closely in tandem in the future, they therefore predict that the 1980s and 1990s will turn out to represent the high-water mark in the correlation between the Australian and US economies.

To anticipate what follows, I have considerable sympathy with each of these theses, and believe that Crosby and Bodman focus our attention on several of the key aspects of the apparent correlation between the Australian and US business cycles. However, there are also some caveats I would add to each of their theses, which I'll discuss briefly in turn.

The roles of trade and structural similarity

As I mentioned, Crosby and Bodman's first thesis concerns the importance of trade and industrial similarity in explaining the degree of co-movement between economies. Here, their chief contribution, and for me the most interesting part of their paper, is their use of an extended period of pre-WWII data to study this issue – covering nine countries, but with a particular focus on Australia, the US and the United Kingdom.

While acknowledging the limitations of the information available, the authors provide data suggesting a fair degree of structural similarity between the Australian and US economies in 1870. Both had large agricultural and mining sectors at that time and were heavily reliant on the UK as an export destination, with these exports concentrated in a small number of important (albeit different) goods. Nevertheless, the Australian and US business cycles do not appear to have been particularly synchronised during any part of the period 1870–1939, save during the 1890s and 1930s depressions; nor was the Australian economy much correlated with that of the UK during the decades from 1870 to 1930, despite remaining reasonably open and highly dependent on the UK for its exports (and capital) throughout this whole period.

These observations certainly argue for caution in attributing too much importance to trade linkages or structural similarities in driving co-movement between economies. However, there are two points of qualification which I think may be worth mentioning here.

The first is that the persistently low Australia–UK business cycle correlation may simply illustrate how the trade channel can actually cut both ways. While Australia's ongoing dependence on the UK as an export destination would have made her economy sensitive to the UK business cycle throughout this period, the extreme specialisation of her exports – with wool alone accounting for between one- and two-thirds of total exports to the UK – would have made her far more subject to the vagaries of idiosyncratic shocks such as drought and disease, and so less likely simply to co-move with the UK.

The second point is that, noting Sir Douglas Copeland's advice that 'if a figure looks wrong it probably is', I would go so far as to say that I simply don't believe the NBER-based US recession dates which Crosby and Bodman invoke to augment their evidence of asynchronicity between Australia and the US over the period 1870 to 1930.[1] For example, it scarcely seems plausible that the US economy could have been in recession for at least part of no fewer than 7 of the 10 years 1920–1929, the decade known colloquially in the US as the 'roaring twenties'! More generally, it seems hard to credit that the US economy could truly have spent around 45 per cent of the whole period from 1870 to 1939 in recession, when Maddison (1995) records the US as having achieved real per capita growth from 1870 to 1913 (over at least the first two-thirds of this period) at an average rate that was faster than that of any of 12 comparable western European countries, and double that of Australia.[2]

1. Whether this reflects inadequacies in the available data from this era, however, or other issues regarding the application of the NBER's methodology to an economy with the structure and dynamics of the US pre-WWII, I would not venture to guess.

2. Maddison also records US population growth as having been faster over this same period than in any of these 12 comparable western European countries – indeed, more than twice as rapid as in 9 of them – and only slightly slower than in Australia (Table A-2, p 62).

Recessions and business cycle correlations

Let me now turn to Crosby and Bodman's second main thesis, which is that impressions of strong co-movement between economies can be driven by the co-incident experience of recessions on only a small subset of any given sample. Crosby and Bodman provide strong evidence that this has indeed been the case for Australia and the US since the 1970s, which raises the possibility that the recent high correlation between their business cycles may not reflect any intrinsic linkage between the two economies. A word of caution, however, would seem to be warranted here.

Certainly, it is possible that two countries whose business cycles display little intrinsic co-movement could be made to appear more closely linked than they actually are by coincidentally experiencing one or more common recessions. In this case, re-computing the correlation between the two countries' business cycles with these joint recessions removed – as the authors do – would give a more accurate impression of the true, low degree of co-movement between them.

However, it could equally be that two countries whose business cycles are strongly correlated might find this correlation masked during normal times by statistical noise – especially where a measure such as GDP growth is used as the cyclical indicator for each country. In this case, it would precisely be recessions, where the 'signal-to-noise' ratio is high, in which the true degree of co-movement between the two economies would be revealed – so that excising these from the sample would be the last thing one would want to do.[3]

Hence, Crosby and Bodman's observation that much of the recent high correlation between the Australian and US business cycles has been driven by a small number of recessionary episodes, while noteworthy, does not necessarily undermine the notion of a strong degree of co-movement between the two economies. To settle this

3. This phenomenon can be thought of as a variant of the usual 'errors in variables' problem in econometrics. To see this, imagine a situation in which the true business cycles of two countries, $\tilde{y}_t^A$ and $\tilde{y}_t^B$, are perfectly correlated but are measured with error (with the measurement errors in each country assumed, for simplicity, to be orthogonal to each other and to the two countries' common true cycle). In this case we would have that

$$\tilde{y}_t^B = \alpha \tilde{y}_t^A$$
$$y_t^A = \tilde{y}_t^A + \varepsilon_t$$
$$y_t^B = \tilde{y}_t^B + \xi_t$$

where y_t^A and y_t^B denote the measured business cycles of countries *A* and *B* respectively. A simple calculation then yields that the observed cycles of the two countries would show a correlation

$$corr(y_t^A, y_t^B) = 1 \Big/ \sqrt{\left[1 + \frac{\operatorname{var}(\xi_t)}{\operatorname{var}(\tilde{y}_t^B)}\right]\left[1 + \frac{\operatorname{var}(\varepsilon_t)}{\operatorname{var}(\tilde{y}_t^A)}\right]}$$

which is strictly less than the true value of 1. Moreover, for given scales of measurement error in each country's cycle, this formula shows that the degree of bias of this measured correlation from its true value will be greater the smaller are the variances of the true cycles, $\tilde{y}_t^A$ and $\tilde{y}_t^B$, of the two countries. Hence, this bias would be exacerbated if periods of high volatility in the true business cycles of the two countries, such as joint recessions, are excised from the sample.

would seem to require detailed study of each episode to identify the factors driving recession in each country. As it happens, this naturally leads us to the authors' final main thesis and the issue of policy synchronisation.

Policy synchronisation

In the latter part of their paper, Crosby and Bodman argue that

> … the Australian economy has been synchronised with the US and other economies in the post-war period mainly through synchronisation of monetary policy in the early 1980s and early 1990s, and the oil shock that affected global economies in the early 1970s. (p 251)

They then argue that this suggests that the Australian economy is not intrinsically closely linked to that of the US, and so will not need to sneeze if the US catches a cold in the future. Once again, I believe that there may be a fair degree of truth to this latter conjecture. However, I think that two objections could be raised to their line of reasoning.

The first is that, if one is to focus on monetary policy as a cause of co-movement, there is a potential endogeneity issue to be addressed. After all, monetary policy itself is likely to be highly dependent on the current or expected future state of a country's business cycle.

To be fair, one might expect this endogeneity to tend to reduce the correlation between any two economies, all other things equal, as independent monetary policy-makers in each country attempt to minimise their own nation's output volatility – including that potentially induced by developments in the other economy. Hence, the observation that synchronised tight monetary policy in two countries had contributed to increased output volatility in each, and hence a higher correlation between their GDP growth rates, could still be noteworthy.

Nevertheless, it would still beg the question: why was monetary policy synchronised in the two countries, contributing to simultaneous recessions in each, and to what degree might this be the result of strong linkages between the two? For example, consider a situation where Economy A moves very strongly in line with Economy B, so that monetary policy in the former could be expected to closely mirror that in the latter. Were an inflationary boom to occur in Economy B, this would then be expected to spread to Economy A, possibly requiring monetary policy in both countries to be used to engineer slowdowns designed to bring inflation back under control. In this case, each country's co-incident experience of a slowdown stemming from synchronised tight monetary policy would be the result of a strong degree of co-movement between the economies, rather than an episode to be discounted on the grounds that both slowdowns were policy-driven.

The second objection, which naturally follows from the preceding discussion, relates to whether Crosby and Bodman are in any case right to fix so strongly on monetary policy as the explanation for the recessions of the early 1980s and 1990s in both the US and Australia. Important as monetary policy is, I cannot help but think that there were other significant factors at work in generating each of these recessions – and that consideration of these additional factors might, in fact, help to strengthen Crosby and Bodman's thesis of limited intrinsic linkage between the Australian and US economies.

For example, two added factors besides monetary policy which immediately spring to mind as contributing to Australia's deep recession from late 1981 to mid 1983 are the very severe drought of the early 1980s, and the direct impact of the so-called 'second wages explosion' in 1981 (as opposed to its indirect impact in causing the increase in real interest rates which Crosby and Bodman focus on). The former saw farm GDP fall by around 23 per cent in 1982–83, subtracting around 1 percentage point from overall GDP growth in that year. The latter saw average earnings increase by 13.3 per cent in 1980–81 and by 13.8 per cent in 1981–82, at a time when median inflation was averaging only just over 9 per cent per annum over the two years.[4]

As it happens, these two added factors were clearly idiosyncratic to Australia. Acknowledging a role for them would actually lend weight to Crosby and Bodman's thesis of limited intrinsic linkage between Australia and the US despite their joint experience of recession at that time – unless, of course, one were prepared to argue that it was the downturn in Australia which dragged the US economy into recession!

That said, to truly settle this question would require a careful analysis of the degree to which Australia's growth co-moved with that of the US in the early 1980s or early 1990s, after suitably abstracting from all such idiosyncratic factors. Such a detailed historical analysis would, I believe, both potentially bolster Crosby and Bodman's thesis of likely limited future co-movement between the business cycles of Australia and the US, as well as represent a nice counterpoint to the valuable pre-WWII historical evidence presented by them in the first half of their paper.

Reference

Maddison A (1995), *Monitoring the world economy, 1820–1992*, OECD Development Centre, Washington DC.

4. As an aside, the 'first wages explosion' in Australia occurred in 1973. This saw Australia's Conciliation and Arbitration Commission – an official body which at the time set wages for much of the workforce under Australia's highly centralised wage-setting system – award a 17.5 per cent increase in minimum wages at a time when consumer price inflation, although rising, was running at an annual rate of less than 6 per cent. This presumably also contributed significantly to Australia experiencing a recession shortly thereafter, rather than this recession being entirely the result of the (admittedly dramatic) first OPEC oil shock of the March quarter 1974.

2. General Discussion

The authors' assertion that similar monetary policies have played an important role in creating recessions, and thus in driving business cycle synchronicity, was contested by several participants. One participant argued that the most recent recession in the US was precisely an example of an insufficient tightening of monetary policy ultimately contributing to a recession, while another participant noted that the close linkage between US and Australian business cycles is econometrically robust to controls for monetary policy. Moreover, one participant expressed concern at drawing implications from the figure of rolling correlations between Australian and US interest rates (Figure 9), given the possibility these may be distorted by known outliers. Similarly, a couple of participants highlighted the role that wars have played in increasing synchronicity, arguing that these episodes should perhaps be treated differently from other periods.

In contrast to Crosby and Bodman's suggestion that monetary policy synchronisation may be a phenomenon of the past, a few participants thought that monetary policy might remain synchronised in the future. One participant pointed to recent experience in Asia, where loose monetary policy by the US Federal Reserve has had a substantial effect on bond and credit markets in the region, and argued that portfolio rebalancing effects are likely to promote similarities in monetary and financial conditions going forward. Other participants highlighted the role that structural reforms, especially relating to monetary policy, had in the 1980s and 1990s in driving business cycle synchronicity, and suggested that growth in capital and financial market linkages may also be important factors underpinning correlations in the future. And another participant built on the discussant's comments by questioning how monetary policy could be similar between countries with flexible exchange rates unless each country is facing a similar business cycle.

The quality of pre-war data was also a consistent theme of comments from participants. There was some question about the robustness of the paper's results to the use of an alternative data source constructed by Haig[1], which, when compared with the Maddison data used by the authors, tends to shift growth into different periods. A second participant suggested that the NBER dating methodology was not applied consistently prior to the 1960s, and that the earlier cycles are more representative of growth cycles than classical cycles. In contrast, though, a third participant argued that the large number of recessions in the US during the 1920s was not inconsistent with its characterisation as the 'roaring 20s', as the amplitude of expansions was substantially larger than the amplitude of contractions during that period.

The nature of the transmission mechanisms in the early part of the paper's sample was also questioned. In particular, it was noted that trade and financial linkages were likely to operate more slowly in the pre-war era, so that it is perhaps unsurprising that the correlation between these countries is not as high as it is

1. Haig B (2001), 'New estimates of Australian GDP, 1861–1948/49', *Australian Economic History Review*, 41, pp 1–34.

currently. In response to this, Mark Crosby noted that lagging one country's cycle does not qualitatively alter the authors' finding that correlations were substantially weaker in the pre-war period.

Finally, one participant questioned the appropriateness of excluding recessions, arguing that it is natural for economies to be growing, and that the joint occurrence of recessions is therefore a notable event. Mark Crosby agreed with this comment, but echoing points raised in the discussion of previous sessions, he noted that his findings imply that research should focus on what causes these recessions.

The Australian Business Cycle: A Coincident Indicator Approach

Christian Gillitzer, Jonathan Kearns and Anthony Richards[1]

1. Introduction

This paper constructs coincident indicators of Australian economic activity and uses them to explore several features of the business cycle. These coincident indicators extract the common component from a large number of series using techniques recently developed by Stock and Watson (1999, 2002a, 2002b) and Forni *et al* (2000, 2001). These techniques have been used to construct coincident indices for the US (the Chicago Fed's CFNAI index) and Europe (the EuroCOIN index published by the CEPR).

There is a long-standing debate in the academic literature, dating from the seminal work of Burns and Mitchell (1946), as to whether the business cycle should be measured using GDP or some average of individual economic series. While GDP by definition measures the total output of the economy, there are several arguments as to why coincident indicators may be a useful alternative measure of the state of the economy. GDP, like other economic series, is estimated with noise. An index that uses statistical weights to combine a large number of economic series may be able to abstract from some of this noise. Assessing the business cycle based only on aggregate GDP may also obscure important developments relating to different sectors of the economy. For example, estimates of GDP may at times be driven by temporary shocks to one part of the economy, for example short-lived shocks to the farm sector or to public spending, that are not representative of developments in the broader economy. A further advantage of coincident indicators is that they can be constructed with monthly data, and if they are produced on an ongoing basis they may be more timely than GDP because many economic series are published with a shorter lag than GDP. Coincident indicators could potentially be less prone to the revisions experienced by GDP, in part because they can be constructed from series that either are not revised or are subject to smaller revisions.

Both the Stock and Watson (hereafter SW) and Forni, Hallin, Lippi and Reichlin (FHLR) techniques assume that macroeconomic variables – or more specifically, growth rates in most macroeconomic variables – can be expressed as linear combinations of a small number of latent 'factors'. The SW and FHLR techniques use large panels of individual data series to estimate these unobserved factors, which are common to the variables in the panel. These factors can be used to produce coincident indices of the common economic cycle in the variables (Altissimo *et al* 2001; Federal Reserve Bank of Chicago 2000, 2003; Forni *et al* 2000, 2001; and Inklaar, Jacobs

1. Thanks to Adrian Pagan, James Stock, Mark Watson, and seminar participants at the RBA for comments.

and Romp 2003). They can also be used to forecast macroeconomic variables (for example see Artis, Banerjee and Marcellino 2005; Bernanke and Boivin 2003; Boivin and Ng 2005, forthcoming; Forni *et al* 2005; and Stock and Watson 1999, 2002a, 2002b) and to identify shocks (for example in a VAR framework by Bernanke, Boivin and Eliasz 2005 and Forni and Reichlin 1998).

The remainder of this paper proceeds as follows. Section 2 discusses coincident indices and the intuition of factor models. Section 3 more formally explains the SW and FHLR techniques. Section 4 briefly discusses the panel of data we use. The estimated quarterly and monthly coincident indices are presented in Sections 5.1 and 5.2. In Section 6 these coincident indices are used to investigate the changing volatility and structure of the Australian business cycle, the length of economic expansions and contractions, and its correlation with the US business cycle. We conclude in Section 7.

2. Coincident Indices and Factor Models

Consider a world in which the growth rate of each macroeconomic variable can be regarded as the sum of a common cyclical component and an idiosyncratic term (which might include any sector-specific shocks). For example, residential construction should broadly follow the overall economic cycle but might also be affected by tax changes or immigration flows. By taking an average of a large number of variables from a wide range of sectors, the shocks to specific series or groups of series – the idiosyncratic components – should tend to average out to zero, leaving just the common component. This common component would capture the business cycle – that is, the overall state of economic activity, which we would expect to be fairly persistent or slow moving and not noisy like individual series.

This is the essence of what coincident indices attempt to achieve – averaging a range of variables to capture the common economic cycle. In practice, there are complexities in the data that alternative methods of constructing coincident indices address in different ways. To account for the fact that some variables are more cyclical than others, coincident indices are often constructed using normalised growth rates, or binary variables to indicate whether a series increased or fell. Some coincident indices place greater weights on series that are considered to be more reliable indicators of the business cycle, while others take a simple average of all of the series. Finally, not all economic series are going to be perfectly aligned, some, such as finance approvals, may be leading while others, such as the unemployment rate, may be lagging. Some techniques restrict the index to series that are coincident, while other methodologies attempt to align the series according to their typical leading or lagging relationships.

The more recent factor methodologies that we use in this paper use advanced statistical techniques to address these issues. They use a broad panel of series with the idea that using more series means that the influence of idiosyncratic shocks of any one series will be smaller, thereby making the estimate of the economic cycle more precise. In addition, they weight particular series according to the information they contain about the common cycle. Series that typically experience larger idiosyncratic shocks will receive a smaller weight. They also use normalised growth rates, rather than censoring the data as binary variables, so as to extract the greatest amount of information from each series. One of the techniques used (FHLR) explicitly takes account of leading and lagging relationships among the variables, while the other (SW) can potentially also deal with this issue. Finally, these methodologies allow for the possibility of several common 'cycles' or factors (rather than just one), some of which may be affecting some economic series more than others.

These new methodologies that extract multiple common factors from large panels of data have not been used to study the Australian business cycle. However, this paper can be seen as the latest iteration in a long literature that has constructed simpler coincident indices to study the Australian economy. Beck, Bush and Hayes (1973) and Bush and Cohen (1968) use large panels of data to construct historical coincident indices by first defining peaks and troughs for each series and then calculating the index as the proportion of series that were in an expansion phase in each month. Haywood (1973) constructs several coincident indices using unweighted and judgementally-weighted averages of both normalised monthly changes and binary indicators of the sign of monthly changes. Boehm and Moore (1984) construct a coincident index from an average of six economic series. The Boehm and Moore work has carried forward as the coincident indicators produced by the Melbourne Institute of Applied Economic and Social Research and the Economic Cycle Research Institute.

3. The SW and FHLR Methodologies

Both the SW and FHLR methodologies assume that economic time series data have an approximate factor representation. That is each series, x_{it}, can be represented by Equation (1)

$$x_{it} = \lambda_{i0} f_t + \lambda_{i1} f_{t-1} + \ldots + \lambda_{is} f_{t-s} + \varepsilon_{it} \tag{1}$$

where f_t is a vector of the q (unobserved) mutually orthogonal factors at time t, λ_{ij} is a row vector of factor loadings on the j^{th} lag of the factors and ε_{it} is the idiosyncratic residual. All of the series, x_i, are expressed in stationary form. For most series, this involves taking the first difference of the log of the monthly or quarterly series. Hence, the factors that emerge from these models can be thought of as monthly or quarterly growth rates. To ensure that the relative volatility of individual series does not affect their importance in estimating the factors, all series are transformed to have zero mean and unitary standard deviation. Equation (1), often referred to as a dynamic factor model, is an approximate factor model in that the residuals, ε_{it}, are allowed to be weakly correlated through time and across series. This differs from the older style of exact factor models in which the residuals are uncorrelated in both dimensions. The common component of series i is that part that can be explained by the factors, and so is equal to the difference between the actual value and the idiosyncratic residual, $(x_{it} - \varepsilon_{it})$.

Where the SW and FHLR methodologies differ is in how they estimate the factors and factor loadings. SW is estimated in the 'time domain', while FHLR is estimated in the 'frequency domain'. SW estimates the loadings and factors by calculating the principal components of the series. To include lags of the factors, the model is estimated using a 'stacked panel', that is, augmenting the data matrix X (the matrix of the x_{it}) with lags of itself. In doing so, SW estimates f_{t-1} and f_t as separate sets of factors, implying that the model has $r=q(s+1)$ separate factors.

While SW uses the eigenvalues and eigenvectors of the covariance matrix of the data (principal components) to calculate the factors and loadings, FHLR obtains the factors and loadings by first calculating the eigenvalues and eigenvectors of the spectral density matrix of the data. By using the spectral density matrix, FHLR explicitly accounts for any leading or lagging relationships among the variables. The FHLR index also removes high-frequency volatility, a step that is possible because FHLR constructs sample estimates of the spectral density matrix of the panel of data.[2] This results in a smoother index.

Because of these differences in the estimation methodologies, SW is often referred to as being a 'static representation' of the factor model while FHLR is referred to as being a 'dynamic representation'. As noted, FHLR explicitly takes into account the possibility of leads and lags in the relationship, while SW treats lagged factors as separate factors. Since FHLR effectively aligns the data to estimate q factors, rather than r factors as in SW, it should be more efficient. This advantage of FHLR comes at the expense of additional complexity in estimation, including the need to decide on values for some estimation parameters (for example, to obtain a sample estimate of the spectral density matrix). SW is typically estimated as a one-sided filter (that is, it uses only lagged data), while FHLR is a two-sided filter, using both leads and lags in its construction. As a result, while SW will truncate the beginning of the sample if lags are included, FHLR will truncate both the beginning and end of the sample. In fact, the FHLR methodology typically uses a longer window to estimate the lagging relationships and so will truncate more of the beginning of the sample. These differences are less of an issue for the historical analysis in this paper, but an extra step is needed to construct provisional up-to-date estimates of a FHLR index.[3] An additional advantage of SW is that it can be estimated using an unbalanced panel (if there are missing data, or with mixed-frequency data) through the use of an iterative procedure that imputes the missing data and re-estimates the model.

The question then arises as to how the estimated factors should be interpreted with regard to the business cycle. If there is only one factor (q=1), then that factor is the only common feature driving the economic series and so has a natural interpretation as a business cycle index. However, that factor can be scaled by a constant (with the factor loadings scaled by the inverse of that constant) without ostensibly changing

2. The quarterly and monthly FHLR indices abstract from volatility with a frequency less than $2\pi/5$ (five quarters) and $\pi/7$ (fourteen months) respectively.

3. The EuroCOIN index, which is calculated using the FHLR method, is initially published on a provisional basis and is revised for several months.

the model. In other words, the factor is only identified up to multiplication by a scalar constant. While relative changes across time have a natural interpretation, the absolute level of the factor has no defined meaning. If there is more than one factor then the interpretation of the individual factors is less clear. Not only can each factor be arbitrarily scaled by a constant, but the model given by Equation (1) can be represented by alternative linear combinations of the factors. Technically, the factors are only identified up to an orthogonal rotation. It is then not possible to interpret one factor as the business cycle, another as the trade cycle, and so on.

In the Chicago Fed's application of the SW methodology, the implicit assumption is that there is only one factor driving the economic series, and so the CFNAI takes the first factor as being the business cycle index (scaled to have a standard deviation of one). Alternatively, statistical criteria or rules can be used to determine the number of factors that are needed to adequately characterise the panel of data. Two approaches have been used in the literature. Authors using the FHLR methodology have used a given threshold for the marginal explanatory power of each factor included in the model; that is, the increase in the panel R-squared from adding one more factor to explain the panel of data (see Altissimo *et al* 2001; Forni *et al* 2000, 2001; and Inklaar *et al* 2003). So, the marginal explanatory power of the q^{th} factor will exceed the threshold (usually 5 per cent or 10 per cent is used) while the marginal explanatory power of the $(q+1)^{\text{st}}$ factor will be less than this threshold. We follow Altissimo *et al* (2001) in using a 10 per cent threshold. Alternatively, Bai and Ng (2002) have developed information criteria for the static (SW) representation based on the trade-off between the improvement in fit from additional factors and model parsimony. Bai and Ng find that their information criteria often selects too many factors in panels with fewer than 40 series. However, for our dataset we find that their information criterion IC2 puts a reasonable bound on the number of factors, and so we use this criterion to guide the number of factors in the SW estimation.[4]

If more than one factor is important in explaining the data in the panel, the business cycle index can then be constructed as a weighted average of those factors. Authors using the FHLR methodology have used as their weights the factor loadings for GDP, which is included in the panel of data in this methodology. Hence, the business cycle index in this case is the common component of GDP; that part of GDP that can be explained by the factors. Because the data used to derive the factors are mostly log differenced, the index has a natural interpretation as a monthly or quarterly growth rate of the economy (scaled to have mean zero and standard deviation of one). However, while more than one factor may be required to represent the entire panel, this does not imply that all of those factors will be important in explaining GDP. Indeed, in our data the factors other than the first factor often have small weights so the common component and business cycle index closely resemble the first factor. This raises the possibility that some of the higher order factors might be better thought of as representing some common feature in particular groups of series represented in the panel, rather than factors that are integral to the business cycle.

4. Some of their other information criteria seem to be less robust in our smaller samples, often picking the maximum number of factors the test allowed.

4. Data and Estimation

The composition of the data panel is crucial when estimating a factor model. If the panel contains a disproportionate number of variables from a particular part of the economy, for example the traded goods sector or the labour market, then the factors are likely to bear a closer resemblance to that part of the economy than the overall economy. In compiling the panel of data used in this study, we take care to avoid having too many similar series, and ensuring that, as far as possible, a wide range of variables (for example, from the expenditure, production and income sides of the economy) are included.

The coincident indices are estimated over two sample periods. For the period September 1960 to December 2004 we estimate the indices with quarterly data using a balanced panel containing 25 series (for brevity, we refer to this as the 1960–2004 sample). We estimate monthly coincident indices over a shorter period, January 1980 to December 2004, as there are insufficient monthly series over the longer sample period. The monthly coincident indices are estimated using a balanced panel of 29 series. The number of various types of economic series contained in the monthly and quarterly panels is shown in Table 1. We also undertake robustness analysis in which we estimate the indices using broader panels that are either unbalanced or have a shorter time span, and include up to 111 series. All series are transformed to make them stationary; for most series, this involves using log differences. Appendix A contains a full list of the series in each panel and their sources, and indicates how they are transformed.

Most earlier studies that estimate approximate factor models have used data for the US or Europe, where there are literally hundreds of suitable data series, so they have typically used over 100 series and even up to 450 series. While there are many hundreds (if not thousands) of economic time series in Australia, many of these are not suitable for this study, either because their histories are too short, they have too many missing observations, or they duplicate other available series.

Table 1: Composition of Data Panels
Number of series in each category of economic series

	Quarterly 1960–2004	Monthly 1980–2004
National accounts	6	0
Employment	2	6
Industrial production	4	0
Building and capital expenditure	2	3
Internal trade	1	2
Overseas transactions	4	7
Prices	4	2
Private finance	2	7
Government finance	0	2
Total	25	29

Some other series are excluded to ensure that the panel has a reasonable balance across different categories of economic variables.

However, using a smaller panel may not necessarily lead to less accurate estimates of the business cycle. Boivin and Ng (forthcoming) argue that adding additional series to a panel need not improve the factor estimates if the additional series are noisy or have correlated errors. In previous applications, larger panels have typically been obtained by disaggregating series into their sectoral or regional components (for example, employment in different industries, or housing approvals in particular areas). Such series are likely to contain more idiosyncratic noise, and are likely to have correlated idiosyncratic components. Indeed, Boivin and Ng find that the factors from a panel with as few as 40 series sometimes produce more accurate forecasts than those derived from a panel of 147 series. Watson (2001) also finds that the marginal improvement in forecasting performance from using greater than 50 series is very small. And Inklaar *et al* (2003) find that they can produce an index that closely matches the EuroCOIN index using a subset of just 38 of the 246 series that are used in constructing the EuroCOIN index.

5. Results

In Section 5.1 we present the coincident indices constructed with quarterly data for the period 1960–2004, and analyse their robustness to alternative specifications. In Section 5.2 we present the indices constructed with monthly data for the period 1980–2004, and consider their robustness.[5]

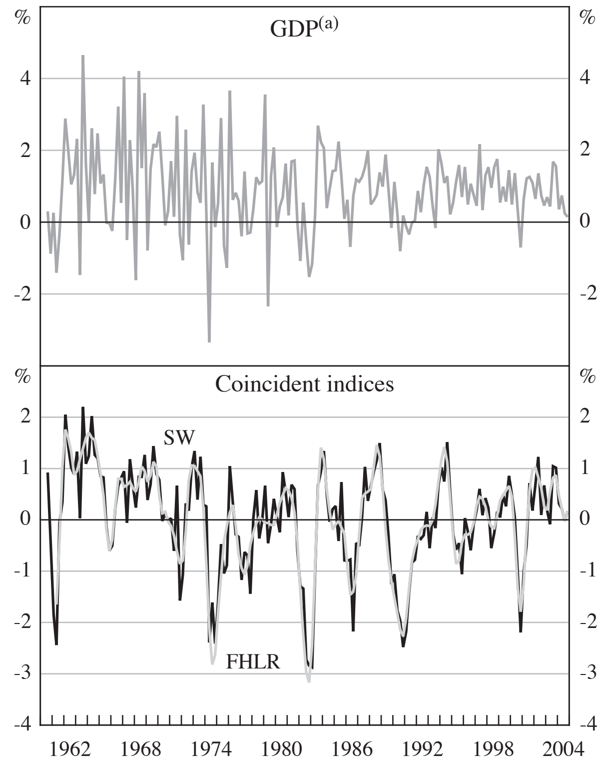
5.1 Quarterly coincident indices

The coincident indices constructed with the SW and FHLR methodologies – using the quarterly balanced panel from 1960 to 2004 – are shown in Figure 1. Recall that most series used to derive the factors are log differenced and so the index has a natural interpretation as a quarterly growth rate of the economy (scaled to have mean zero and standard deviation of one). The SW index is estimated with no lags so that each value is a function of only the contemporaneous data (and constant weights which are estimated using the full sample). However, if the common component is sufficiently persistent it may not matter too much if some series are slightly leading or lagging. Providing that the leads and lags are short compared to the length of the common cycle, these series will still help to provide an estimate of the common cycle, despite not being perfectly aligned.

As discussed in Section 3, an information criterion can be used with the SW methodology to determine the number of factors required to explain the panel. The information criterion finds that there is only one factor, and so our SW index is simply the first factor, that is the first principal component. This first factor explains 23 per cent of the variation in the panel of 25 series. For the FHLR index, the explanatory

5. We would like to thank Robert Inklaar for providing Matlab code used to estimate FHLR, and Mark Watson, from whose website we obtained Gauss code used to estimate SW.

Figure 1: Quarterly Coincident Indices



(a) 100 × log difference of GDP

Sources: ABS; authors' calculations

power threshold selects two factors. These two factors explain 37 per cent of the total variance in the panel.

As can be seen in Figure 1, the two indices are very similar; indeed their correlation is 0.91. The most apparent difference is that the FHLR index is somewhat smoother because it removes high-frequency volatility by construction (as is discussed further below). Note also that the FHLR index is shorter by three quarters at both its beginning and end, because it requires leads and lags to estimate the spectral density matrix.

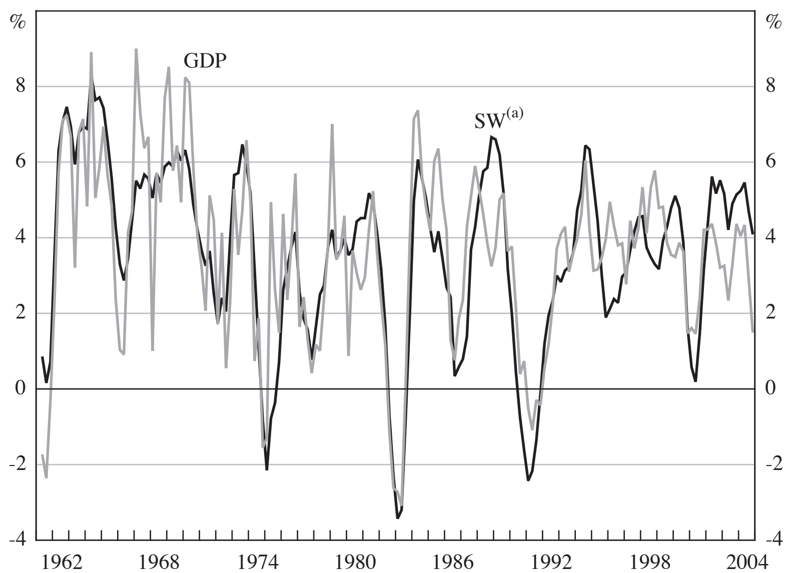
Both series are substantially smoother than quarterly changes in GDP (throughout we use 100 × log difference of GDP, to be consistent with the log differences used in the construction of the indices). It is not surprising that the FHLR index is less volatile than GDP as it is constructed as a two-sided filter, that is, using data either side of a given quarter to provide a smoother indicator, and is additionally smoothed by removing high-frequency movements. But the value of the SW index in a given quarter is constructed from only data in that quarter – it is not smoothed in any way other than the fact that it uses the cross section of data. Further, the SW index uses only the first factor, while the FHLR index is an average of two factors.

There are clear economic cycles in the two constructed coincident indices, while it takes a more highly trained eye to discern a cycle in the quarterly changes in GDP. Both of our indices show three major downturns in economic activity over the 45-year period; in the mid 1970s, the early 1980s and the early 1990s. Smaller economic downturns show up clearly in the early and late 1970s, the mid 1980s, and a spike down in 2000 associated with the introduction of the GST. The long boom of the 1960s is evident with both indices around one standard deviation above zero for much of the decade. The past ten years or so has also seen the indices being positive on average, indicating stronger-than-average economic conditions.

Annual growth rates are often used to get a smoother picture of GDP growth. However, Figure 2 shows that annual GDP growth is still much noisier than the annual change in the SW index (the four-quarter sum, scaled to have the same mean and variance as annual GDP growth). The FHLR index is not shown since the annual changes are almost identical to those of the SW index.

While the scaled growth in the SW index is typically around the same rate as GDP, differences do open up at times. Indeed, the SW index has been notably stronger than GDP growth over the past few years. This presumably reflects the relative importance of some series that have been very strong over this period (including employment and domestic demand).

Figure 2: Annual Rates of Change



(a) SW is the 4-quarter rolling sum of the SW quarterly index, scaled to have the same mean and variance as annual GDP growth. For consistency, GDP growth is also measured as the four-quarter log difference.

Sources: ABS; authors' calculations

5.1.1 Robustness of the quarterly indices

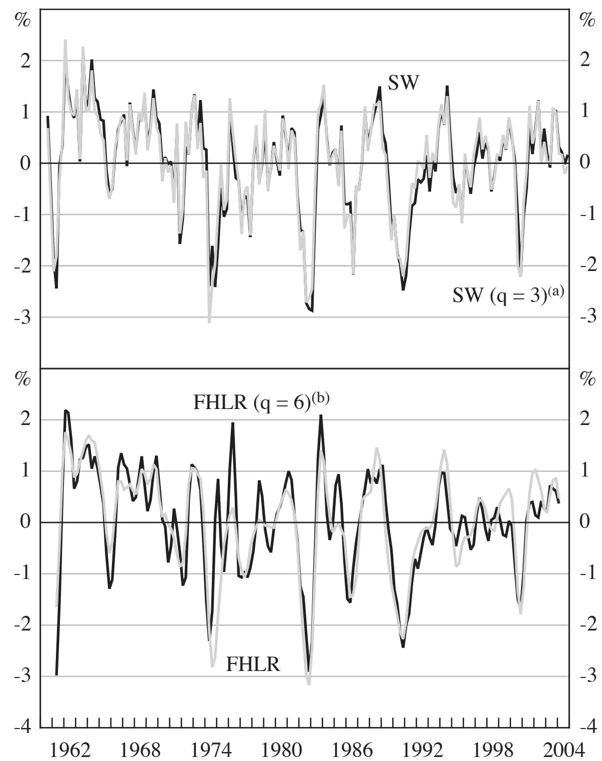
As discussed in Sections 2 and 3, the number of factors that are combined to form an index, and the composition of the panel used for estimation, will influence the behaviour of that coincident index. We examine the sensitivity of the SW and FHLR indices along these two dimensions.[6] Firstly, we construct both indices using alternative numbers of factors. Secondly, both indices are estimated using a much broader panel of 76 series that are available from 1980. We also examine the sensitivity to the breadth and composition of the panel by using even broader panels that are not balanced (that is they contain some missing observations) which can be used with the SW methodology. The non-balanced panels starting in 1960 and 1980 contain 68 and 111 series, respectively.

The information criterion for the SW index shown in Figure 1 selects one factor. However, an alternative information criterion proposed by Bai and Ng (2002), the IC1, selects three factors. As shown in the top panel of Figure 3, the coincident index constructed as the common component of GDP explained by the first three factors is very similar to, though slightly more noisy than, the one-factor SW index. The similarity implies that the extra two factors may be useful in explaining the panel of data, but do not contain much incremental explanatory power for GDP relative to the first factor. Adding more factors tends to make the index less persistent, that is, more noisy. The correlations of the alternative coincident indices, and their autocorrelation coefficients, are reported in Table 2.

The second panel of Figure 3 plots the FHLR index against an alternative constructed using six factors, the number selected if the explanatory power threshold is set to 5 per cent rather than 10 per cent. Again, the series are very similar but, as with the SW indices, the alternative index constructed with more factors is less persistent. The result that the SW index gains little by using more than one factor also carries over to the FHLR index. The FHLR first factor has a correlation of 0.99 with the FHLR index that is the common component of two factors and is equally persistent (the autocorrelation of both is 0.88). We continue with the common component using two factors as our FHLR index, because it derives from the criterion used in the literature, but note that the results in the remainder of the paper are virtually identical if the FHLR first factors is used as the coincident index. In general, for other sample periods and panels of data, using more factors changes the common component little, but does tend to make it slightly more noisy (as seen by the smaller autocorrelation coefficients in Table 2). This raises questions about the benefits of adding additional factors in studies such as this one, in which we are interested in characterising the business cycle.

6. We also examined the robustness of the indices to correction for outliers. Setting extreme values (say, those greater than four or ten times the interquartile range) to either missing values or maximum values generally has little effect on the estimated indices. The indices are also robust to using a panel of data in which large consecutive offsetting observations (for example a normalised growth rate of –5 per cent followed by +5 per cent) which possibly represent timing issues in the data, are smoothed.

Figure 3: Sensitivity of the Indices to the Number of Factors



(a) Alternative SW index constructed as the common component of GDP explained by three factors (IC1 criterion).

(b) Alternative FHLR index constructed as the common component of GDP explained by six factors (5 per cent threshold rule).

Using a broader, non-balanced, panel with 68 series for the period 1960–2004 also makes little difference to the estimated SW coincident index. The alternative SW index estimated with this broader panel has a correlation of 0.95 with the SW index (column 5 of Table 2).[7]

An alternative test of the impact the breadth of the panel has on the coincident indices comes from the use of the broader balanced panel of 76 series available over the period 1980–2004 to estimate the indices. Figure 4 plots the SW and FHLR indices against these alternative indices. These alternative indices differ from our two main indices along two dimensions; they use a panel containing over twice

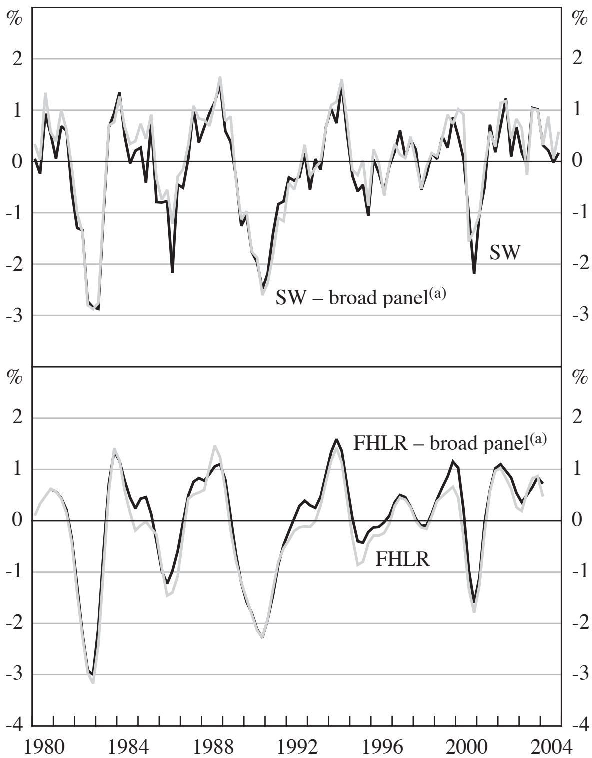
7. The information criteria selects three factors but we present the first factor for direct comparison with the SW index from the balanced panel. The common component using three factors has a higher correlation with GDP but is much more noisy, and is substantially less persistent than the first factor.

Table 2: Alternative Quarterly Coincident Indices
Correlations and autocorrelations – 1960–2004

	GDP	**SW**	**FHLR**	**Alternative indices**			
				SW		FHLR	
				q=3[(a)]	NBP *q*=1[(b)]	*q*=1[(c)]	*q*=6[(d)]
GDP	1	0.62	0.45	0.64	0.52	0.44	0.53
SW		1	0.91	0.97	0.95	0.92	0.81
FHLR			1	0.90	0.90	0.99	0.86
SW (*q*=3)				1	0.88	0.89	0.81
SW (NBP *q*=1)					1	0.92	0.78
FHLR (*q*=1)						1	0.84
FHLR (*q*=6)							1
Autocorrelation	–0.07	0.67	0.88	0.64	0.80	0.88	0.77

(a) SW common component using three factors
(b) SW first factor from the non-balanced panel
(c) FHLR first factor
(d) FHLR common component using six factors

Figure 4: Sensitivity of the Indices to the Size of the Panel



Note: SW and FHLR are estimated over the full 1960–2004 sample.
(a) Broad panel indices are calculated with the larger panel of 76 series available from 1980.

Table 3: Alternative Quarterly Coincident Indices
Correlations and autocorrelations – 1980–2004

	GDP	**SW**[(a)]	**FHLR**[(a)]	**Alternative indices (broad panel)**		
				SW		FHLR
				q=1[(b)]	NBP q=1[(c)]	q=2[(d)]
GDP	1	0.68	0.62	0.68	0.66	0.64
SW		1	0.94	0.96	0.95	0.93
FHLR			1	0.92	0.90	0.98
SW (q=1)				1	0.99	0.93
SW (NBP q=1)					1	0.91
FHLR (q=2)						1
Autocorrelation	0.36	0.73	0.88	0.77	0.80	0.88

(a) Estimated over the period 1960–2004
(b) SW first factor using the broader 1980 balanced panel (76 series)
(c) SW first factor using the broader 1980 non-balanced panel (111 series)
(d) FHLR common component using two factors with the broader 1980 balanced panel (76 series)

as many series, and they are estimated over a shorter period. Despite this, they are almost identical to our two main indices; the correlation of the two SW indices is 0.96 and the correlation of the two FHLR indices is 0.98, as reported in Table 3. Note that the difference between the two SW and two FHLR indices in Figure 4 is slightly exaggerated because the SW and FHLR indices estimated from 1960 have a small negative mean and standard deviation marginally less than one when plotted over the period 1980–2004. Broadening the panel further to estimate the SW index with the 111 series in the non-balanced 1980 panel similarly has little impact on the estimated index (column 5 of Table 3). This series has a correlation with the SW index of 0.95 and is only slightly smoother.

5.2 Monthly coincident indices

For the period 1980–2004, we estimate SW and FHLR indices using a panel of 29 monthly series. The FHLR methodology requires the inclusion of GDP in the panel, and so to estimate the monthly FHLR index the panel of monthly data is augmented with GDP (with the growth rate in each month assumed to be one-third of the quarterly growth rate for each month in the quarter, as is standard in the FHLR methodology).[8] In contrast to the quarterly panel, the panel of monthly

8. As our discussant Chris Caton notes, this series of constant growth in each month of the quarter will effectively lag the true underlying monthly growth in GDP by one month, an issue we had considered. We use this timing assumption as it has been used in the existing literature, and shifting the imputed monthly GDP growth forward by one month makes an indiscernible difference to the calculated index.

data has no national accounts series (household income, etc) and no measures of production. Rather it contains proportionately more overseas sector variables (trade, the exchange rate, etc) and private finance variables (credit, lending approvals, etc). Every effort is made to keep this panel as representative as possible, but given that some types of series are not produced at a monthly frequency they are obviously under-represented. The sensitivity to this constraint is considered in Section 5.2.1 with the construction of mixed-frequency indices that also include some of these quarterly series.

The quarterly SW index is estimated with no lags, as the series in the panel are taken to be mostly contemporaneously related at a quarterly frequency. This assumption is validated by the fact that FHLR places relatively small (and generally reasonably symmetrical) weights on leads and lags, and the close contemporaneous relationship of the FHLR index with the SW index. However, leads and lags are presumably more important in constructing a monthly index. To account for this we estimate the SW index using a stacked panel (with s=2 in Equation (1)). We interpret this model as having one lead and one lag, rather than two lags. This alignment of the index corresponds better with the path of the economic series and the FHLR index.

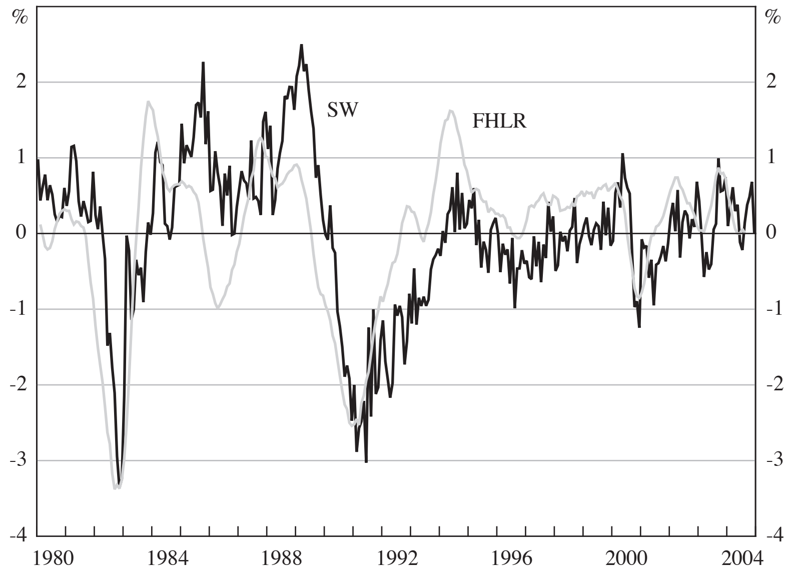
In a dynamic factor model, in which the data depend on leads and lags of the factors, the Bai and Ng (2002) information criteria will only provide an upper bound for the number of factors relevant for the model.[9] The IC2 information criterion selects two factors. However, the weight on the second factor in the regression of GDP on the two factors is very small and so we present the first factor as our monthly SW index (the correlation of the two-factor common component with the first factor is 0.99).[10] As for the quarterly index, the 5 per cent threshold criterion selects two factors for the monthly FHLR index. The SW and FHLR indices are substantially different, especially around the 1990s recession (Figure 5). These differences are almost entirely a function of the fact that the SW index uses only one factor while the FHLR index is a linear combination of two factors. The SW index displays the same timing and magnitude of movements as the FHLR first factor; while the SW and FHLR indices have a correlation of 0.60, the SW index and FHLR first factor have a correlation of 0.90.

As already noted, the second SW factor has an insignificant weight when included in a regression of GDP on the factors. Similarly, the third factor has little correlation with GDP. In contrast, if both the first and fourth factors are used to explain GDP they have virtually identical weights. Indeed, the SW common component that uses just the first and fourth factors (which we report as q*=2) displays similar movements to the FHLR index (which also uses two factors). This alternative SW index that uses two factors has a correlation of 0.92 with the FHLR index. The second and third SW factors appear to be 'nuisance' factors which result from the use of a stacked

9. In the SW setting this can be seen because the estimation technique does not recognise that f_t and f_{t-1} are the same factors. Therefore, the information criteria will provide a guide to r rather than q.

10. To determine the weights to combine the factors we regress GDP on the monthly factors. GDP is assumed to grow at one-third of the quarterly rate in each month of the quarter. This assumption is consistent with the assumption made about GDP growth in construction of the monthly FHLR index.

Figure 5: Monthly Coincident Indices



panel.[11] While the business cycle could be well characterised by one factor for the quarterly panel of data, in the monthly case there are two factors that each represent different cycles, and so a common component of the two may better characterise the business cycle. The main difference between the SW and FHLR indices that use the same number of factors is that FHLR indices are smoother, largely because, by construction, they remove high-frequency volatility. This comes at the expense of the estimation procedure truncating the beginning and end of the sample. The FHLR index also incorporates information from four leads and four lags while the SW index has just one lead and one lag.

11. The second and third factors have small weights when included in a regression of GDP on the first four factors. They are very noisy, with autocorrelation coefficients of –0.63 and –0.55. This is seemingly the result of using a stacked panel. We also find negatively autocorrelated factors, though weaker than for Australia, when stacking the panel used to construct the CFNAI. We thank Mark Watson and Jim Stock for discussing this point with us, and Watson for the following intuitive example. Suppose the data panel is explained by only one factor, which is positively autocorrelated, $f_t = \rho f_{t-1} + \eta_t$. Then the stacked panel, which augments the data matrix with one lag, will be spanned by two factors. Since they must be orthogonal, if one factor is $f_t + f_{t-1}$ the other could be $f_t - f_{t-1}$. In this example, the second factor from the stacked panel will be negatively autocorrelated even though the true factor is not.

5.2.1 Robustness of the monthly indices

As discussed in the previous section, the monthly coincident indices are sensitive to whether one or two factors are used in their construction, unlike the quarterly indices for which the cycle changes little with the use of more factors (though the amount of noise in the index does change). However, the indices do seem to be fairly robust to the use of more than two factors in their construction. For example, Table 4 shows that the monthly FHLR index, which uses two factors, has a correlation of 0.92 with the alternative FHLR index that combines six factors (the number determined by the 5 per cent threshold) and the persistence is essentially unchanged.

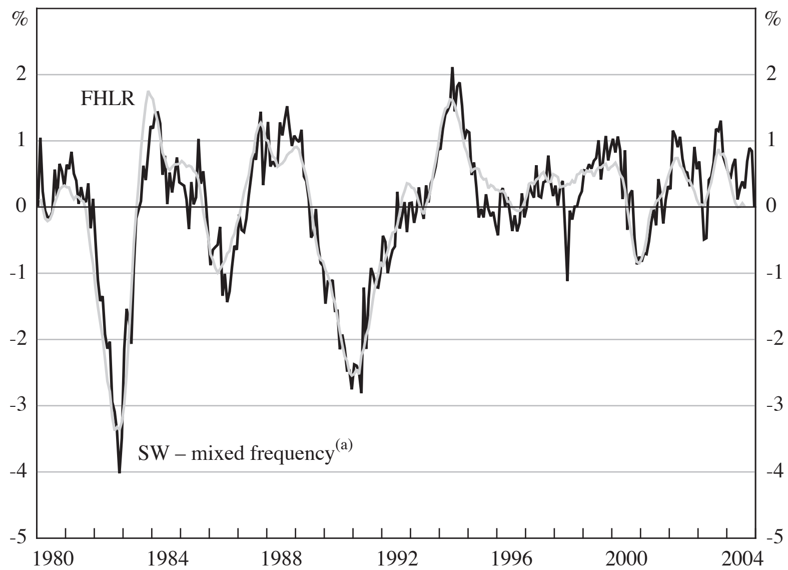
At the monthly frequency, the correlations of the coincident indices using alternative specifications are lower than at the quarterly frequency. However, the monthly SW index is quite robust to using a broader panel; for example, the SW index has a correlation coefficient of 0.88 with an alternative index using the non-balanced panel with 45 series that also only uses the first factor. The SW index is also robust to estimation with a mixed-frequency panel of the 29 monthly series and 19 quarterly series. In this case, the common component of five factors (as selected by the information criterion) is very similar to the FHLR index (Figure 6)

Table 4: Alternative Monthly Coincident Indices
Correlations and autocorrelations – 1980–2004

	SW	**FHLR**	**Alternative indices**					**Westpac/ MI**[(f)]
			SW			FHLR		
			q*=2[(a)]	NBP r=1[(b)]	MF r=5[(c)]	q=1[(d)]	q=6[(e)]	
SW	1	0.60	0.71	0.88	0.64	0.90	0.53	0.51
FHLR		1	0.92	0.83	0.93	0.84	0.92	0.61
SW (BP q*=2)			1	0.87	0.94	0.81	0.78	0.59
SW (NBP r=1)				1	0.87	0.93	0.70	0.60
SW (MF r=5)					1	0.81	0.78	0.62
FHLR (q=1)						1	0.77	0.59
FHLR (q=6)							1	0.57
Westpac/MI								1
Autocorrelation	0.89	0.98	0.89	0.93	0.92	0.99	0.97	0.23

(a) SW common component using two factors; the first and fourth factors (q* is used to indicate that we selected the factors)
(b) SW first factor from the non-balanced panel containing 45 series (the total number of factors is denoted by r in the stacked panel)
(c) SW common component using five factors from the mixed-frequency panel that adds 19 quarterly series to the balanced panel
(d) FHLR first factor
(e) FHLR common component using six factors
(f) Westpac-Melbourne Institute Coincident Index of Economic Activity

Figure 6: Mixed-frequency SW Index



(a) SW first factor from a mixed-frequency panel consisting of the 29 series in the monthly balanced panel and 19 quarterly series.

and to the two-factor SW index, with correlations of 0.93 and 0.94.[12] This suggests that the inability to include national accounts series in the monthly panel does not distort the shape of the business cycle captured by the indices.

Table 4 also reports the correlations of SW and FHLR, and their various alternative specifications, with the Westpac-Melbourne Institute Coincident Index, a commonly cited monthly composite indicator in Australia. As discussed in Section 1, it is based on a simpler methodology and is noisier than the other coincident indices in Table 4, in part because it does not include leads or lags.

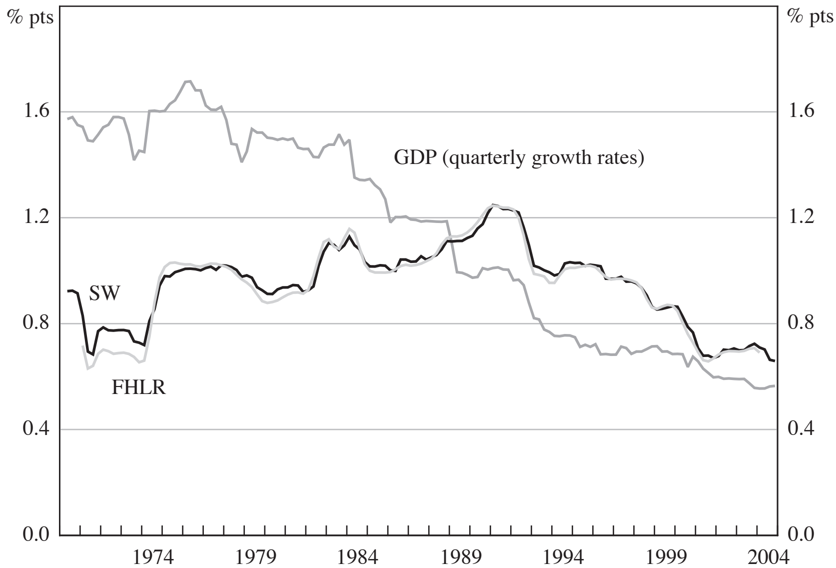
6. Applications of the Coincident Indices

6.1 The decline in volatility

Simon (2001) documents the decline in the volatility of quarterly GDP growth over the past 45 years that was evident in Figure 1. Figure 7, which plots the rolling standard deviation of quarterly GDP growth calculated over 10-year windows, also demonstrates this decline in volatility. Interestingly, and in contrast, the 10-year

12. The mixed-frequency SW index does not use interpolated quarterly data, unlike GDP used in the FHLR index. Rather, monthly values are calculated as functions of the factors, subject to the constraint that they 'add up' to the quarterly values.

Figure 7: The Decline in Volatility
Rolling 10-year standard deviation(a)



(a) Dates refer to end of 10-year window used to calculate the standard deviation. Note that the SW and FHLR indices have been standardised, so that their level is not comparable with GDP.

rolling standard deviations of the SW and FHLR indices display no marked trend in volatility over the full sample.[13]

To better understand this divergence in trends in volatility, we focus on the SW index and the series used in its compilation, since it is simply a weighted average of the data in each quarter. The variance of the coincident index, which for the SW index is simply the first factor, can be decomposed into the variances and covariances of the series used in its construction. First, note that a factor can be expressed as a weighted average of the data, as given by Equation (2),

$$f = \sum_{i=1}^{N} c_i x_i \tag{2}$$

where c_i is the weight on the i^{th} series, x_i. The variance of the factor can then be decomposed as the weighted sum of the variances of the component series and their covariances, as given by Equation (3):

$$\mathrm{var}\left(f\right) = \sum_{i=1}^{N} c_i^2 \,\mathrm{var}\left(x_i\right) + \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} 2 c_i c_j \,\mathrm{cov}\left(x_i, x_j\right) \tag{3}$$

13. This feature is not repeated with US data. The rolling standard deviations of the Chicago Fed's CFNAI, which uses the SW methodology, are very similar to those of US GDP.

Given that the volatility of quarterly GDP has declined substantially, we decompose the volatility of the SW factor separately into the variances and covariances of the 6 national accounts series and the 19 other series. We calculate the variances in two sub-samples, before and after 1980, which is close to the middle of the full sample period and avoids splitting during a recession (Table 5).[14]

Confirming the picture suggested by Figure 7, the variance of quarterly GDP growth in the latter sample is around a quarter of its variance in the first sample (the last column of Table 5). In contrast, the variance of the SW index is little changed (column six). The first five columns in Table 5 give the weighted variances and covariances that sum to the variance of the SW index. The weighted sums of the variances and covariances of the national accounts series used in the SW index declines by about one half (this is less than the decline in GDP volatility because the two capital formation series included in our index experienced an increase in volatility).[15] In contrast, the weighted sums of the variances and covariances of the 19 other series used in the SW index are virtually unchanged, as are the covariances between the national accounts and other series. In total, the SW index has only a minor decline in volatility because the other economic series (which cumulatively have a greater weight in the SW index) did not experience the same decline in volatility as the national accounts aggregates. To the extent that the coincident index provides a good indicator of the business cycle by abstracting from idiosyncratic noise in individual series, this suggests that the decline in the volatility of the common component of economic activity has not been as marked as indicated by quarterly estimates of GDP. If the analysis of volatility is performed using annual growth rates, the decline in the standard deviation of GDP is less dramatic but is still apparent, at least over the latter half of the sample. Again, the SW index shows no decline in volatility and the findings from decomposing the volatility of quarterly movements in the SW index carry over to the decomposition using annual changes.

Table 5: Decomposition of the Volatility of the SW Index
Quarterly frequency

	Variance terms		**Covariance terms**			**Variance of SW index**	**Variance of GDP**
	National accounts	Other	National accounts	Other	National accounts/other		
1960–1979	0.07	0.11	0.14	0.36	0.34	1.03	2.45
1980–2004	0.04	0.11	0.08	0.36	0.33	0.92	0.63

Note: The scaling ensures the SW factor has unit variance over the full sample.

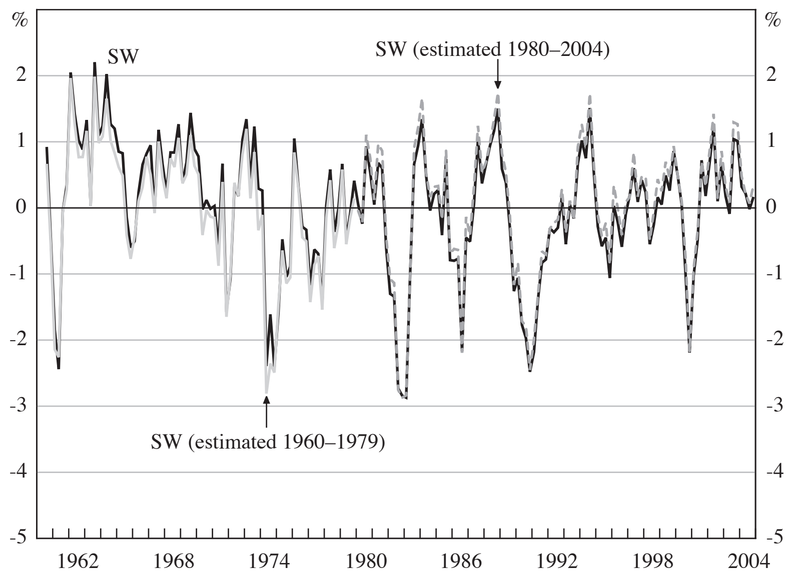
14. The results are broadly unchanged if we end the second sample in 1999 to abstract from the impact of the GST on variances and covariances.

15. In the case of dwelling investment, this is the result of large movements in the year the GST was introduced, but for total capital formation, the increase in volatility occurred more broadly through the sample.

One possible explanation for the divergent trends in volatility is that some of the volatility in GDP in the earlier part of the sample reflects measurement error and that the SW index is able to abstract from such idiosyncratic noise. As GDP has become better measured over time, the volatility of measured GDP has declined. Harding (2002) provides further discussion on the decline in the volatility of GDP in Australia, suggesting that it largely reflects reduced measurement errors, and in particular less residual seasonality. It may be that other series, such as employment or dwelling approvals, have not had this reduction in measurement error because they have always been easier to measure than GDP. A second explanation is that it may be that the parts of the economy that have experienced a decline in volatility are underrepresented in the panel. This would seem less likely as one of the main criteria for selecting the panel of data series is that it should provide a broad representation of the economy. In addition, the magnitude of the decline in sectoral volatilities (or shifts in sectoral shares) that would be required to explain the decline in GDP volatility seems somewhat implausible.

Given the volatility of some economic series has changed it may be that the importance of various series in the construction of the coincident indices has also changed. To examine this, we estimate the SW index over the two sub-samples, 1960–1979 and 1980–2004, using the panel of data that is available over the full 1960–2004 sample.[16] As Figure 8 shows, the coincident indices estimated over the two sub-samples are virtually identical to the index constructed over the full sample. The only visible difference is that the SW index, estimated over the full sample,

Figure 8: Changes in the SW Coincident Index



16. We do not report sub-sample estimates using the FHLR methodology as the conclusions do not differ.

has a slightly positive (negative) mean over 1960–1979 (1980–2004) while the two sub-sample indices have zero mean by construction; this reflects the higher average economic growth in the 1960s.

Not surprisingly, given the insignificant change in the coincident index, the weights used to estimate the factors are little changed when the shorter sub-samples are used. Indeed, the panel R-squared for the first factor increases only marginally from 0.231 to 0.257 demonstrating that, for the panel as a whole, idiosyncratic shocks have declined only marginally.[17]

6.2 Dating the business cycle

In this section, we use the coincident indices to date classical cycles, that is cycles involving a decline in activity rather than just a slowing in growth rates. To identify periods of recession, we use the Bry and Boschan (1971) algorithm. This is an NBER-style rule that identifies the peaks and troughs in the level of a series and so dates expansions and contractions in an objective manner. Appendix B provides further details on the procedure, including the construction of a levels series from the SW index.

Table 6 reports the recessions identified by GDP and the quarterly SW and FHLR indices.[18] While six recessions are located by GDP, only three recessions are identified by the two coincident indices. The three recessions that GDP identifies, but the indices do not, occur in the mid 1960s, and early and late 1970s. As discussed in Section 6.1 the volatility of quarterly GDP growth has declined, while the coincident indices that are based on many series (and statistical weights) have not seen such a reduction in volatility. The greater number of recessions that are identified by GDP appears to be the result of its higher volatility early in the sample. Assuming no change in mean growth rates, higher volatility of measured GDP growth would tend to increase the likelihood of recording (possibly spurious) declines in the level of GDP, and so of recessions being identified in the data.[19] Alternatively, we could date the business cycle using non-farm GDP to abstract from the possibility that the volatile farm sector could result in declines in aggregate GDP even when there was no decline in the broader non-farm economy. Unlike GDP, non-farm GDP does not locate recessions in 1965–1966 and 1971–1972, but it does identify the other recessions found in GDP, and an additional recession in the mid 1980s (1985:Q4–1986:Q2). So, abstracting from farm output does reduce the number of recessions identified, but still results in more recessions than the three identified by the coincident indices.

17. This is true even if we consider more factors. For example, the panel R-squared for four factors only increases from 0.515 to 0.535.

18. As discussed in Appendix B, the dates for the SW index are sensitive to the choice of a scaling parameter. This does not affect the dates for the FHLR index.

19. For a recession to be identified there will have to be a decline in GDP in at least one quarter. The probability of a fall in GDP will be higher if the volatility of quarterly GDP growth is higher, so making the identification of a recession more likely.

Table 6: Business Cycle Peaks and Troughs
Dated with the Bry-Boschan algorithm

	Quarterly			Monthly		
	1960–2004			1960–2004	1980–2004	
	GDP	SW	FHLR	Melbourne Institute	SW	FHLR
Peak	1965:Q2					
Trough	1966:Q1					
Peak	1971:Q3					
Trough	1972:Q1					
Peak	1975:Q2	1974:Q1	1974:Q1	1974:M7		
Trough	1975:Q4	1975:Q1	1975:Q1	1975:M10		
Peak	1977:Q2			1976:M8		
Trough	1977:Q4			1977:M10		
Peak	1981:Q3	1981:Q4	1982:Q1	1981:M9	1982:M5	1982:M2
Trough	1983:Q1	1983:Q1	1983:Q1	1983:M5	1983:M1	1983:M3
Peak	1990:Q2	1990:Q1	1990:Q1	1989:M12	1990:M7	1990:M5
Trough	1991:Q3	1991:Q2	1991:Q1	1992:M12	1992:M5	1991:M8

Note: The Melbourne Institute business cycle dates are an update of those in Boehm and Moore (1984).

Overall, we conclude that using a broad panel of series provides less evidence that the GDP downturns in the mid 1960s, and early and late 1970s were recessions, but that three recessions are unambiguously identified, in 1974–1975, 1982–1983 and 1990–1991. These three recessions occurred at times when most industrialised countries experienced recessions.[20]

The recession dates produced by the Melbourne Institute (which follow on from the work by Ernst Boehm and Geoffrey Moore) are also given in Table 6. These dates are based on several monthly and quarterly series, but not as many as the SW and FHLR indices. Like these indices, the Melbourne Institute does not date 1965 and 1971 as being recessions. However, they do consider 1976 to have been a recession. This implies that there was an expansion in 1975–1976 that lasted just 10 months.

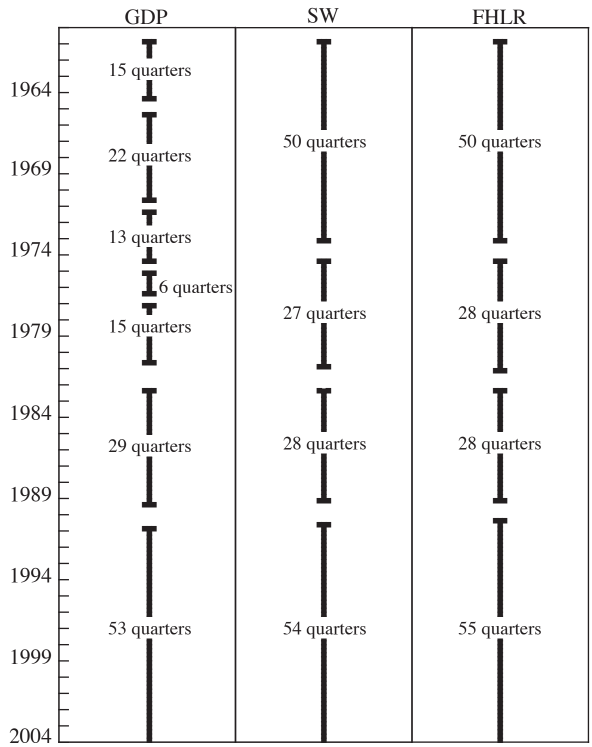
The monthly SW and FHLR indices (which cover the period 1980–2004) also identify the early 1980s and early 1990s as periods of recession (columns five and six of Table 6). The two indices imply similar timing for the early-1980s recession, but the SW index dates the end of the early-1990s recession nine months later than the FHLR index. This highlights the sensitivity of these monthly indices to the number

20. Out of 12 other OECD countries contained in the European Cycle Research Institute dating, 10, 11 and 12 experienced recessions within 18 months either side of the 1974–1975, 1982–1983 and 1990–1991 recessions in Australia.

of factors used to form the index. The SW index which only uses one factor picks up a different cycle to the common component from two factors – the two-factor SW index (q^*=2) identifies similar turning points to the FHLR index.

The length of the three main recessions identified in the quarterly data differs only modestly according to whether the dating uses GDP, SW or FHLR. FHLR indicates that all three recessions were four quarters long, while for GDP they range between three and six quarters. In contrast, because GDP and the two indices identify different numbers of recessions, the lengths of the expansions identified differ greatly (Figure 9). Since the use of GDP suggests there have been more recessions, it identifies expansions as being shorter on average, with one lasting only six quarters. This follows from the extra recessions identified by GDP in the 1960s and 1970s, which appear to be the result of the higher level of noise in GDP. The smoother FHLR and SW indices identify a long expansion at the beginning of the sample, two expansions of about seven years each in the middle, and then another ongoing long expansion.

Figure 9: The Length of Economic Expansions

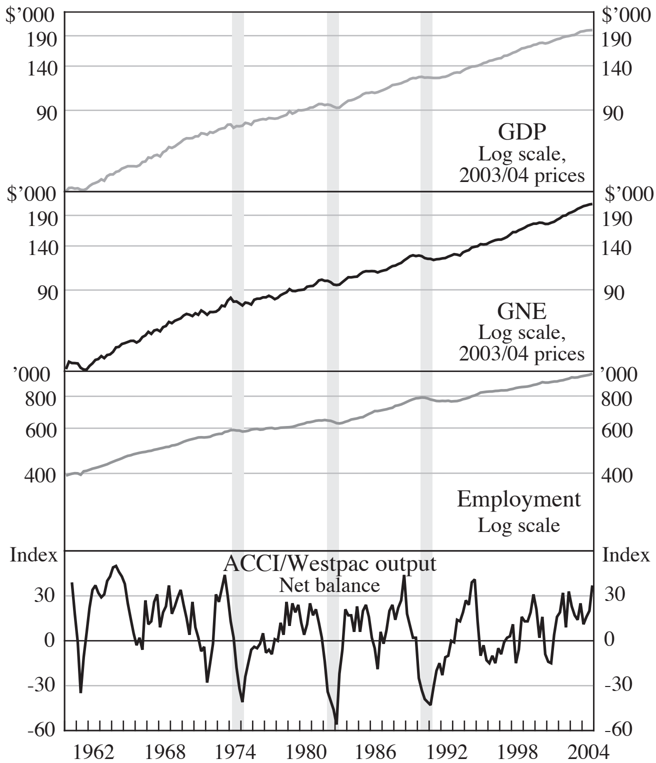


Notes: All three series are assumed to begin an expansion in December 1961. The SW and FHLR indices do not date a trough at the beginning of the sample as they begin too close to the economic downturn for the Bry-Boschan algorithm to identify a trough.

Figure 10 plots GDP along with three representative series – GNE (to capture domestic demand), employment, and the ACCI/Westpac survey of actual output (to capture production) – and highlights the three recessions identified by the SW and FHLR coincident indices. The economic downturn in the three recessions was widespread. In all three recessions, not only did GDP contract, but domestic demand fell, the net balance of actual output from the ACCI/Westpac survey was strongly negative, employment experienced sustained falls, and the unemployment rate increased by over three percentage points. The fall in GDP was less severe in the 1974 recession. Indeed, as shown in Appendix C, various vintages of GDP have not identified this as being a recession. However, both coincident indices strongly identify this episode as being a recession. To reconcile these facts we note that while private demand and production (and, therefore, many of the series in our data panel) experienced a significant downturn, there was a substantial boost in public expenditure, offsetting much of the decline in the other components of GDP. But given the widespread decline in economic activity it seems reasonable to characterise this episode as a recession.

Figure 10: Recessions

Dated using FHLR index



Sources: ABS; ACCI-Westpac; authors' calculations

The end of all three recessions marks the end of the sharp decline of demand, and coincides with the turnaround in the ACCI/Westpac survey. While the recovery in employment also dates from the end of the 1970s and 1980s recessions, employment was weak for a sustained period after the 1990s recession. These disparate trends in different variables around the 1991 recession appear to explain the sensitivity of the monthly SW index to the number of factors used in its construction.

In contrast, in the other three recessions identified by GDP, the downturn was not as uniform across different economic variables.[21] In 1965, employment continued to grow, GNE fell only in one quarter, while the ACCI/Westpac survey continued to record a positive net balance of respondents. In 1971, GNE did contract, and the ACCI/Westpac actual output net balance fell, though not by as much as in the three recessions. However, employment fell in only one quarter and there was still reasonable strength in housing and construction. So there is some evidence of a contraction in economic activity, but it was not widespread. In 1977, once again, GNE fell while employment fell in only one of the quarters. But the ACCI/Westpac survey was only slightly negative and investment and exports showed no sign of a downturn.

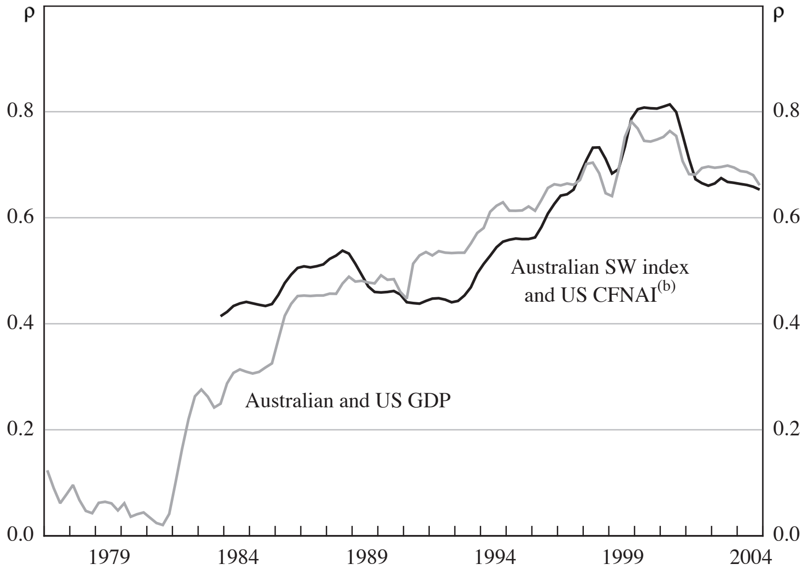
The constructed indices are less noisy measures of the business cycle than GDP, especially in the early part of the sample, suggesting that there are advantages from using a large range of series and a statistically based set of weights. Notwithstanding the fact that GDP has become less noisy over time, we conjecture that these advantages may also carry over to real-time analysis (though without real-time data for the series used to construct the indices we cannot test this conjecture). Some of the series used in the construction of the indices are not revised, and those series that are revised come from a range of different surveys or collection methods, so that revisions to particular series may be largely independent (and therefore mostly 'wash out'). In addition, as shown in Section 6.1, the weights in the indices are quite stable between the first and second halves of the sample. In contrast, as Appendix C shows, the identification and timing of recessions can change substantially with revisions to GDP, although it must be noted that the periods of most substantial revisions predate methodological improvements in the construction of GDP.

6.3 Changes in international correlation of business cycles

Another aspect of the changing nature of the business cycle is the extent to which correlations of cycles across countries may have changed, a topic which is addressed in this volume by Andrews and Kohler, in a study using correlations of GDP. Our indices allow another perspective on this question. If the extent of measurement error in GDP changes over time then this may alter the measured correlation of countries' business cycles. Comparing coincident indices across countries can provide a check on the extent to which measurement error might affect the measurement of synchronisation. Accordingly, Figure 11 shows the rolling correlation of annual

21. Further discussion of these earlier slowdowns, along with evidence on behaviour of other economic variables is provided in RBA (1997, pp 4–6).

Figure 11: Correlation of Australian and US Activity
Rolling 16-year correlations of year-ended growth rates[(a)]



(a) Dates refer to end of 16-year window.
(b) Australian SW index is the quarterly SW index constructed in Section 5.1, CFNAI is the Chicago Fed National Activity Index which also uses the SW methodology.

rates of change in US and Australian GDP, and the correlation of the annual change in the Australian SW index constructed in Section 5.1 and the annual change in the Chicago Fed's US CFNAI (which is also constructed using the SW methodology).[22] These two rolling correlations demonstrate that the increase in the correlation of the Australian and US economic activity over the 1970–2000 period is robust to alternative measurement, suggesting that measurement issues are not a significant element in the changing correlation of the Australian and US business cycles.

6.4 The relationships of the indices with other economic variables

We conclude the analytical part of this paper by considering how closely the quarterly indices estimated in Section 5 are correlated with a range of other more standard measures of the Australian business cycle, to get a better sense of exactly what our indices may be measuring. First, we compare the persistence (or first order autocorrelations) of our indices with the persistence of the quarterly change in GDP

22. Note that Andrews and Kohler (this volume) use a more advanced measure of the correlations based on band-pass filters rather than growth rates as used here. For the US–Australian correlation of GDP these techniques deliver qualitatively equivalent results. We use the correlation of growth rates as the coincident indices have already been filtered and so are not level variables.

and some other standard variables. In principle, the concept of the business cycle is one of a relatively persistent process, so we would expect that a good measure of the cycle should have a relatively high degree of persistence.

Both the SW and FHLR indices have a high degree of persistence over the full sample, even at a quarterly frequency, with autocorrelations of 0.67 and 0.88, respectively (Table 7). By contrast, the standard national accounts aggregates display little persistence, with quarterly growth in GDP and non-farm GDP displaying negative autocorrelation, at least in the early part of the sample. In the later part of the sample, quarterly changes in the national accounts aggregates have become more persistent, but they are still much less persistent than the two coincident indicators. For year-ended growth rates the difference in persistence remains, though it is less marked (not shown). In short, the indices appear to be a better measure of the persistent economic cycle than is GDP, or other national accounts aggregates – certainly historically and, to a lesser extent, more recently.

Second, we consider how closely our indices are correlated with some national accounts measures, to get a slightly better sense of exactly what aspect of the business cycle they may be capturing. Although the panel of variables used to estimate the coincident indices was constructed to be as representative of the economy as possible, it does not have the coverage of measures of income, production or expenditure components which together are used to construct GDP. We expect that the common cycle estimated by our indices will be closely related to GDP, given that many of the series used to construct the indices are related to GDP or its components. Even so, it is possible that they bear a closer resemblance to other national accounts aggregates. The bottom panel of Table 7 shows that this is indeed the case. The two quarterly coincident indices have a marginally higher correlation with non-farm GDP than GDP, and a higher correlation still with domestic final demand. This ordering of correlations also holds for annual growth rates (not shown). In the latter part of the

Table 7: Coincident Indices and Economic Aggregates

Correlations and autocorrelations of quarterly growth rates – 1960–2004

	GDP	Non-farm GDP	DFD[(a)]	SW	FHLR
Autocorrelations					
1960–2004	–0.07	–0.07	0.04	0.67	0.88
1960–1979	–0.22	–0.19	–0.08	0.58	0.86
1980–2004	0.34	0.10	0.17	0.73	0.88
Correlations					
GDP	1	0.77	0.50	0.62	0.45
Non-farm GDP		1	0.60	0.64	0.48
DFD			1	0.69	0.55
SW				1	0.91
FHLR					1

Notes: Correlations are for the full sample 1960–2004.
(a) DFD is domestic final demand.

sample the correlation of the national accounts aggregates with the FHLR index in particular has increased, but the relative rankings of correlations has not changed. Even though the coincident indices are closely related to GDP, at times differences are apparent. As mentioned in Section 5.1, the coincident indices have been notably stronger than GDP growth over the past few years.

The higher correlation with non-farm GDP is perhaps not surprising, given that the contribution of the farm sector to GDP is highly volatile and often uncorrelated with other sectoral developments. This result would lend support to the idea that developments in non-farm GDP sometimes give a better sense of general trends in the economy than does aggregate GDP, which is implicit in the frequent use of non-farm GDP in much analysis by official sector and private sector economists. The finding of a higher correlation with domestic final demand is perhaps more surprising. One explanation could be that production variables are under-represented in our panel. Alternatively, it may be that short-term shocks to production that show up in GDP are not in the common cycle because they have a limited effect on a range of expenditure decisions by households and firms which depend more on expectations about permanent incomes.

7. Conclusion

The results in this paper suggest that coincident indices based on the recently developed techniques of Stock and Watson (1999, 2002a, 2002b) and Forni *et al* (2000, 2001) for estimating approximate factor models with many series are useful tools for studying the Australian business cycle. The quarterly indices are quite robust to the selection of variables used in their construction, the sample period used in estimation, and the number of factors included. Somewhat surprisingly, we find that increasing the number of factors beyond the first does not substantially change the shape of the cycle, but often makes the indices noisier (less persistent). So, while a handful of factors may be required to provide an adequate representation of the data panel, it is not clear that as many factors are needed to form a coincident index. In contrast, the monthly indices are sensitive to the number of factors included in the indices. Two factors seemingly capture different economic cycles so that an index based on only one of these presents a very different impression of the business cycle to one based on a combination of the two. The monthly indices also seem to be fairly robust to the composition of the panel of data.

The coincident indices provide a much smoother representation of the cycle in economic activity than do standard national accounts measures. To the untrained eye, quarterly changes in GDP appear to be largely white noise, at least in the early part of the sample. However, the quarterly coincident indicators are highly persistent and display the type of long swings that one would expect from a measure of the business cycle. Since the coincident indices are essentially a weighted average of the growth rates of the panel of data, this highlights the benefits of assessing the business cycle using a wide range of data series, and using statistical criteria to weight them together.

Notably, the indices do not display the marked decline in volatility evident in Australian quarterly GDP growth, suggesting this decline may overstate the reduction in the volatility of economic activity and at least partially reflect improvements in the measurement of GDP. One consequence of the high volatility of quarterly GDP growth before 1980 is that it identifies many recessions. Some of these appear to be spurious, the result of noise at a time of low, but probably not negative, growth. In contrast, because they present a smoother perspective of the business cycle in the 1960s and 1970s, the coincident indices identify fewer recessions in this period than does GDP. Over the past 45 years, the coincident indices locate three recessions – periods when there was a widespread downturn in economic activity. The three recessions occurred in 1974–1975, 1982–1983 and 1990–1991. These recessions break the past 45 years into four expansions, with two long expansions of over 12 years each, bracketing two shorter expansions of around 7 years each.

It is obviously difficult to offer general conclusions about factor modelling based on data from just one country. However, our results appear to strengthen the finding of Inklaar *et al* (2003) who show (using European data) that relatively small numbers of appropriately selected series may be able to provide similar results to factor models using much larger panels. A second conclusion might be that a coincident index can often be constructed using just one factor, but this is dependent on the panel of data.

Appendix A: Composition of Data Panels *(continued next page)*

	Code[(b)]	Sample			Alternative indices					
			Q: BP1960	M: BP1980	Q: NBP1960	Q: BP1980	Q: NBP1980	M: NBP1980	MF: BP1980	MF: NBP1980
Total number of series in each panel			**25**	**29**	**68**	**76**	**111**	**45**	**48**	**64**
National accounts			6	0	22	13	23	0	7	7
Employment			2	8	8	13	20	13	8	13
Industrial production			4	0	24	12	24	0	4	4
Building and CAPEX			2	3	2	13	13	4	10	11
Internal trade			1	2	1	2	5	4	2	4
Overseas transactions			4	5	4	6	6	9	5	9
Prices			4	2	4	6	6	2	3	3
Private finance			2	7	3	9	12	11	7	11
Government finance			0	2	0	2	2	2	2	2
Quarterly										
National accounts										
Final consumption expenditure: households, sa	5	1959:Q3–2004:Q4	o		o	o	o			
GDP, sa	5	1959:Q3–2004:Q4	o		o	o	o		o	o
GDP non-farm, sa	5	1959:Q3–2004:Q4			o	o	o		o	o
GFCF total, sa	5	1959:Q3–2004:Q4			o		o			
GNE, sa	5	1959:Q3–2004:Q4	o		o	o	o		o	o

Appendix A: Composition of Data Panels *(continued next page)*

	Code[b]	Sample	Q: BP1960	M: BP1980	Q: NBP1960	Q: BP1980	Q: NBP1980	M: NBP1980	MF: BP1980	MF: NBP1980
			Alternative indices							
GOS: total non-financial corporations, sa	5	1959:Q3-2004:Q4	o		o	o	o		o	o
GOS: financial corporations, sa	5	1959:Q3–2004:Q4			o		o			
GOS: private non-financial corporations, sa	5	1959:Q3–2004:Q4			o		o			
GOS: public non-financial corporations, sa	5	1959:Q3–2004:Q4			o		o			
GOS: total corporations, sa	5	1959:Q3–2004:Q4			o		o			
Household disposable income, sa	5	1959:Q3–2004:Q4			o		o			
Household final consumption expenditure:										
Cigarettes and tobacco, sa	5	1959:Q3–2004:Q4			o		o			
Clothing and footware, sa	5	1959:Q3–2004:Q4			o	o	o			
Food, sa	5	1959:Q3–2004:Q4			o	o	o			
Furnishing and HH equipment, sa	5	1959:Q3–2004:Q4			o	o	o			
Purchase of vehicles, sa	5	1959:Q3–2004:Q4			o		o			
Rent and other dwelling services, sa	5	1959:Q3–2004:Q4			o	o	o			
Industrial production, sa (c)	5	1974:Q3–2004:Q4				o	o		o	o
Private GFCF: dwellings: alterations and additions, sa	5	1959:Q3–2004:Q4			o		o			
Private GFCF: dwellings: new and used, sa	5	1959:Q3–2004:Q4			o		o			
Private GFCF: dwellings: total, sa	5	1959:Q3–2004:Q4	o		o	o	o		o	o
Private GFCF: total, sa	5	1959:Q3–2004:Q4	o		o	o	o		o	o
Private non-farm inventories to sales ratio, sa	2	1959:Q3–2004:Q4			o	o	o			

Appendix A: Composition of Data Panels *(continued next page)*

	Code[b]	Sample	Q: BP1960	M: BP1980	Alternative indices Q: NBP1960	Q: BP1980	Q: NBP1980	M: NBP1980	MF: BP1980	MF: NBP1980
Employment										
Civilian labour force participation rates: females, sa (c, mqa)	2	1966:Q3–2004:Q4			o	o	o			
Civilian labour force participation rates: males, sa (c, mqa)	2	1966:Q3–2004:Q4			o	o	o			
Employment: females, sa (s, a, mqa)	5	1949:Q3–2004:Q4	o		o					
Employment: males, sa (s, a, mqa)	5	1949:Q3–2004:Q4	o		o					
Employment: total, sa (s, a, mqa)	5	1949:Q3–2004:Q4			o	o	o			
Employment: full-time, sa	5	1978:Q2–2004:Q4				o	o			
Employment: part-time, sa	5	1978:Q2–2004:Q4				o	o			
Industrial disputes: working days lost, sa (a)	5	1976:Q3–2004:Q3					o			
Overtime in the manufacturing industry, sa (a, m)	5	1979:Q3–1999:Q2					o			
Total job vacancies: private sector, sa (m)	5	1979:Q2–2002:Q4				o	o			
Total job vacancies: public sector, sa (m)	5	1979:Q2–2004:Q4				o	o			
Total job vacancies, sa (s, a, m)	5	1966:Q1–2004:Q4				o				
Unemployment rate: females, sa (c, mqa)	1	1966:Q3–2004:Q4			o	o	o			
Unemployment rate: males, sa (c, mqa)	1	1966:Q3–2004:Q4			o	o	o			
Wage and salary earners in civilian employment:										
Building & construction: private, sa (a, m)	5	1983:Q3–2001:Q4					o			
Building & construction: public, sa (a, m)	5	1983:Q3–2004:Q4					o			

Appendix A: Composition of Data Panels *(continued next page)*

	Code[(b)]	Sample	Q: BP1960	M: BP1980	Q: NBP1960	Q: BP1980	Q: NBP1980	M: NBP1980	MF: BP1980	MF: NBP1980
Government: persons, sa (a, m)	5	1983:Q3–2004:Q4					o			
Manufacturing: private, sa (a, m)	5	1983:Q3–2001:Q4					o			
Manufacturing: public, sa (a, m)	5	1983:Q3–2004:Q4					o			
Persons, sa (a, m)	5	1983:Q3–2001:Q4					o			
Number receiving unemployment benefits: persons, sa (s, f)	5	1963:Q1–2004:Q4			o	o	o			
Industrial production										
ACCI/Westpac Survey:										
Actual level of capacity utilisation at which firms are working: net balance, nsa	1	1960:Q3–2004:Q4	o		o	o	o		o	o
Capital expenditure on buildings: during next 12 mths net balance, nsa	1	1961:Q1–2004:Q4			o		o			
Capital expenditure on plant and machinery: during next 12 mths net balance, nsa	1	1961:Q1–2004:Q4			o		o			
Employment actual: change in past 3 mths net balance, nsa	1	1960:Q3–2004:Q4			o		o			
Employment expected: change in next 3 mths net balance, nsa	1	1960:Q3–2004:Q4			o		o			
Export deliveries actual: change in past 3 mths net balance, nsa	1	1960:Q3–2004:Q4			o	o	o			
Export deliveries expected: change in next 3 mths net balance, nsa	1	1960:Q3–2004:Q4			o	o	o			

Appendix A: Composition of Data Panels *(continued next page)*

	Code[(b)]	Sample	Alternative indices							
			Q: BP1960	M: BP1980	Q: NBP1960	Q: BP1980	Q: NBP1980	M: NBP1980	MF: BP1980	MF: NBP1980
General business situation expected: during next 6 mths net balance, nsa	1	1960:Q3–2004:Q4	o		o	o	o		o	o
New orders actual: change in past 3 mths net balance, nsa	1	1960:Q3–2004:Q4			o	o	o			
New orders expected: change in next 3 mths net balance, nsa	1	1960:Q3–2004:Q4			o	o	o			
Output actual: change in past 3 mths net balance, nsa	1	1960:Q3–2004:Q4	o		o	o	o		o	o
Output expected: change in next 3 mths net balance, nsa	1	1960:Q3–2004:Q4	o		o	o	o		o	o
Overtime actual: change in past 3 mths net balance, nsa	1	1960:Q3–2004:Q4			o	o	o			
Overtime expected: change in next 3 mths net balance, nsa	1	1960:Q3–2004:Q4			o	o	o			
Stocks, nsa (finished goods) actual: change in past 3 mths net balance	1	1960:Q3–2004:Q4			o	o	o			
Stocks, nsa (finished goods) expected: change in next 3 mths net balance	1	1960:Q3–2004:Q4			o	o	o			
Stocks, nsa (raw materials) actual: change in past 3 mths net balance	1	1960:Q3–2004:Q4			o		o			
Stocks, nsa (raw materials) expected: change in next 3 mths net balance	1	1960:Q3–2004:Q4			o		o			
Basic iron production, sa (a)	5	1956:Q1–2000:Q3			o		o			

Appendix A: Composition of Data Panels *(continued next page)*

	Code[b]	Sample			Alternative indices					
			Q: BP1960	M: BP1980	Q: NBP1960	Q: BP1980	Q: NBP1980	M: NBP1980	MF: BP1980	MF: NBP1980
Beer production, sa (a)	5	1956:Q1–2004:Q3			o		o			
Clay bricks production, sa (a)	5	1956:Q1–2004:Q3			o		o			
Electricity production, sa (a)	5	1956:Q1–2004:Q3			o		o			
Portland cement production, sa (a)	5	1956:Q1–2004:Q3			o		o			
Tobacco and cigarettes production, sa (a)	5	1956:Q1–2004:Q2			o		o			
Building and CAPEX										
Capital: expenditure private new buildings & structures, sa	5	1969:Q3–2004:Q4				o	o		o	o
Capital: expenditure private new capital equipment, sa	5	1969:Q3–2004:Q4				o	o		o	o
Capital: expenditure private total, sa	5	1969:Q3–2004:Q4				o	o			
Commencements: private new houses excluding conversions, sa	5	1969:Q3–2004:Q4				o	o			
Commencements: total new houses and flats excluding conversions, number, sa (s, a)	5	1959:Q1–2004:Q4	o		o	o			o	o
Commencements: total new houses and flats including conversions, number, sa	5	1980:Q3–2004:Q4					o			
Completed: private new houses excluding conversions, sa	5	1969:Q3–2004:Q4				o	o			
Completed: total new houses and flats excluding conversions, number, sa (s, a)	5	1959:Q1–2004:Q4	o		o	o			o	o

Appendix A: Composition of Data Panels *(continued next page)*

	Code[(b)]	Sample	Q: BP1960	M: BP1980	Q: NBP1960	Q: BP1980	Q: NBP1980	M: NBP1980	MF: BP1980	MF: NBP1980
					Alternative indices					
Completed: total new houses and flats including conversions, number, sa	5	1980:Q3–2004:Q4					o			
Work done: private engineering construction, sa	5	1976:Q3–2004:Q4				o	o		o	o
Work done: private new houses and flats, sa	5	1974:Q3–2004:Q4				o	o		o	o
Work done: private non-residential buildings, sa	5	1974:Q3–2004:Q4				o	o		o	o
Work done: total buildings, sa	5	1974:Q3–2004:Q4				o	o			
Work done: total new houses and flats, sa	5	1974:Q3–2004:Q4				o	o			
Work done: total non-residential buildings, sa	5	1974:Q3–2004:Q4				o	o			
Internal trade										
Retail sales, all items excluding parts, petrol etc, sa (s)	5	1968:Q3–2004:Q4				o	o			
Retail sales, all other goods excluding petrol, parts etc , sa (c)	5	1983:Q3–2004:Q4					o			
Retail sales, clothing and soft goods, household goods, sa	5	1983:Q3–2004:Q4					o			
Motor vehicle registrations: total, sa (f)	5	1980:Q1–2001:Q4					o			
Motor vehicle registrations: cars & station wagons, sa (s, a, f)	5	1959:Q3–2004:Q4	o		o	o	o			
Overseas transactions										
Exports of wool and sheepskins, sa	5	1974:Q3–2004:Q4				o	o			
Services imports, sa	5	1959:Q3–2004:Q4	o		o	o	o			

Appendix A: Composition of Data Panels *(continued next page)*

	Code[b]	Sample			Alternative indices					
			Q: BP1960	M: BP1980	Q: NBP1960	Q: BP1980	Q: NBP1980	M: NBP1980	MF: BP1980	MF: NBP1980
Total imports: goods, sa	5	1959:Q3–2004:Q4	o		o	o	o			
Total exports: goods, sa	5	1959:Q3–2004:Q4	o		o					
Rural exports, sa (a)	5	1974:Q3–2004:Q4				o	o			
Non-rural exports, sa (a)	5	1974:Q3–2004:Q4				o	o			
Services exports, sa	5	1959:Q3–2004:Q4	o		o	o	o			
Total arrivals, sa (a, f)	5	1977:Q1–2004:Q4				o	o			
Total departures, sa (a, f)	5	1977:Q1–2004:Q4				o	o			
Prices										
CPI: all goods, nsa (s)	5	1959:Q3–2004:Q4	o		o	o	o		o	o
CPI: food, nsa (c)	5	1969:Q3–2004:Q4				o	o			
Export price index: goods & services credits IPD, sa (c)	5	1959:Q3–2004:Q4	o		o	o	o			
Import price index: goods and services debits IPD, sa (c)	5	1959:Q3–2004:Q4	o		o	o	o			
JP Morgan RER, nsa (f)	5	1970:Q1–2004:Q4				o	o			
RBA commodity price index, nsa (f)	5	1959:Q3–2004:Q4	o		o	o	o			

Appendix A: Composition of Data Panels *(continued next page)*

	Code[b]	Sample	Q: BP1960	M: BP1980	Alternative indices: Q: NBP1960	Q: BP1980	Q: NBP1980	M: NBP1980	MF: BP1980	MF: NBP1980
Private finance										
Official reserve assets, sa (a, f)	5	1969:Q3–2004:Q4				o	o			
Credit: total (including securitisations), sa (f)	5	1976:Q3–2004:Q4				o	o			
Government securities: 10-year Treasury bond yield, nsa (f)	2	1969:Q1–2004:Q4				o	o			
Government securities: 5-year Treasury bond yield, nsa (f)	2	1972:Q3–2004:Q4					o			
90-day bank bill, nsa (f)	2	1969:Q3–2004:Q4				o	o			
10-year–90-day spread, nsa (c, f)	1	1969:Q3–2004:Q4				o	o			
Housing loans approved: total, number, sa (s, a, f)	5	1970:Q3–2004:Q4				o	o			
Housing loans approved: new dwellings, number, sa (s, a, f)	5	1960:Q1–2004:Q4	o		o		o			
Bank assets: resident assets – residential loans and advances, sa (a, f)	5	1976:Q3–2004:Q4				o	o			
Bank assets: resident assets – personal loans and advances, sa (a, f)	5	1976:Q3–2004:Q4					o			
Share prices, nsa (f)	5	1959:Q3–2004:Q4	o		o	o	o			
Volume of money – total: M3, sa (f)	5	1965:Q1–2004:Q4			o	o	o			
Government finance										
Australian Government revenues, sa (m, a, f)	5	1973:Q4–2004:Q4				o	o			
Australian Government expenses, sa (m, a, f)	5	1973:Q4–2004:Q4				o	o			

Appendix A: Composition of Data Panels *(continued next page)*

	Code[b]	Sample	Q: BP1960	M: BP1980	Alternative indices: Q: NBP1960	Q: BP1980	Q: NBP1980	M: NBP1980	MF: BP1980	MF: NBP1980
Monthly										
Employment										
Employment, sa	5	1978:M2–2004:M12		o				o	o	o
Employment: full-time, sa	5	1978:M2–2004:M12		o				o	o	o
Employment: part-time, sa	5	1978:M2–2004:M12		o				o	o	o
Industrial disputes: working days lost, sa (a)	5	1976:M6–2003:M12						o		o
Number receiving unemployment benefits: persons, sa	5	1976:M7–2004:M12		o				o	o	o
Participation rate, sa	2	1978:M2–2004:M12		o				o	o	o
Total arrivals, sa (a)	5	1977:M1–2004:M12		o				o	o	o
Total departures, sa (a)	5	1977:M1–2004:M12		o				o	o	o
Unemployment rate, sa	2	1978:M2–2004:M12		o				o	o	o
Wage and salary earners in civilian employment:										
Government: persons, sa	5	1983:M1–2001:M12						o		o
Private: persons, sa	5	1983:M1-2001:M12						o		o
Building & construction: total, sa	5	1983:M1–2001:M12						o		o
Manufacturing: total, sa	5	1983:M1–2001:M12						o		o

Appendix A: Composition of Data Panels *(continued next page)*

	Code[(b)]	Sample	Q: BP1960	M: BP1980	Alternative indices: Q: NBP1960	Q: BP1980	Q: NBP1980	M: NBP1980	MF: BP1980	MF: NBP1980
Building and CAPEX										
Approvals: private new houses and flats, number, sa	5	1965:M1–2004:M12						o		o
Approvals: total residential buildings, value, sa (d)	5	1978:M1–2004:M12		o				o	o	o
Approvals: total new houses and flats, number, sa (s, a)	5	1959:M9–2004:M12		o				o	o	o
Approvals: total non-residential buildings, value, sa (s, a, d)	5	1978:M3–2004:M12		o				o	o	o
Internal trade										
Motor vehicle registrations: total, spliced to sales at 2002:M1, sa (s)	5	1980:M1–2004:M12						o		o
Motor vehicle registrations: cars & station wagons, sa (s, a)	5	1959:M1–2004:M12		o				o	o	o
Retail sales excluding petrol, parts etc, sa (s, a, d)	5	1968:M9–2004:M12		o				o	o	o
WMI consumer sentiment index, sa (m)	1	1974:M9-–2004:M12						o		o
Overseas transactions										
Capital goods imports, sa (d)	5	1985:M9–2004:M12						o		o
Consumption goods imports, sa (d)	5	1985:M9–2004:M12						o		o
Exports of wool and sheepskins, sa (a, d)	5	1977:M7–2004:M12						o		o
Intermediate goods imports excluding RBA gold, sa (d)	5	1985:M9–2004:M12						o		o
Non-industrial transport equipment imports, sa (a, d)	5	1985:M9–2004:M12						o		o

Appendix A: Composition of Data Panels *(continued next page)*

	Code[(b)]	Sample			Alternative indices					
			Q: BP1960	M: BP1980	Q: NBP1960	Q: BP1980	Q: NBP1980	M: NBP1980	MF: BP1980	MF: NBP1980
Services imports, sa (d)	5	1971:M7–2004:M12		o				o	o	o
Rural goods exports, sa (d)	5	1977:M7–2004:M12		o				o	o	o
Non-rural goods exports, sa (d)	5	1974:M9–2004:M12		o				o	o	o
Services exports, sa (d)	5	1971:M7–2004:M12		o				o	o	o
Prices										
JP Morgan RER, nsa	5	1970:M1–2004:M12		o				o	o	o
RBA commodity price index, nsa (s)	5	1959:M9–2004:M12		o				o	o	o
Private finance										
Official reserve assets, nsa	5	1969:M7–2004:M12						o		o
Credit: total (incl securitisations), sa	5	1976:M9–2004:M12		o				o	o	o
Government securities: 10-year Treasury bond yield, nsa	2	1969:M7–2004:M12		o				o	o	o
90-day bank bill, nsa	2	1969:M6–2004:M12		o				o	o	o
10-year–90-day spread, nsa (c)	1	1969:M7–2004:M12		o				o	o	o
Housing loans approved: total, number, sa	5	1975:M1–2004:M12		o				o	o	o
Housing loans approved: new dwellings, number, sa (s, a)	5	1960:M1–2004:M12						o		o
Bank assets: resident assets – residential loans and advances, sa (a)	5	1976:M8–2004:M12						o		o
Bank assets: resident assets – personal loans and advances, sa (a)	5	1976:M8–2004:M12						o		o

Appendix A: Composition of Data Panels *(continued)*

	Code[(b)]	Sample	Q: BP1960	M: BP1980	Q: NBP1960	Q: BP1980	Q: NBP1980	M: NBP1980	MF: BP1980	MF: NBP1980
					Alternative indices					
Share prices, nsa	5	1947:M7–2004:M12		o				o	o	o
Volume of money – total: M3, sa	5	1965:M3–2004:M12		o				o	o	o
Government finance										
Australian Government revenues, sa (m, a)	5	1973:M8–2004:M12		o				o	o	o
Australian Government expenses, sa (m, a)	5	1973:M8–2004:M12		o				o	o	o

Notes: o indicates series included in index. The following abbreviations apply: c (calculation); d (deflated with interpolated quarterly deflator); a (seasonally adjusted by authors with X12); f (monthly series converted to quarterly frequency); m (level observed in mid-month of quarter); mqa (level observed in mid-month of quarter before June 1978, quarterly averages thereafter); s (series is spliced).

Q: BP1960 quarterly, balanced panel, 1960–2004
M: BP1980 monthly, balanced panel, 1980–2004
Q: NBP1960 quarterly, non-balanced panel, 1960–2004
Q: BP1980 quarterly, balanced panel, 1980–2004
Q: NBP1980 quarterly, non-balanced panel, 1980–2004
M: NBP1980 monthly, non-balanced panel, 1980–2004
MF: BP1980 mixed frequency, balanced panel, 1980–2004
MF: NBP1980 mixed frequency, non-balanced panel, 1980–2004

(b) Transformation codes (as in Stock and Watson 2002):
1: no transformation
2: first differenced
5: log first differenced

Appendix B: Dating Recessions

In this paper, we use the Bry and Boschan (1971) algorithm to date recessions. This algorithm implements NBER-style dating of business cycle peaks and troughs in monthly data. The Gauss code to implement Bry-Boschan for monthly data was obtained from Mark Watson's website <http://www.wws.princeton.edu/~mwatson/publi.html> and was used in Watson (1994). The Bry-Boschan algorithm has been applied to Australian monthly data by Boehm and Moore (1984), Boehm and Summers (1999) and Pagan (1997). We also use a variant of the Bry-Boschan algorithm to date cycles in quarterly series. A quarterly version of the Bry-Boschan algorithm has been used by many authors, including Altissimo *et al* (2001), Cashin and Ouliaris (2004), Harding and Pagan (2002, 2003, 2005) and Inklaar *et al* (2003).

The quarterly algorithm, which also serves as an intuitive analogy to the more complex monthly algorithm, is given by the following steps:

Step 1: Local peaks (troughs) in real GDP are found as quarters greater (less) than their neighbouring two quarters either side.

Step 2: Peaks and troughs are forced to alternate by eliminating the shallower of any two consecutive peaks/troughs.

Step 3: A minimum phase length (peak-to-peak or trough-to-trough) of five quarters is enforced. The peak or trough removed is chosen such that the average depth of recessions is greatest after removing that point.

Step 4: Peaks (troughs) that are lower (higher) than previous troughs (peaks) are eliminated by removing that trough-peak (peak-trough) phase.

Step 5: The first and last peaks (troughs) are eliminated if they are not greater (less) than the maximum (minimum) of the points at the ends of the series.

While the FHLR methodology produces a level index, SW does not. We construct a level SW index in an analogous way to FHLR, as shown in Equation (B1):

$$g_t = \mu + \sigma\chi_t^* \tag{B1}$$

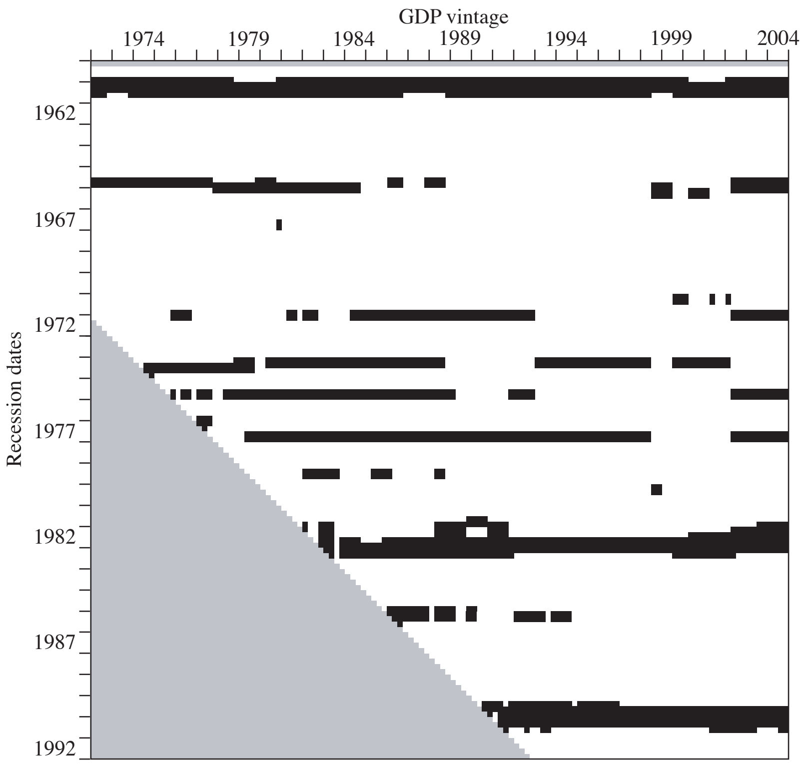
The growth rate of the level series, g_t, is calculated by scaling each observation of the business cycle index, χ_t^*, by the parameter σ and adding a mean growth rate μ. The scaling ensures movements of a reasonable magnitude relative to the mean. These adjusted growth rates are cumulated to form an index level. The choice of μ and σ will affect the dating of recessions by determining whether the level of the index falls in any given period. If σ is too small (large) relative to μ the resulting level series will have too few (too many) falls and so too few (too many) recessions. We set μ equal to the mean growth rate of log GDP, and σ equal to the ratio of the standard deviations of four-quarter changes in log GDP relative to four-quarter changes in the coincident indices.[23] This choice produces similar dating to FHLR.

23. FHLR scale the index (which has a standard deviation of one) by the standard deviation of quarterly GDP growth to obtain the level index. While this scaling produces sensible results for FHLR, a similar scaling produces too many recessions for SW because the original SW index is less smooth than FHLR.

Appendix C: Revisions to GDP and Recession Dating

Figure C1 shows the dating of recessions for the period 1960:Q1 to 1992:Q4 for vintages of GDP from 1971:Q1 to 2004:Q4. Recessions are shown as black bars. Looking across the figure shows which GDP vintages classified that quarter as being in recession. Looking down the figure shows the dates of recessions for a given GDP vintage. The recessions observed in 1960–1961, 1982–1983 and 1990–1991 are robust across the different vintages of GDP, although the length and precise timing of these recessions has changed with revisions to the national accounts. All vintages of GDP after 1974:Q2, with the exception of the 1998:Q3–1999:Q2 vintages, identify at least one recession in the 1970s. However, the timing of recessions in the 1970s has been subject to substantial revision. In part, this appears to be the result of larger revisions to GDP in the 1970s. Furthermore, with lower average growth in the 1970s, small revisions to GDP can easily change the dating of recessions. No recessions are found after 1992.

Figure C1: Recession Dating for Different Vintages of GDP



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Discussion

1. Chris Caton

I enjoyed reading this paper. It is not often that a private-sector economist gets to spend more than 30 minutes thinking about one topic. I have to say that I can't give equal justice to all parts of the paper, since my level of technical competence has been in decline for some time. Indeed, when I got to Section 3, which outlines the methodology behind the construction of the indices, I was struck by two thoughts. I am an old dog. And this is a very new trick.

The paper begins so well. The two indices constructed from the quarterly data first behave well, and second, behave similarly, which gives one confidence that they must be doing the right thing. As Figure 2 shows, the SW index clearly follows a similar path to GDP, but with a lot less noise, and the requisite tests show that it makes very little difference if one uses more factors to construct the indices, or if one uses a broader panel of data (Figures 3 and 4). So far so good.

It is when we get to the construction of the monthly indices, for the shorter period 1980–2004, that it gets a little more perplexing. First, the authors' methodology leads them to identify the one-factor SW index and the two-factor FHLR index as respective bests of breed. Suddenly, the indices no longer appear similar, as Figure 5 illustrates. It is clear what is causing this: it is not the different methods of construction but the different number of factors. The authors make the point that the behaviour of the two series is very different around 1990. Let me make the same point another way. Suppose you were to ask SW and FHLR for an assessment of the relative strength of the economy in 1986 and 1994. SW would reply that the two years were about equal in terms of growth, while the FHLR index would suggest that 1986 was a very weak year and 1994 a very strong year. All of the comfortable feeling generated by the fact that the two indices were sending a broadly similar message has gone.

It needs somebody smarter than I am to articulate why a small difference in the number of factors makes such a difference to the monthly indices, when it made so little difference to the quarterly indices. This is important, because if we are going to use such indices for current, rather than just historical, analysis, then a monthly index would obviously be far preferable. Indeed, it would need to be the SW variant, because of the lags involved in the FHLR.

I have a small quibble with the construction of the monthly FHLR index. There are many important economic time series (GDP and the CPI are the most obvious examples) that are available only quarterly. They can't be ignored so, in constructing the index, one needs to come up with an equivalent monthly series. This is done by constructing a series that in each month grows at one-third of the quarterly rate of growth for that quarter. A moment's thought will show that such a monthly series doesn't sum to the quarterly series but, more importantly, this methodology in fact imposes an average lag of 1 month on the relevant series. This doesn't seem a desirable property, and it is very easily fixed! You just need to take the quarterly growth rate, divide it by three, and then apply that rate to the three months beginning the month *before* the quarter begins.

The authors then look at the clear decline in the volatility of GDP growth over the past 45 years, a topic also visited in several of the papers presented earlier. Their conclusion is that, since the coincident indices have experienced no such similar decline over the whole interval, it is quite likely that most of the decline in GDP volatility is a result of improved measurement, rather than a true decline in the volatility of the economy (see Figure 7). But I see two other things when I look at Figure 7. First, the indices appear to show a step up in volatility during recessions (hardly surprising), and a consequent step down 10 years later, when the recession years roll out. Second, I see a trend decline in the volatility of the indices since 1990, which suggests to me that the overall volatility of the economy *has* declined (or have we just had a freakishly long expansion?).

I found the section on the dating of recessions also to be interesting. In brief, the quarterly indices find only three recessions since 1970, while the GDP data find six. I want to return to this count later, but a question that occurred to me, which the authors don't address, is: do the indices have any tendency to act as an early warning for 'GDP recessions'? Or, if they don't, do we at least get the data earlier? At first glance, they both appear to lead both peaks and troughs in two of the three common recessions (Table 6). But there are two problems. First, the indices say that the mid-1970s recession was finished one quarter before the GDP data suggest that it began. Second, of course, we need a real-time analogue of Table 6. We could accept that the indices are less susceptible to revision over time, so what we have now may not be very different from what we would have seen in real time, but we know from Appendix C and the Morse code chart (Figure C1) that GDP has certainly been revised significantly. Indeed, the mid-1970s recession suggested by the indices seems to coincide with one recently revised out of existence.

There are two more broad points that I want to make about recessions. First, the SW index has a transatlantic cousin in the Chicago Fed National Activity Index (CFNAI), which was first constructed some five years ago. This is a monthly series, formed from 85 indicators, and it comes with its own rules of thumb about recessions and recoveries; when a three-month moving average of the series dips below –0.7, this is taken as a signal of a recession. Such a rule in fact sends a couple of false signals either side of the 1990–1991 recession; a better threshold would be –1. Now if you go all the way back to Figure 1, such a threshold for the Australian SW index would identify a large number of recessions, including in 1986 and 2001. The indices appear to be standardised in the same way, so why is the threshold apparently so much bigger in Australia? Australian data would naturally be noisier than US data (we're a smaller economy), but the standardisation should take care of this. The SW quarterly series uses 25 components, while the Chicago Fed uses 85, but we've been told that using more series makes very little difference.

Is it something to do with the type of series used? In particular, the Chicago Fed index uses no series relating to overseas transactions or to finance, while the Australian index takes account of six such series. In addition, all the US data are adjusted for inflation. Intuitively, these differences don't seem to be enough, leaving the question: why do we need a far greater negative reading in the Australian index to signal recession?

The CFNAI also commits itself to two other thresholds. A sustained move above 0.2 in the three-month moving average signals recovery, and a move above 1 well into an expansion signals a pick-up in inflation. Do the authors have any thoughts on similar thresholds for the Australian index, or on the use of simple thresholds in the first place?

And now for something completely different. I can't get away from the feeling that recessions have something to do with unemployment. In this respect, it is perhaps noteworthy that the word unemployment appears just twice in the main body of the paper. Suppose that one in fact defined a recession as having taken place if and only if the unemployment rate has risen by a percentage point. Certainly our American visitors would have little trouble with such a definition. Because unemployment lags, one may have to do further work to determine the timing of the recessions. Recoveries would be defined as periods in which the unemployment rate was stable or falling. Again this would satisfy the Americans.

In the 1970s, there were three occasions in which Australian unemployment rose by more than a percentage point. It rose from 1.6 per cent to 2.9 per cent between the December quarter of 1970 and the September quarter of 1972 (we had only quarterly data on unemployment until 1978). It rose again, from 2.1 per cent to 5.4 per cent between June 1974 and December 1975, and then again, from 4.5 per cent to 5.9 per cent between June 1976 and December 1977. These episodes are consistent with the timing of recessions according to the GDP data, but not according to the coincident indicators. Of course, during the 1970s, real wages increased massively. Presumably some are prepared to say that the huge upward drift in unemployment in that decade was secular rather than cyclical, but to me the behaviour of unemployment adds weight to the GDP timing of recessions rather than that of the coincident indices.

Which brings us to 2000–2001, when the unemployment rate rose from 6 per cent in October 2000 to 7.2 per cent in October 2001. Nobody has ever labelled this episode as a recession to my knowledge, but how close does it come? It used to be said, at that time, that no country had ever introduced a GST (or a VAT) without quickly experiencing a recession. Perhaps none still has.

I am sure there are many more questions raised by this paper. This is not a criticism, in fact it suggests that the authors have done some very useful work – I just want to know more about the applications from here.

2. General Discussion

A number of participants asked about potential uses for the index constructed by the authors, particularly with regards to forecasting. In discussing this issue, one participant questioned whether the predictive capabilities of the index had been tested, while another suggested that it is important to have a better understanding of the relative weights placed on various series in the index, and which series the index most closely matches, if it is going to be more than a 'black box'. In response, the authors noted that the index was constructed to be a coincident index, rather than a leading index, and that its predictive content had not been a criterion in its construction. Furthermore, Anthony Richards commented that the index approach is still considered experimental, and it remains to be seen whether the monthly index will perform as well as equivalent indices in other countries that are based on many more series.

Related to this, there was much discussion of the likely performance of the index in real time. One participant questioned what effect data revisions would have on the index in real time. In the context of forecasting of current-quarter GDP, another participant commented on some US experience comparing the performance of an index with judgmental forecasts from a team of forecasters, which had shown a number of challenges to be overcome in implementing an index approach. While judgemental forecasts still tend to be more accurate, the performance of these types of indices is likely to improve with further work.

The benefit of using a coincident index instead of GDP to gauge the state of the business cycle was questioned by some participants. One highlighted that GDP is itself a system of around 100 series, but with several theoretical advantages; in particular, the weights are determined by the relative importance of the sector in question in the economy, rather than estimated; and the system for its construction is time-tested. Furthermore, they commented that there are alternative methods for reducing the noise in GDP, such as the use of (Henderson) trend estimates. Anthony Richards responded by saying that it was not intended that these indices would replace GDP, but the analysis so far suggested strongly that they are better means of assessing the state of the business cycle in real time than applying trend filters to GDP, given the end-point problems involved in the latter approach.

A few participants also questioned the logic behind the inclusion of price variables when the index is aimed at representing real activity. In response, the authors noted that the index includes several nominal variables, and that the price series are therefore included to possibly remove trends in these series induced by inflation. This resulted in some discussion about whether the persistence of the index was due to the inclusion of inflation, which is itself very persistent; one participant asserted that at least one series included in the index needed to be persistent if the index was to be persistent itself, a point which was challenged by the authors.

Financial System Liquidity, Asset Prices and Monetary Policy

Hyun Song Shin[1]

Abstract

Monetary policy works through changes in asset prices – especially through its impact on long-term interest rates. As well as affecting the economy through the usual 'IS' relationships – through consumption and investment – monetary policy has wider repercussions. It affects balance sheets through changes in the relative prices of liabilities and assets, the availability of credit and through property prices – a set of interrelated features that we can dub 'financial system liquidity'. When balance-sheet changes affect asset prices, and asset-price changes affect balance sheets, the loop thus created can generate amplified responses to an easing of monetary policy that cannot easily be unwound without exacting large economic costs.

1. Introduction

Monetary policy works by manipulating asset prices, especially long-term interest rates. Although a central bank generally directly controls only the overnight interest rate, its communication policy serves to guide the market's expectations into doing its bidding. By moulding market expectations, the central bank can manipulate long-term interest rates, and thereby affect mortgage rates, corporate lending rates and other prices that have a direct impact on the economy.

However, even though financial markets are the medium through which the central bank gives effect to its monetary policy, the consequences of the central bank's actions are seen almost exclusively through the lens of the IS curve – that is, through quantities such as consumption and investment. The wider consequences of monetary policy for the financial system as a whole receive less weight in central bank pronouncements on monetary policy. The task of maintaining financial stability is allocated to the central bank's role (if any) in financial supervision and prudential regulation. In effect, a Tinbergen-style allocation of instruments to goals is envisaged where the goal of monetary policy is to ensure price stability, and supervisory/prudential policy is aimed at financial stability. This allocation of roles is neatly summarised in a speech by Fed Governor Ben Bernanke (2002):

1. I am grateful to the discussant, Peter Westaway, and other participants at the conference for their comments. I thank Charles Goodhart and Raghu Rajan for their comments on an earlier draft. I am grateful to the IMF Research Department for its hospitality during the Northern summer of 2005 while this paper was prepared, and to the United Kingdom Economic and Social Research Council for its support under research grant RES-156-25-0026 as part of the World Economy and Finance programme.

> ... as a general rule, the Fed will do best by focusing its monetary policy instruments on achieving its macro goals – price stability and maximum sustainable employment – while using its regulatory, supervisory, and lender-of-last resort powers to help ensure financial stability.

It is not my intention here to revisit the debate on whether it is better for the central bank to attempt to 'prick' a suspected asset-price bubble or whether instead it should wait for the bubble to burst of its own accord, and work toward softening the impact of the resulting downturn.[2] In one sense, this debate is not entirely helpful since it takes for granted the existence (or suspected existence) of an asset-price bubble, and the focus is on how to deal with it once it has taken hold. What is less widely discussed is how monetary policy may contribute to the *inflating* of an asset-price bubble in the first place. It is this issue that I attempt to address in what follows.

The role of monetary policy in setting the general tenor of financial market conditions has returned as a topical issue in the wake of the unprecedented monetary easing in the US in recent years. Commentators are fond of using expressions such as the financial markets being 'awash with liquidity', leading to compressed yield spreads and the chasing of yields. Indeed, recent developments in financial markets have posed a challenge to central bankers and other public officials. Signals emanating from the financial markets – in the form of low long-term interest rates, compressed yield spreads and low implied volatility – seem to paint an implausibly benign economic picture that gives very little weight to the potential sources of downside risk.[3]

More recently, the debate in the US (on the heels of similar debates in Australia and many other countries) has moved to the relationship between monetary policy and its role in fuelling the rise in the price of residential property. Fed Governor Donald Kohn (2005) puts the matter thus:

> Low interest rates have, in turn, been a major force driving the phenomenal run-up in residential real estate prices over the past few years, and the resultant boost to net worth must be one of the reasons households have felt comfortable directing so little of their current income to saving. However, whether low interest rates and other fundamental factors can fully explain the current lofty level of housing prices is the subject of substantial debate.

The purpose of my paper is to shed some additional light on this debate. To the extent that monetary policy works by manipulating asset prices – in particular, long-term interest rates – we may expect broader repercussions on financial institutions and markets through changes in the relative values of liabilities and assets (and hence net worth), the availability of credit, and asset prices. Inevitably, such effects will harbour feedback elements that serve to magnify the responses to initial shocks. Balance-sheet changes will affect asset prices and asset-price changes will affect balance sheets. The loop thus created will generate amplified responses to the changing of monetary policy.

2. The conference volume from the Reserve Bank of Australia's 2003 conference gives a good snapshot of the state of the arguments at the time (see Richards and Robinson 2003).
3. Official publications express these worries in more guarded terms. See Bank of England (2004a, 2004b) and IMF (2005a, 2005b).

The literature on the transmission of monetary policy has distinguished two potential 'credit channels' through which monetary policy affects lending. The first is the increased credit that operates through the *borrowers'* balance sheets, where increased lending comes from the greater creditworthiness of the borrower (Bernanke and Gertler 1989; Kiyotaki and Moore 1998, 2001a, 2001b). The second is the channel that operates through the *banks'* balance sheets (the 'bank lending channel'), where open market operations that drain reserves would limit bank loans by reducing banks' access to loanable funds (Bernanke and Blinder 1988; Kashyap and Stein 2000).

The channel explored in my paper is a variation of the second, and emphasises the net worth of the banks themselves, and the incentive effects to restore leverage when balance sheets are continuously marked to market. Van den Heuvel's (2002a, 2002b) notion of the 'bank capital channel' is most closely related to the ideas explored here. Although the assumption of continuous marking to market is not appropriate if taken literally, the 'banks' in my framework could be seen as the US mortgage agencies such as Fannie Mae, that deal mainly with marketable claims. In any case, I will argue below that trends in financial markets and accounting rules are likely to make marking to market more important in determining the behaviour of financial institutions.

The amplified response to the easing of monetary policy, by itself, need not be a problem for policy-makers if they can fine-tune their monetary policy levers to take account of the amplification. Rather, the problem is the highly asymmetric nature of the mechanisms at play 'on the way up' versus the mechanisms 'on the way down'. If the bursting of a property bubble impairs the solvency of the financial sector, then the dynamics 'on the way down' can turn into an extremely messy affair, involving a whole new set of mechanisms that did not figure in the initial inflating of the bubble. Default, financial distress, and inefficient liquidations will all conspire to exact very large economic costs.

Marked-to-market snapshots of the household balance sheet cannot always be relied on as a source of comfort. Although the marked-to-market value of the residential housing stock goes up in proportion to the current market price (assuming a fixed housing stock), this increase in the value of the housing stock cannot be seen as an increase in net wealth for the economy as a whole. It merely reflects the reallocation of housing between households – or more accurately, the rate at which the marginal reallocation takes place. The shift is *within* the Edgeworth box, rather than an *expansion* of the Edgeworth box.

The new holders of the housing stock may (almost tautologically) have a higher consumption value for housing, but this higher consumption value is not fungible, and so is not available for repayment of debt. It is only when the indebted households can rely on a secure, independent stream of cash flow (say, from wage income) that debt service is assured. It is one of the tenets of good banking practice that the banker should look at the borrower's future cash flows, rather than be fixated by the value of the borrower's collateral assets. Japanese banks were reminded of the wisdom of this rule following the bursting of the property bubble there.

Marking the current housing stock to market can create a misleading impression of the strength of aggregate balance sheets. Consider the following passage from a recent commentary in the *Wall Street Journal*:[4]

> While many believe that irresponsible borrowing is creating a bubble in housing, this is not necessarily true. At the end of 2004, U.S. households owned $17.2 trillion in housing assets, an increase of 18.1% (or $2.6 trillion) from the third quarter of 2003. Over the same five quarters, mortgage debt (including home equity lines) rose $1.1 trillion to $7.5 trillion. The result: a $1.5 trillion increase in net housing equity over the past 15 months.

The author minimises the dangers from the $1.1 trillion increase in indebtedness by appealing to the marked-to-market value of housing equity. The counterargument would be that the marked-to-market value of the housing stock (assessed at the current marginal transaction price) may not be a good indicator of the strength of the *aggregate* household sector balance sheet. In aggregate terms, the relevant question is how much value can be realised if a substantial proportion of the housing stock were to be put up for sale. The value realised in such a sale would be much smaller than the current marked-to-market value. This is one instance in which marking to market gives a misleading indicator of the aggregate position.[5]

It is not inevitable that the bursting of a property bubble undermines the financial system as a whole. The experience in Hong Kong following the bursting of the housing bubble in 1997 is a case in point. Residential property prices declined by around 70 per cent in Hong Kong between 1997 and 2004, but there was no banking crisis. There are important lessons to be learned from the Hong Kong experience. Loan-to-value ratios were generally very low in Hong Kong. Also, households continued to service their debt, even though the value of their houses fell far short of their mortgage obligations, pointing to the importance of the bankruptcy regime in place. If the borrower can declare bankruptcy, return the keys, and walk away, then it is the banking sector that will end up holding the depreciating property stock. It is unclear how far Hong Kong's experience can be extrapolated to the US, Australia, Spain and the many other countries that have experienced residential property booms. Loan-to-value ratios and bankruptcy rules may differ substantially from those in place in Hong Kong.

More systematic empirical evidence is not so encouraging for a country that undergoes a property-price boom financed by large increases in private credit. Borio and Lowe (2002a, 2002b, 2004) exhibit evidence that the joint occurrence of property booms and 'excessive' private-sector credit growth help predict banking distress, economic weakness and disinflation over a three- to five-year horizon. The important point is that even as financial imbalances build up, goods price inflation can remain low and stable (Japan in the 1980s being a prime example).

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4. 'Mr. Greenspan's Cappuccino' commentary by Brian S Wesbury, *Wall Street Journal*, 31 May 2005, p A16. The title makes reference to Alan Greenspan's comments on the 'froth' in the US housing market.
5. Plantin, Sapra and Shin (2004, 2005) discuss other dimensions of the trade-off between marking to market and historical cost accounting.

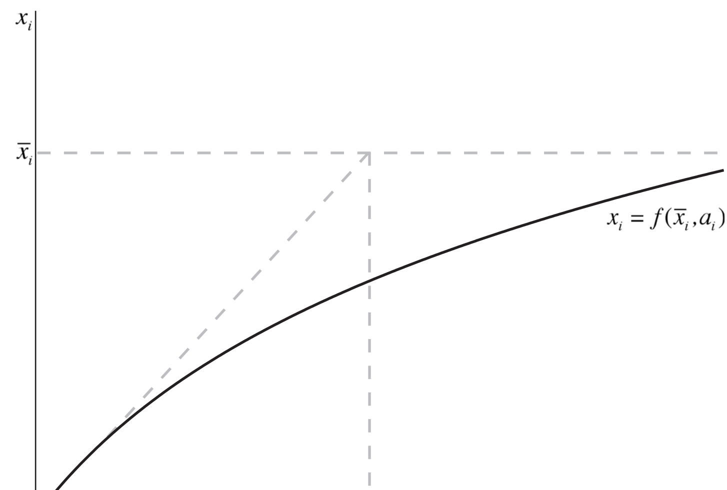
I begin the main body of the paper by outlining a general framework for examining the interrelationships between the value of obligations in a system of interlocking balance sheets, which is then applied to a highly stylised model of an economy with property as the sole real asset. The amplifying effect of monetary easing and its effect in raising property prices is illustrated within the stylised model. In keeping with the theme of this year's RBA conference – on the changing nature of the business cycle – I close by outlining a number of factors affecting financial institutions and markets that have served to sharpen the effects outlined here.

2. Framework for a Financial System

The basic problem can be posed in the following way. The marked-to-market value of my claim against *A* depends on *A*'s creditworthiness, and so depends on the value of *A*'s claims against *B*, *C*, etc. However, *B* or *C* may have a claim against me, and so we are back full circle. The task of valuing claims in a financial system thus entails solving for a consistent set of prices – that is, solving a fixed-point problem.

Suppose that borrower i has issued debt with face value $\bar{x}_i$, and has assets with market value a_i. The market value of i's debt, denoted by x_i, is less than its face value, but is increasing in the value of i's assets. Denote by $f_i(\bar{x}_i, a_i)$ the market value of i's debt with face value $\bar{x}_i$ when i's assets have market value a_i. Figure 1 depicts this relationship. As noted by Merton (1974), the market value of i's debt is the price of a short position in a put option on i's assets with strike price equal to

Figure 1: Price of Debt



the face value of the debt. Among other things, this implies that x_i is increasing in $\bar{x}_i$, and is also increasing in a_i, but the slope is less than 1 everywhere.

The value of *i*'s assets will depend, in part, on the value of his claims against other borrowers in the financial system. The value of *i*'s assets will also depend on the prices of real assets (assets that are not the obligations of some other party). Suppose that there is only one type of real asset in the economy, and denote its price by *v*. We thus have the following system for the determination of the value of financial system claims:

$$\begin{aligned} x_1 &= f_1(\bar{x}_1, a_1(x,v)) \\ x_2 &= f_2(\bar{x}_2, a_2(x,v)) \\ &\vdots \\ x_n &= f_n(\bar{x}_n, a_n(x,v)) \end{aligned}$$

The notation $a_i(x,v)$ reflects the fact that the value of *i*'s assets depends on the vector of all claims in the financial system (given by *x*) as well as the price of the real asset. More succinctly, we can write this system as

$$x = F\left(x; \bar{x}_1, v\right) \tag{1}$$

A consistent set of valuations is a fixed point *x* of the mapping *F*. The following set of results can be shown[6] to hold in this setting:

- there is a unique fixed point *x* of the mapping *F*;
- *x* is increasing in $\bar{x}$; and
- *x* can be computed numerically as the limit of the sequence $F(0)$, $F^2(0)$, $F^3(0)$, … where $F^n(0)$ is the *n*-fold composition of the mapping *F* on the zero vector.

If the level of debt (as given by the vector $\bar{x}$) is endogenously chosen by the constituents of the system themselves, then there is the potential for feedback from $\bar{x}$ (the level of indebtedness) to *v* (the price of the real asset) to *x* (the market value of claims/obligations). Since *x* determines the net worth of the financial system constituents, this in turn influences the decisions on $\bar{x}$. We would then be back full circle, and another round of increases (decreases) will take place. When the sole real asset is property, the feedback can be described in terms of a property boom (bust) being fuelled by the buoyancy (weakness) of demand as reflected in the availability of credit and the health of balance sheets.

Assessing financial claims in a system setting captures a number of features that are missing in a partial equilibrium setting. For instance, it is possible for spreads to *fall* as debts *rise*. If *v* is sufficiently sensitive to the flow of new funds

6. *F* is an increasing function of *x* on the complete lattice $\left[0,\bar{x}_1\right] \times \left[0,\bar{x}_2\right] \times \ldots \times \left[0,\bar{x}_n\right]$, and so has a largest and smallest fixed point by Tarski's fixed point theorem. Uniqueness follows from the fact that $\partial f_i / \partial a_i < 1$ everywhere. The fact that *x* is increasing in $\bar{x}$ follows from results on the comparative statics on lattices (Milgrom and Roberts 1994). See Shin (forthcoming) for proofs of all results reported here.

into the property sector, then the increase in market values x can be so large as to swamp the increase in face values $[0,\bar{x}_1]\times[0,\bar{x}_2]\times\ldots\times[0,\bar{x}_n]$. Symmetrically, it is possible that *de-leveraging* leads to *increases* in spreads (as is often observed during crises).

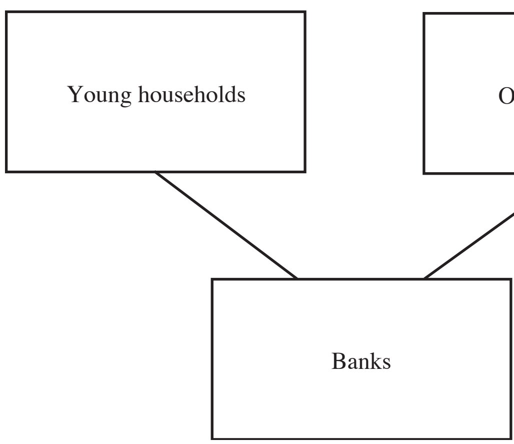
In any case, property prices, creditworthiness and the level of debt are all interrelated, and we could call the snapshot of the current state of these variables the state of 'financial system liquidity'. Into this heady mix comes monetary policy. Monetary policy operates by manipulating the prices of treasury securities – in particular by manipulating (through the central bank's policy rate and its communication policy) the prices of long-dated treasuries. When monetary policy is loosened, for example, long-duration assets (and liabilities) will gain in value by more than short-duration assets/liabilities. Thus, the market value of claims and obligations (given by the vector x) will shift, affecting the balance sheets of the financial system constituents. When x shifts, so will $\bar{x}$ and hence v. In this way, an easing of monetary policy can be expected to have an impact on the overall level of debt through changes in net worth and the creditworthiness of borrowers. The overall level of debt then has an impact on the real asset price. In concrete terms, banks that borrow short and lend long will experience an increase in their market net worth, and may react to their stronger balance-sheet position by increasing their lending. Increased credit will lead to a rise in the real asset price.

Having outlined the basic framework in general terms, I present a concrete example of this framework, and illustrate the feedback loop generated by a loosening of monetary conditions. The example is that of a highly stylised financial system.

3. Stylised Financial System

Our financial system has three groups – young households, old households and the banking sector (Figure 2). The only qualification to be a member of the financial

Figure 2: Simplified Financial System

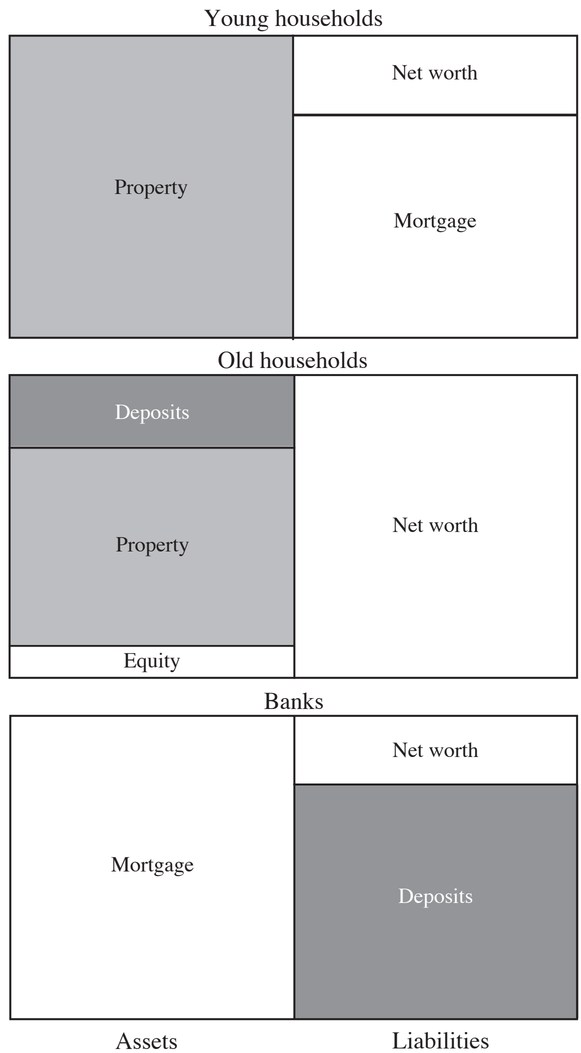


system is to have a balance sheet. In this sense, households are fully-fledged constituents of the financial system.

The sole real asset that underpins the financial system is residential property. The young households hold part of the residential housing stock financed by borrowing from the banks. The young households thus have a particularly simple balance sheet (Figure 3, top panel). Their assets consist of property, while their liabilities consist of mortgages and net worth (if any).

From the banking sector's point of view, the mortgage liabilities of the young households are its assets. The banks finance their lending through deposits of the

Figure 3: Balance Sheet of Financial System Participants



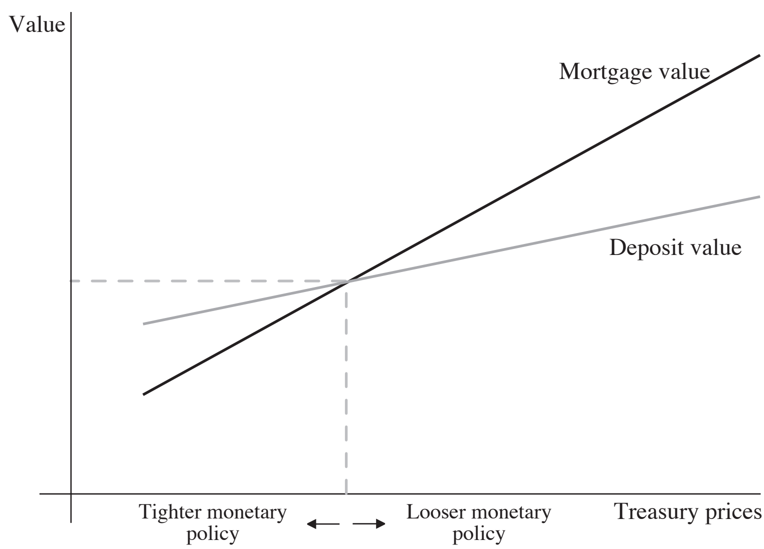
old households. The contractual features of the deposit contract do not play a role in my argument, but it is important that banks' liabilities are of shorter duration than their assets. For my purposes, it is better to think of deposits as short-term claims on the banks. The balance sheet of the banking sector can be depicted as in the bottom panel of Figure 3. Old households hold residential property, deposits in the banking system, and are the equity holders of the banks themselves. They have no liabilities to other parties in the financial system, so that the whole of the liabilities side of their balance sheet consists of net worth (middle panel, Figure 3).

3.1 Duration difference in assets and liabilities

As I have described already, the contractual features of the deposit contract (such as the demandable nature of deposits) are not crucial for my story, but it is important that the marked-to-market value of deposits is less sensitive to long-term interest rates than the marked-to-market value of mortgage claims.

For simplicity, let us suppose that the treasury yield curve is flat, and that monetary policy works through parallel shifts of the yield curve. In this setting, a loosening of monetary policy induces a downward shift in the yield curve, raising both the value of deposits and mortgages. However, the value of mortgages rise by a larger proportion, reflecting their longer duration. Figure 4 illustrates the effect of monetary policy on the prices of mortgages and deposits. The relationships in Figure 4 are depicted in terms of straight lines, but this should not be taken literally. Among other things, mortgages may have embedded option elements such as early repayment. What is important is the fact that one unit of mortgage claims and one

Figure 4: Duration Difference Between Assets and Liabilities



unit of deposits that start out with the same market value will diverge in value as monetary policy is either loosened or tightened.

The banking sector holds mortgages on the asset side and deposits on the liabilities side. Thus, any shift in interest rates has a differential impact on its assets and liabilities. When monetary policy is eased, mortgage values rise by more than the value of deposits, raising the net worth of the banking sector, and reducing its leverage. Crucial to my story is the reaction of the banking sector to the increase in net worth. I will suppose that the banks react to the increase in net worth by increasing lending to the young households. The increase in lending could be quite moderate – for instance, the leverage of the banks could still be lower than before the fall in interest rates. However, the assumption is that the banks do not sit still when they see an increase in their net worth. The more accountable are the banks' management to their shareholders, and the more responsive they are to short-term incentives, the more likely it is that the banks will attempt to increase their lending.

I will assume that the banks can always find young households that are willing to borrow in order to finance the purchase of property, and that they (the banks) can find old households that are willing to lend to them in the form of greater deposits. Thus, from the point of view of the banks, they can always increase the size of their balance sheets by borrowing from old households and lending the proceeds to the young households.

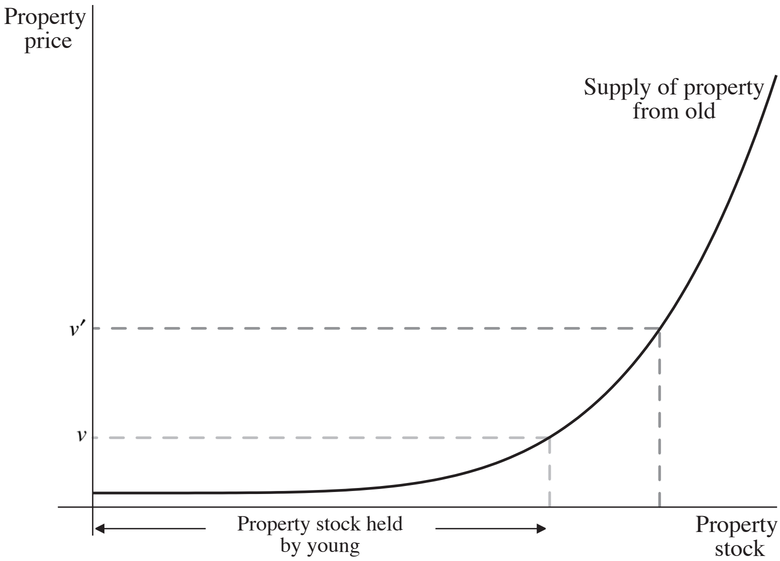
The upshot of my assumptions on the behaviour of banks is that an increase in banking sector net worth resulting from the loosening of monetary policy results in a net flow of funds into the property sector, via the banks' balance sheets.

3.2 Property prices

An important part of my story is that the greater allocation of funds into the property sector leads to an increase in property prices. Let us suppose that there is an upward-sloping supply curve for property from the old households so that as bank lending to the young households increases, the price of the marginal property increases. Figure 5 depicts the upward-sloping supply curve. The implicit assumption is that there is some heterogeneity in the preferences of old households for housing services (which leads to the gradual increase in housing supply as the price rises), and that young households (as a group) place a higher value on housing than the old households. These differences may reflect, among other things, differences in remaining lifespans. Even if the per-period consumption value of housing were the same, younger households have longer to live, and hence may place a higher subjective value on owning the house, reflecting the higher capitalised value of housing services.

Figure 5 also illustrates the nature of property wealth in a financial system. The marked-to-market value of the housing stock increases in proportion to the price of the marginal-traded property. Does this mean that the net wealth of the economy has increased by the amount of the increase in the marked-to-market value of the

Figure 5: Property Price

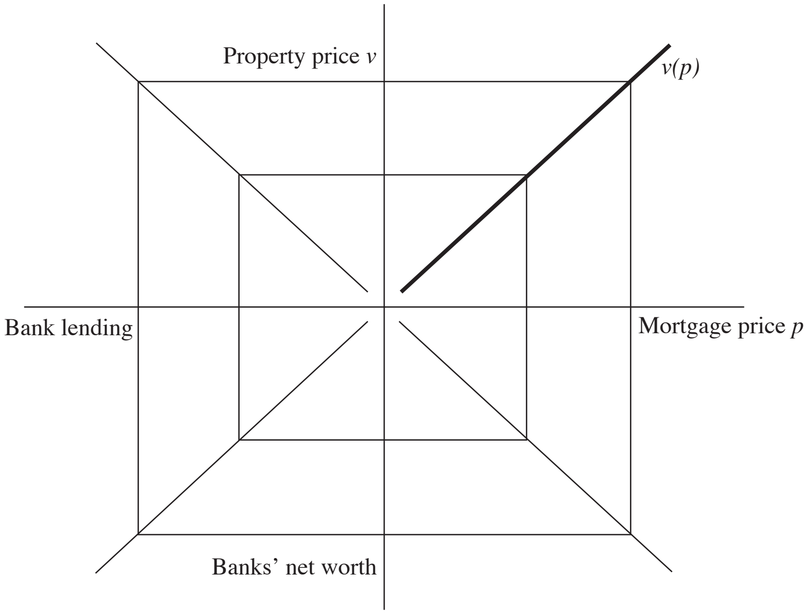


housing stock? In our framework the answer would be ‘no’, since the increased property price simply reflects the marginal rate at which housing is reallocated from the old to the young. We have simply moved from one point in an Edgeworth box to another, rather than seeing an *expansion* of the Edgeworth box.

Bringing the various elements of the story together, we can now trace the impact of the strengthening balance sheet of banks on property prices. Denote the market price of mortgage claims as p, and suppose that monetary policy is eased, resulting in p rising by a greater proportion than the marked-to-market value of deposit liabilities. Monetary easing results in an increase in the net worth of the banking sector, inducing an increase in lending to young households (financed by greater deposits from old households). The young households then enter the property market with the new funds, raising the price of the marginal-traded property. Denote the price of property as v. Thus, an increase in the mortgage price p is associated with an increase in property price v. We can thus define $v(p)$ as the price of property that is consistent with mortgage price p. Figure 6 illustrates the derivation of this relationship.

The bottom-right-hand quadrant indicates that as the mortgage price rises, banks’ net worth increases. The bottom-left-hand quadrant is the key. It illustrates our assumption that as banks’ net worth increases, banks are induced to increase their lending to young households. The top-left-hand quadrant shows the increasing relationship between bank lending and the price of property. This sequence of implications enables us to derive the curve $v(p)$ that gives the property price as a function of the mortgage price.

Figure 6: Property Price *v* as a Function of Mortgage Price *p*



4. Feedback

As the property price increases, the net worth of the household borrowers who have invested in property increases. To the extent that the loans to the household sector are collateralised against property, the rise in the property price raises the credit quality of the mortgage claims held by the banks against the young households, raising the marked-to-market value of the mortages held on the asset side of the banks' balance sheets.

Thus, we can define the price of mortgages, $p(v)$, that is consistent with property price v. The price of mortgages is an increasing function of the price of property. Figure 7 illustrates this relationship. Since the increase in p is due to the increasing value of the assets that back the mortgage, there is an upper bound to p given by the price of the risk-free counterpart to the mortgage. This upper bound is indicated by the grey line.

We can now bring the ingredients together to examine how the price of property interacts with the price of mortgages. Let us define $h(.)$ as the inverse of the function $v(p)$. Thus, $h(v)$ is the mortgage price p that would give rise to price v of property. Plotting $h(v)$ and $p(v)$ on the same figure, we can derive the combination (v,p) of property price and mortgage price that would be mutually consistent. This is indicated in Figure 8.

With this framework, we can conduct some comparative statics with respect to some of the key quantities. Consider the effect of looser monetary policy that shifts the treasury yield curve down (Figure 9).

Figure 7: Mortgage Price *p* as a Function of the Property Price *v*

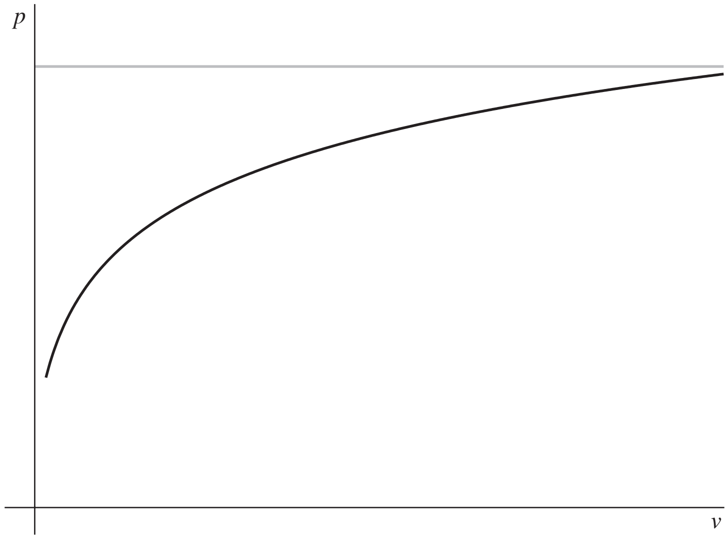
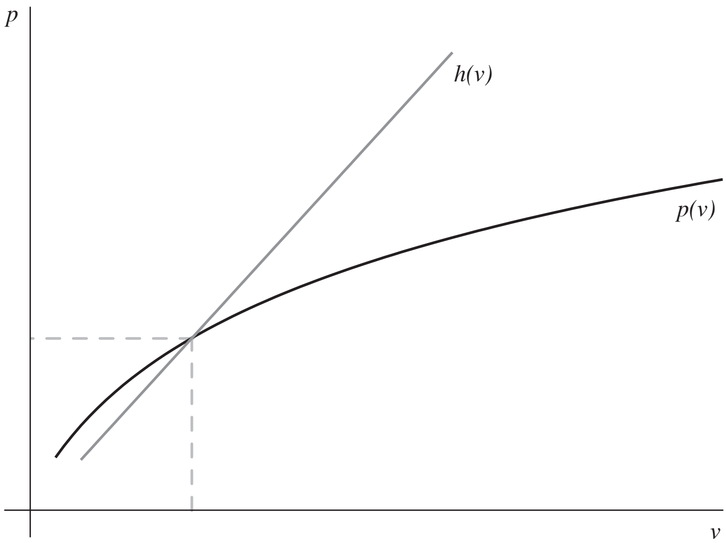


Figure 8: Joint Determination of Mortgage Price and Property Price

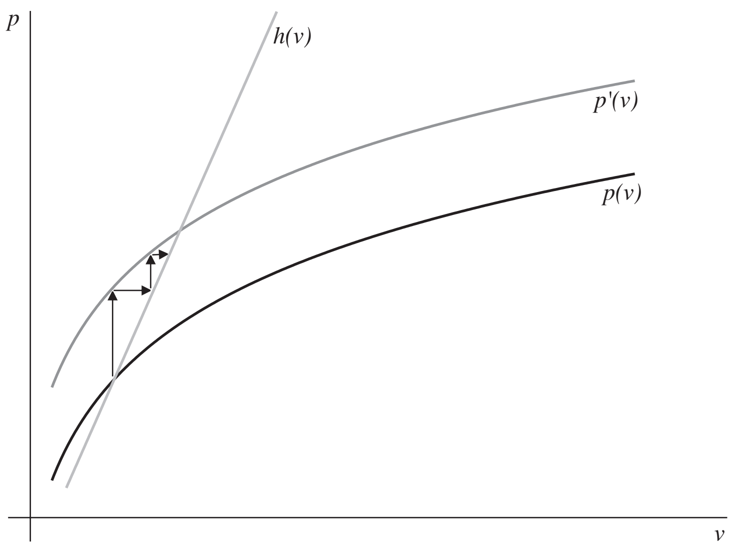


As monetary policy is eased, the yields on treasuries decline, inducing an upward shift in the price of mortgages that is consistent with the rise in treasury values (taking into account the assumed credit risk of mortgages). This initial movement is indicated by the left-most upward-pointing arrow following the upward shift in the $p(v)$ curve. However, this initial change sets off a response from the property market. The higher price of mortgages strengthens the banks' balance sheets, and this in turn induces an increase in credit to young households. The proceeds of the increased loans end up in the property market, driving up the price of property. This second-round effect is indicated by the horizontal arrow pointing right, indicating an increase in v, the price of property.

The knock-on effects then propagate through the financial system. The second-round increase in v feeds through to higher credit quality of mortgages, which induces a further increase in the price of mortgages. This is indicated by the second vertical arrow, representing an increase in the price of mortgages. In turn, this induces a further increase in property prices, and so on. The financial system finds its new equilibrium where the higher $p'(v)$ curve meets the $h(v)$ curve. Depending on the slopes of the two curves, the eventual impact of the easing of monetary policy can be substantial.

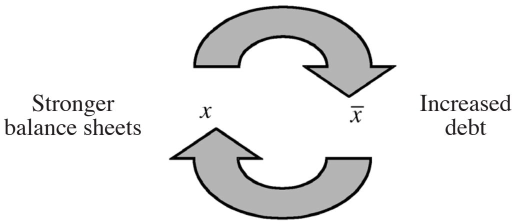
In terms of the framework of Section 2, the step adjustment mechanism depicted in Figure 9 can be seen as the feedback from the market value of claims (given by x) to the face value of claims (given by $\bar{x}$). The market value of claims determines the strength of the marked-to-market balance sheets of the banks, and this influences the banks' lending policy. In turn, the increased lending flows into the property sector, raising property prices and mortgage values, thus influencing the market

Figure 9: Impact of Looser Monetary Policy



value of claims (Figure 10). I shall comment at the end of the paper on how this feedback mechanism may have been reinforced by recent developments in corporate governance and accounting regimes.

Figure 10: Feedback Between Increased Debt and Stronger Balance Sheets



5. Reversal

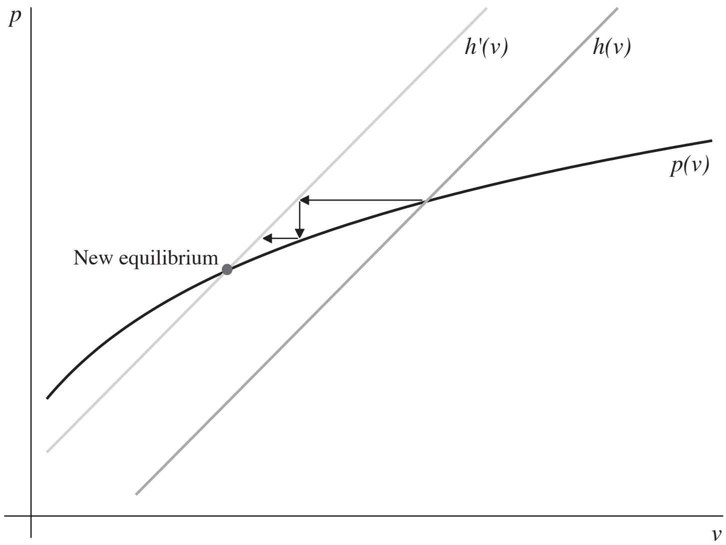
The amplified response to the easing of monetary policy, by itself, need not be a problem for policy-makers if they can fine-tune their monetary policy levers to take account of the amplification. The problem would be rather like learning how to control the temperature of an unfamiliar shower by learning to turn the knob by the correct amount, and learning how quickly the water temperature reacts to turns of the knob.

Rather, the problem is the highly asymmetric nature of the mechanisms at play ‘on the way up’ versus the mechanisms ‘on the way down’. If the bursting of the property bubble impairs the solvency of the banking sector as a whole, then the dynamics ‘on the way down’ are likely to involve a whole new set of mechanisms that did not figure in the inflating of the bubble. These new mechanisms – default, distressed selling, and inefficient liquidations – are likely to conspire to exact very large economic costs.

Before turning to these new mechanisms, it is illuminating to see how far we can take the amplifying channels sketched above (that are responsible for the *inflating* of the property bubble) in explaining the reversal. Figure 11 illustrates the argument.

Starting from the initial intersection of the $h(v)$ curve and the $p(v)$ curve, let us trace through the impact of an exogenous fall in the property price, as represented by the leftward shift in the $h(v)$ curve. The right-most horizontal arrow pointing left is the initial fall in property price. This fall in property price lowers the equity value of households, and so lowers the marked-to-market value of the mortgage assets held by the banks, leading to a fall in p. This fall in p is represented by the vertical arrow pointing downwards in Figure 11. The fall in p then lowers the banks’ net worth, and the banks would respond by cutting back their lending to households. In our simplified model, the banks would have to foreclose on lending to some households, but this is due to the static nature of the model. In a dynamic model, the retrenchment of the banks would be manifested in the reduced flow of new lending to households. The reduction in the funds supporting the property market leads to a fall in the property price v. The feedback mechanism that was responsible for the amplified reaction of the property price then kicks into reverse gear. The credit quality of the collateral assets backing the mortgage declines further, leading to a further fall in the mortgage price, which then translates into less funds devoted to the property sector, and further falls in the property price. The system comes to rest at the new intersection point where both the property price and the bond price are considerably lower than their initial values. Depending on the relative slopes of the two curves, the eventual impact of a fall in asset prices can be very substantial.

Figure 11: Effect of Shock to Property Price

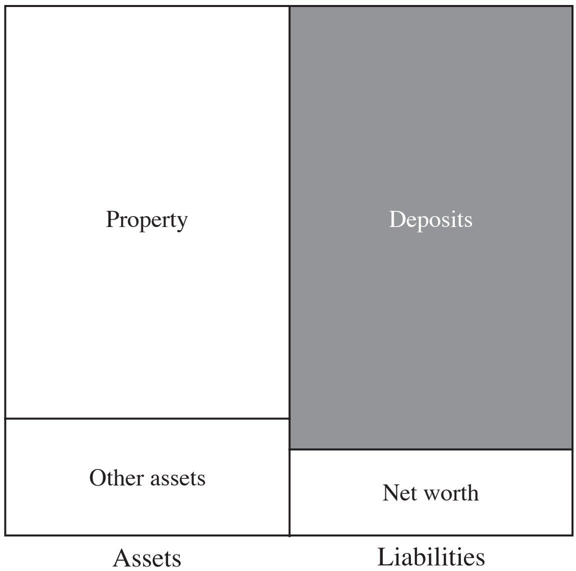


5.1 New mechanisms

The story of reversal I have sketched above has important missing elements. New mechanisms will kick in 'on the way down' that did not figure in the process 'on the way up'. In order to illustrate these new mechanisms, let us modify the story drastically by supposing that the banks hold property directly on their balance sheets, and that they mark their holding of property to market. Neither of these assumptions is appropriate in normal times, but they are a good approximation of an economy in the aftermath of the bursting of a property bubble where defaulting borrowers have handed property assets back to the banks, so that the banks end up holding the property directly. The balance sheet of a bank looks as in Figure 12.

Assume that the assets held by a bank attract a regulatory minimum capital ratio, which stipulates that the ratio of the bank's capital – here taken to be simply the ratio of its marked-to-market net worth to the marked-to-market value of its assets – must be above some pre-specified ratio r^*. When a bank finds itself violating this constraint, it must sell some of its assets so as to reduce the size of its balance sheet.

Figure 12: Bank Balance Sheet



I should emphasise that, although this constraint is expressed in regulatory terms, any bank that operates an internal risk management system will follow prescriptions that are similar to those expressed by the regulatory constraint. Under this alternative interpretation, the minimum ratio r^* could be much higher than the bare regulatory minimum.

I continue to denote the price of property as v. Let us denote bank i's holding of property by e_i, its holding of liquid assets by c_i, and its liabilities by l_i. It would be straightforward to extend this framework to take account of interbank claims along the lines discussed in Section 2 (see also Cifuentes, Ferrucci and Shin 2005). If we denote by s_i the amount of property sold by bank i, and by t_i the sale by bank i of its liquid assets, the capital adequacy constraint can be expressed as follows.

$$\frac{ve_i + c_i - l_i}{v(e_i - s_i) + (c_i - t_i)} \geq r^* \tag{2}$$

The numerator is the (marked-to-market) equity value of the bank while the denominator is the marked-to-market value of its assets after the sale of s_i units of property and sale t_i of the liquid assets. The underlying assumption is that the assets are sold for cash, and that cash does not attract a capital requirement. Thus, if the bank sells s_i units of property, then it obtains vs_i of cash, and holds $v(e_i - s_i)$ worth of property. Hence, we have the sum of these (given by ve_i) on the numerator, while we have only the marked-to-market value of post-sale holding of property (given by $v(e_i - s_i)$) on the denominator. By selling its assets for cash, the bank can reduce the size of its balance sheet, reduce the denominator in the capital-to-asset ratio, and thus exceed the minimum capital asset ratio.

By re-arranging the capital adequacy condition (2), together with the condition that s_i is positive only if $t_i = c_i$, we can write the sale s_i as a function of v. If the capital adequacy ratio can be met by sales of liquid assets or from no sales of assets, then $s_i = 0$, but otherwise is given by

$$s_i = \min\left\{e_i, \frac{l_i - c_i - (1 - r^*)ve_i}{r^* v}\right\}$$

Thus, the sale of property s_i is itself a function of v, and we write $s_i(v)$ for the sales by bank i as a function of the price v. Let $s(v) = \Sigma_i s_i(v)$ be the aggregate sale of property by the banking sector given price v. Since each $s_i(.)$ is decreasing in v, the aggregate sale function $s(v)$ is decreasing in v.

I will now suppose that sales of property by banks can be absorbed by other constituents in the economy, provided the price is low enough. To give form to this idea, suppose that there is an exogenous demand function for property given by $d(v)$. In my story sketched earlier, the old households would have a price at which they would be willing to buy back property. An equilibrium price of property is a price v for which

$$s(v) = d(v)$$

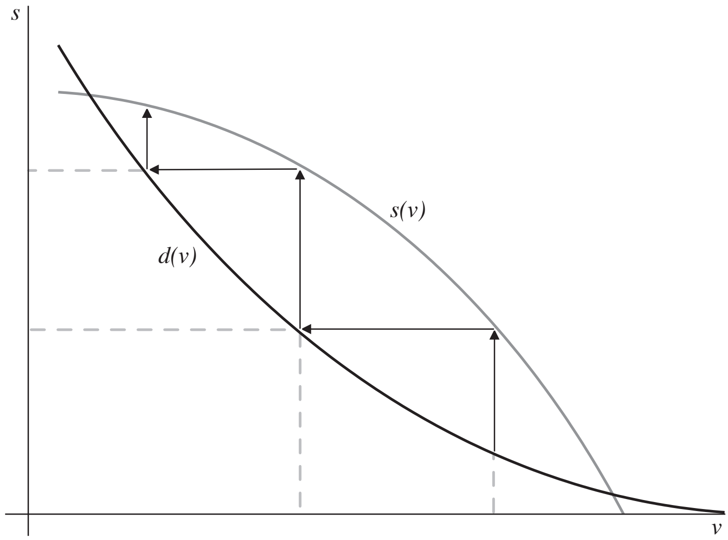
An initial shock to the property price may have an amplified response if the additional sales of property cause the price to fall further. The argument is illustrated in Figure 13.

Consider a shock to the property price. The price adjustment process can be depicted as a step adjustment process in the arc below the $s(v)$ curve, but above the $d(v)$ curve. The process starts with a downward shock to the price of property. At the new lower price, the forced sales of the banks place a quantity of property on the market as indicated by the $s(v)$ curve. However, the additional supply of property pushes the property price down, as implied by the $d(v)$ curve. When the banks' balance sheets are evaluated at this lower price, the capital adequacy constraint may be violated, forcing yet more sales. The second-round supply of property is implied by the $s(v)$ curve at the lower price. Given this increased supply, the price falls further, and so on. The price falls until we get to the nearest intersection point where the $d(v)$ curve and $s(v)$ curve cross. Equivalently, we may define the function Φ as

$$\Phi(v) = d^{-1}(s(v))$$

and an equilibrium price of property is a fixed point of the mapping $\Phi(.)$. The function $\Phi(.)$ has the following interpretation. For any given property price v, the value $\Phi(v)$ is the market-clearing price of property that results when the price of property on the banks' balance sheets is evaluated at price v. Thus, when $\Phi(v) < v$, we have the pre-condition for a downward spiral in the property price, since the price that results from the sale of property is lower than the price at which the balance sheets are evaluated.

Figure 13: Amplified Fall in Property Price



The lessons here are quite general. Changes in asset prices may interact with externally imposed solvency requirements or the internal risk controls of financial institutions to generate amplified endogenous responses that are large relative to any initial shock.

Regulators are familiar with the potentially destabilising effect of solvency constraints in distressed markets. To take one recent instance, the decline in European stock markets in the Northern summer of 2002 was met by the relaxation of various solvency tests applied to large financial institutions such as life insurance firms. In the UK, the usual 'resilience test' applied to life insurance companies in which the firm has to demonstrate solvency in the face of a further 25 per cent market decline was diluted so as to pre-empt the destabilising forced sales of stocks by the major market players.[7]

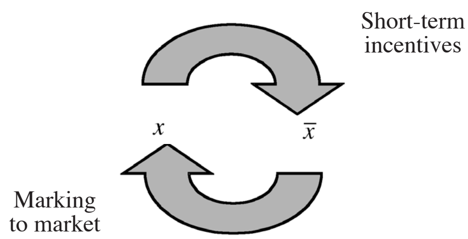
More generally, the importance placed on asset prices follows the recent theoretical literature on banking and financial crises that has emphasised the limited capacity of the financial markets to absorb sales of assets (see Allen and Gale 2004, Gorton and Huang 2004, and Schnabel and Shin 2004), where the price repercussions of asset sales have important adverse welfare consequences. Similarly, the inefficient liquidation of long assets in Diamond and Rajan (2005) has an analogous effect. The shortage of aggregate liquidity that such liquidations bring about can generate contagious failures in the banking system.

7. FSA Guidance Note No 4 (2002), 'Resilience test for insurers'. See also FSA Press Release No FSA/PN/071/2002, 'FSA introduces new element to life insurers resilience tests', 28 June 2002.

6. Changing Nature of Monetary Policy

I conclude this paper by addressing myself more squarely to the theme of this year's RBA conference by drawing attention to a number of trends that have served to sharpen the effects outlined in my paper. In doing so, it is helpful to draw on the framework outlined in Section 2. There, I described the feedback between the strength of balance sheets (as implied by x) and the level of debt (as given by $\bar{x}$). Strong balance sheets induce banks to increase their lending. In turn, increased lending raises property prices, leading to stronger balance sheets. Figure 14 depicts the feedback, and has labelled the possible forces at work in strengthening the feedback.

Figure 14: Feedback



The reason why banks would increase their lending in the face of stronger balance sheets would be intimately tied to the short-term incentives facing the banks' management. Stronger balance sheets imply a larger marked-to-market value of equity for the bank. Suppose for the moment that shareholder value is measured in terms of return on marked-to-market equity (I return to this below). The more conscious is a bank's management to shareholder returns, the greater will be the incentive to react to the erosion of leverage by trying to restore leverage to some extent.

Indeed, the trend in recent years towards improved corporate governance through greater transparency, greater accountability to shareholders and greater use of incentive schemes tied to the share price will all strengthen the motives of the management to restore leverage. Whether such a move is *actually* in the interests of shareholders is a moot point (time horizons are the key). However, in a second-best world with many-layered agency problems, the shareholders would not wish to water down such short-term incentives.

What about the arrow going in the other direction – from increased debt (given by $\bar{x}$) to stronger balance sheets (given by x)? The issue is how quickly the increased indebtedness translates into higher property prices and how quickly the increase in property prices is reflected in visibly stronger balance sheets. Here, marking to market is the key. For the US, the prevalence of mortgage-backed instruments as the prime source of finance for the property sector means that this pre-condition is already in place. For those economies that rely on bank lending, the accounting regime will be important. When assets and liabilities are marked to market continuously, the accounting numbers mirror the underlying market prices immediately.

Accounting numbers serve an important certification role in financial markets. They are audited numbers that carry quasi-legal connotations in bringing the management to account. As such, accounting numbers serve as a justification for actions. If decisions are made not only because you believe that the underlying fundamentals are right, but because the accounts give you the external validation to take such decisions, then the accounting numbers take on great significance.

To date, a thorough application of marking to market has affected only a small segment of the financial sector – notably, hedge funds and other hedge fund-like institutions that deal mainly with marketable claims. Marking to market has been limited by the lack of reliable prices in deep and liquid markets for many assets. Loans, for instance, have not been traded in large enough quantities to mark the loan book to market in a reliable way.

However, all this is about to change. The advent of deep markets in credit derivatives has removed the practical barriers to marking loans to market. The price of a credit default swap can be used to price a 'notional' loan corresponding to its standardised characteristics, much like the price of a futures contract on a bond, which indicates the price of a notional bond. Feasibility is no longer a hurdle to a thorough-going application of marking to market (or will not remain a hurdle for long).

It can be argued that mark-to-market accounting has already had a far-reaching impact on the conduct of market participants through those institutions that deal mainly with tradable securities, such as hedge funds and the proprietary trading desks of investment banks. However, even these developments will pale into insignificance compared with the potential impact of the marking to market of loans and other previously illiquid assets.

Accounting numbers, such as return on equity, have traditionally made reference to book equity (the accumulated value of past profits) rather than the market price of equity claims. However, this distinction is becoming increasingly less relevant. The recent trend (as prescribed by the new accounting standards) is to feed any capital gains to the profit and loss account (the income statement) so that capital gains and losses will be reflected immediately on the balance sheet.[8]

Taken together, the increased reliance on short-term incentives and the greater immediacy given by marking to market hold huge significance for the conduct of monetary policy. I opened this paper by noting that monetary policy works by manipulating asset prices, especially long-term interest rates. The orthodox view of monetary policy is that, although the central bank generally directly controls only the overnight interest rate, it can nevertheless manipulate long-term interest rates since long-term rates are determined by expectations of the future course of short-term rates (modified by the appropriate risk premium). By charting a path for future short rates, and communicating this path clearly to the market, the central bank can control long-term rates. Having thus gained control of long-term rates, monetary policy works through the IS curve – through quantities such as consumption and investment.

8. Plantin *et al* (2004, 2005) discuss these and related issues.

This view of monetary policy reflects the origins of today's macroeconomics in the IS-LM view of the world, except for the fact that the 'LM' part has now been discarded. We have ended up with an exclusively 'IS' view of the world. In this world, financial markets play only a passive role, populated with far-sighted but essentially passive agents. It is a moot point whether such a view of financial markets was ever valid, but it is becoming evident that it is less of a good approximation today. Fed Chairman Alan Greenspan's 'conundrum' as to why long rates are so low today is a symptom of the breakdown of this view of markets.

When fixed-income traders and hedge funds trade 10-year swaps, are they influenced primarily by their forecasts of the future path of the fed funds rate over the next 10 years? Perhaps. What is clear is that there will be other shorter-term considerations that enter into their calculations. Understanding these considerations and heading them off will become an increasingly important part of monetary policy. The distinction between monetary policy and policies towards financial stability are perhaps less clear-cut than is supposed.

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Discussion

1. Peter Westaway

Thank you for inviting me here to Sydney and thank you for giving me the opportunity to discuss this really interesting paper by Hyun Shin.

This paper has a very different tone to those of the rest of this conference. Most papers so far have been concerned with explaining the 'Great Stability'; the observation that the volatility of inflation and output growth has declined markedly in recent years in most developed economies. Hyun Shin's paper instead suggests that there may be forces which are tending to make business cycles more unstable.

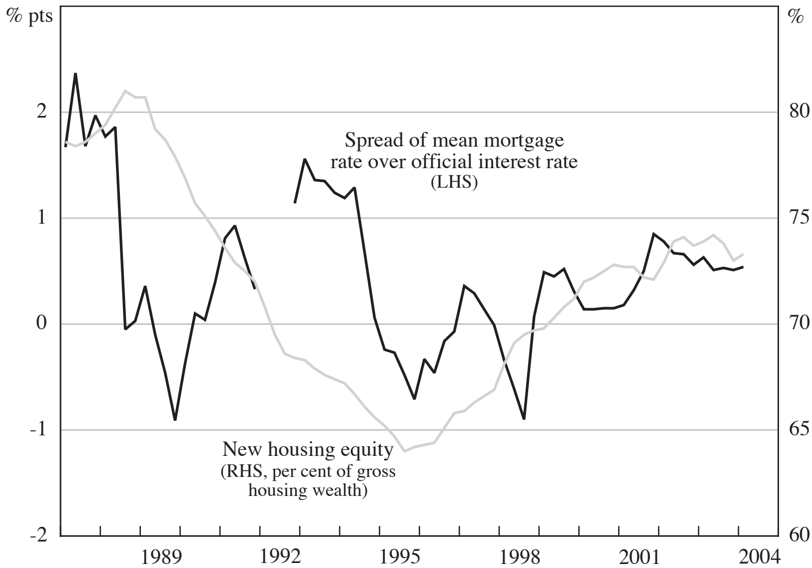
Of course, the notion that asset prices interact with balance sheets to amplify business cycle responses is a familiar one (see, for example, the financial accelerator model of Bernanke, Gertler and Gilchrist 1999). The particular points that Hyun draws our attention to are that, in the context of household balance sheets, it may be dangerous to rely on housing collateral at the level of the aggregate economy; and that to the extent that housing collateral works via the bank capital channel, the increasing tendency for banks to mark their assets to market may accentuate these effects. And this may lead to significant non-linearities if it is more costly for households to unwind their debt when house prices fall, in particular if banks run up against Basel-related regulatory constraints on their capital requirements. Hyun also draws attention to the dangers for monetary policy-makers of ignoring these potential effects; a situation he characterises as one where policy-makers place too much focus on the IS curve, while ignoring the LM curve.

The mechanisms which Hyun describes are a particular type of credit channel effect. What do we mean by the credit channel? In its simplest terms, credit channel effects arise when the usual Modigliani-Miller assumptions are violated. So lending and investment decisions will be affected by the balance sheets of firms or households.

Credit channel effects have some important implications for the way that we should think about monetary policy. First, it means that the risk-free short-term interest rate is no longer a sufficient statistic for the effects of monetary policy – we also need to worry about the external finance premium. Second, it means that asset prices are no longer a shadow price reflecting underlying fundamentals – instead, asset prices will contain independent information and their movements will have effects on the real economy.

It is useful to link these abstract concepts with their empirical counterparts in the real world. So focusing on the behaviour of households, and here for the sake of my own convenience I unashamedly rely on the data for the UK that I could most easily lay my hands on, it is interesting to note in Figure 1 that there is a reasonably strong relationship between the external finance premium for households (measured by the spread of the mean mortgage rate over the official interest rate) and a measure of their net worth, here proxied by households' new housing equity.

Figure 1: Household External Finance Premium and Net Worth



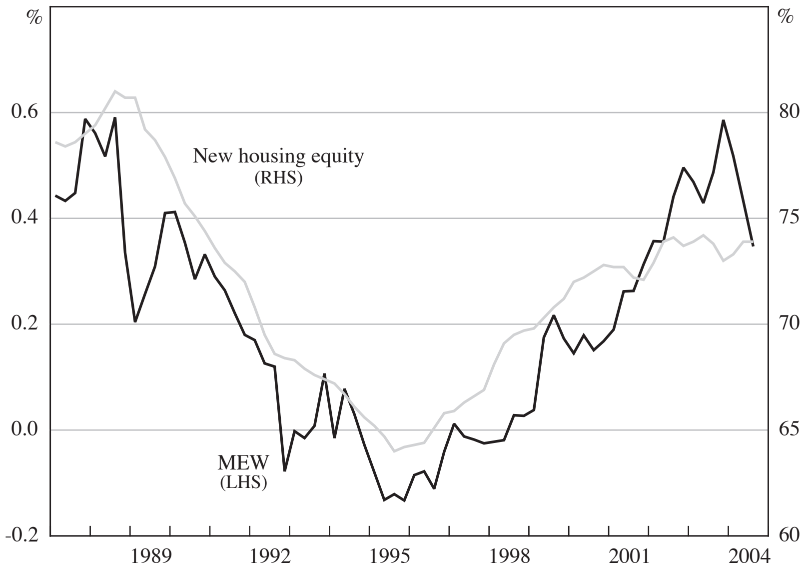
Sources: Bank of England; Council of Mortgage Lenders (CML) and the Office of the Deputy Prime Minister (ODPM), 'Survey of Mortgage Lenders'

And for households, one of the key mechanisms by which shocks to their net worth are translated into effective demand is via their ability to take out credit through mortgage equity withdrawal (MEW). Figure 2 illustrates that there has been a close correspondence between these series over the past two decades, although MEW had had a tendency to grow even more quickly during the recent episode of house price strength.

Now one question which Hyun raises in his paper is whether it is appropriate for borrowing to be collateralised by housing wealth when, from the perspective of the economy as a whole, housing does not really constitute net wealth. Or, as Hyun puts it much more graphically, when changes in housing wealth brought about by house price changes represent 'changes inside the Edgeworth box', rather than constituting an expansion of the Edgeworth box itself.

First, let me consider this question from the perspective of a macroeconomist. There is a longstanding debate about whether housing wealth should be included as part of a household's overall net wealth in the context of reduced form consumption functions that are typically included in macroeconomic models. The purist's view is that changes in aggregate housing wealth should not affect consumption since these increases can not be realised in aggregate (although the fact that one country's householders can sell their houses to foreigners represents a caveat to this view, as does the fact that older householders who do not have a perfect bequest motive may trade down to consume their housing equity at the expense of lower future consumption for their descendants). As an aside, I should mention that the Bank of England's new macroeconomic quarterly model (BEQM) does not include such a

Figure 2: Household Net Worth and Mortgage Equity Withdrawal
Per cent of gross housing wealth



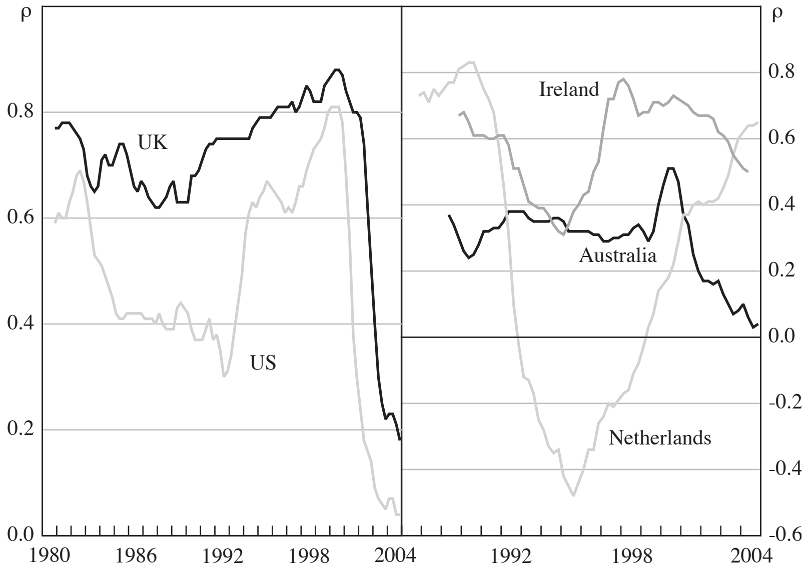
Sources: Bank of England; CML and ODPM, 'Survey of Mortgage Lenders'

direct wealth effect in its core dynamics, though house price effects are included in the non-core dynamics, to proxy the very type of collateral-based housing wealth effects articulated in Hyun's paper (see Harrison *et al* 2005).

Of course, because the channel by which housing wealth impinges on consumer spending is not straightforward, the strength of the bilateral correlation between them will depend on the shocks that are driving both. This is illustrated clearly by Figure 3, which shows how the apparently strong relationship between housing wealth and consumption in the UK through the 1980s and 1990s has since broken down completely. This suggests that a common set of shocks may originally have been driving both series, for example, relating to the strength of expected income growth. But more recently, shocks specific to the housing market may have caused the behaviour of the two to diverge. And a similar pattern has been present in the US. Interestingly, the pattern is largely absent in the countries shown in the right-hand panel, which include Australia.

Now let me turn to the financial stability question raised by Hyun, namely, whether housing wealth is a valid form of collateral. As he notes, it is certainly the case that housing wealth represents net worth at the level of the individual borrower, since for him it represents a claim on a future stream of housing services which he is able to exchange for goods in order to meet his liabilities. But for the system as a whole, householders can not all simultaneously convert their future housing services into goods. So if widespread attempts were made to realise this collateral and extract the housing equity, house prices would fall. This is the systemic risk that Hyun is highlighting in his model.

Figure 3: Real House Price Inflation and Consumption Growth
Rolling 10-year correlations



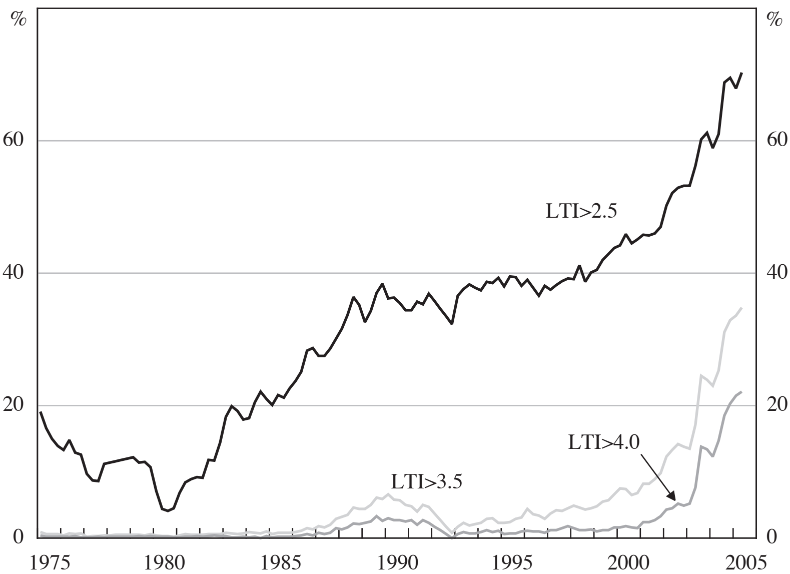
Source: author's calculations

The question I want to raise is whether equity-based collateral is necessarily any safer in a systemic sense. Equities, of course, represent a claim on a future flow of dividend income, which sounds as if it might be easier to convert into a medium that can be used to settle debt payments. But even so, if there were system-wide attempts to liquidate this equity-based wealth, it would also be the case that equity prices would fall and the value of the collateral would be compromised; this is exactly what happens to equity prices in models where demographic shifts in the size of the cohort of working-age people cause equity prices to fall.

So I remain to be convinced that the fact that housing does not represent net wealth in an aggregate sense necessarily makes it more vulnerable than other types of collateral. Ultimately I would like to see this proposition tested within a calibrated general equilibrium model of asset prices.

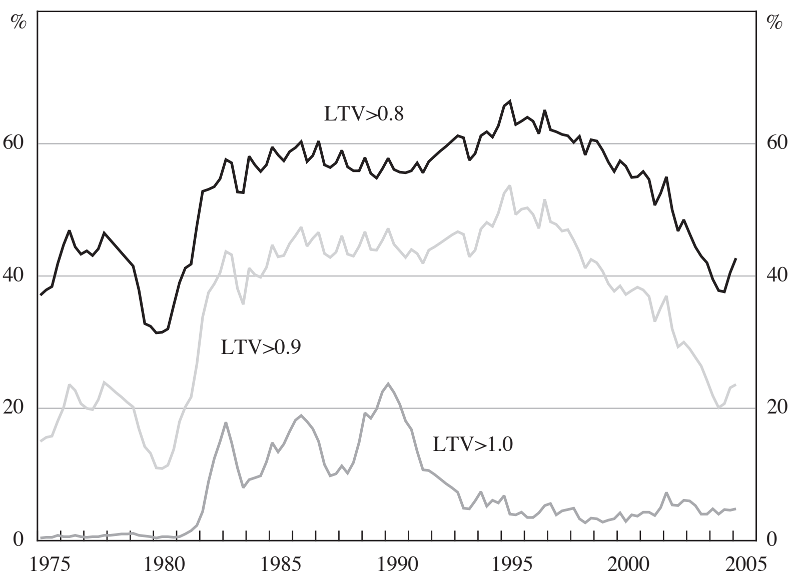
Even so, the logic of Hyun's argument is that it may be the case that lenders are over-reliant on this form of housing collateral, which may cause them to overestimate borrowers' ability to repay their debts. Again, to evaluate this proposition in the context of recent experience in the UK, Figure 4 shows that it would certainly seem that loan-to-income (LTI) ratios on new mortgages have increased markedly, as might be predicted by Hyun's model. But the message in Figure 5 from loan-to-valuation (LTV) ratios on new mortgages is much more encouraging and less alarming than Hyun's model might suggest, showing that only 5 per cent of new loans currently have LTV ratios greater than unity compared to over 20 per cent in 1990.

Figure 4: Loan-to-income Ratios of New Mortgages
Share of number of new mortgages



Source: CML and ODPM, 'Survey of Mortgage Lenders'

Figure 5: Loan-to-value Ratios of New Mortgages
Share of number of new mortgages



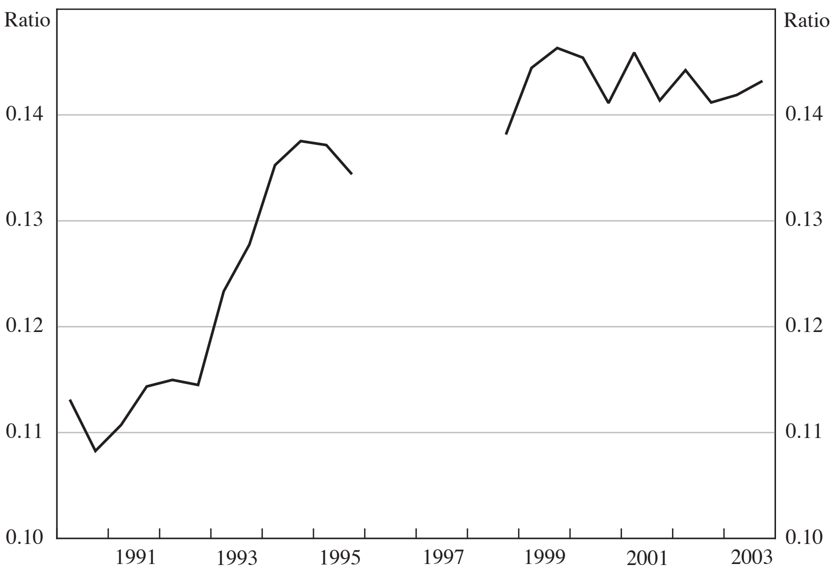
Source: CML and ODPM, 'Survey of Mortgage Lenders'

So how important do we think the 'bank capital channel' is? This is the particular form of credit channel emphasised by Hyun, whereby the effect of asset price changes on banks' collateral impinges on their capacity to lend because of imperfections in the market for bank equity. Friedman once famously remarked that the bank capital channel was a 'macroeconomic irrelevance and a pedagogical inconvenience'. But more recent work, summarised nicely by Van den Heuvel (2002), suggests that this channel may be important. The particular aspect that Hyun emphasises is the trend towards new accounting conventions which might cause banks to mark their assets to market more quickly than previously. In other work Hyun has done, he has drawn attention to the fact that this may inject artificial volatility into banks' decision-making, thus leading to inefficient lending behaviour. In this paper, he shows how it implies that the usual amplification effect of the bank credit channel is likely to be speeded up (though it is difficult in Hyun's stylised model to gauge how large these effects might be, and in practice his model may exaggerate the effects if banks are able to hedge their interest rate risk to some extent). He also suggests that significant non-linearities may be introduced in the downward phase of the cycle if falling bank capital interacts with regulatory constraints implied by the Basel II regulations. On this latter point, Figure 6 suggests that the risk-weighted capital asset ratio for UK banks, at least, is still well above the 8 per cent Basel recommendation (though, of course, individual banks may be affected by this constraint).

Finally, let me comment on the significance for monetary policy of the mechanisms identified by Hyun.

First, as Hyun correctly notes, it is important to be aware that the fact that credit channels may amplify the business cycle is not, of itself, a problem for monetary

Figure 6: Risk-weighted Capital Asset Ratio



Source: Financial Services Authority

policy, because the impact of a given change in interest rates is correspondingly greater in a world with higher leverage. The problem arises, of course, if the scale of these effects is uncertain and subject to non-linearities, and central banks need to be wary of this.

The second point Hyun raises, and one I want to take issue with, is the idea that central banks manipulate the yield curve by means of their communication policy. It is certainly true that there are times when the whole yield curve seems to move in the face of news which economic theory would suggest should only affect the front end of the forward rate curve. But in general, the aim of monetary policy is to affect real interest rates at cyclical frequencies, recognising the fact that neutral real interest rates are not under the control of central banks.

The final point Hyun makes is that policy-makers may be led astray if they continue to focus on an IS-curve view of the world which ignores shifts in the LM curve caused by credit cycle effects. My response to this is that an IS-curve approach is appropriate if modellers are capable of capturing the causes and effects of shifts in the external finance premium, and modify the effect of the interest rate in the model's implicit IS curve accordingly.

Let me conclude by reiterating that I found this a really interesting paper and any work that improves our understanding of how credit channels impact on the business cycle is very important in the context of both monetary and financial stability.

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Harrison R, K Nikolov, M Quinn, G Ramsay, A Scott and R Thomas (2005), *The Bank of England quarterly model*, Bank of England, London.

Van den Heuvel SJ (2002), 'Does bank capital matter for monetary transmission?', Federal Reserve Bank of New York *Economic Policy Review*, 8(1), pp 259–265.

2. General Discussion

The issue of whether houses should be viewed as part of net wealth was widely debated. One participant sought to distinguish between an increase in house prices stemming from pure price effects – in which case they conceded that there would be no increase in net worth – and an increase in house prices stemming from reduced interest rates, in which case they felt that savings on interest payments could be used to increase spending on other goods (and hence the price increase viewed as an increment to net wealth). Similarly, another participant noted that the role of foreigners in some countries' housing markets is increasing, raising the possibility that increased housing wealth can be realised by selling to non-residents. It was also argued that higher house prices can bring forward consumption spending if consumers are not fully Ricardian, particularly with the growing prevalence of reverse mortgages. In reply to this, the author noted that the consumption of housing services is not fungible with other forms of consumption, making it very difficult for the household sector to reallocate their budget away from housing and towards other goods in the event of a rise in house prices. Furthermore, he sought to distinguish the role that equities play in net worth from that played by housing – following the comments of Peter Westaway – by saying that equities are, in theory, backed by a consistent flow of dividend income that can be liquidated.

The discussion then moved onto the financial system implications of the concerns raised by the author. One participant noted that this paper stands in contrast to some others presented at the conference in warning of the possibility of increased, not decreased, volatility associated with the financial system working to amplify shocks, often in an asymmetric fashion. It was suggested that this difference might stem from a different time horizon, with the current paper assessing volatility over a lower frequency than that addressed in earlier papers. Following these comments, other participants suggested that there would appear to be a role for regulation of the banking system, and not just of individual banks, if the concerns raised by the author are valid. Hyun Shin agreed with both these comments, but noted that it is very difficult for prudential supervision to address these issues, given that individual banks may have sound balance sheets in isolation (just not in aggregate), and that prudential supervision is largely the domain of lawyers, rather than economists. For this reason, he advocated for central banks to take a greater role in raising the debate on these issues.

This provoked a comment from one participant about the possibility of increasing moral hazard if regulation of the credit markets is increased. This participant argued that the increase in leverage seen in many countries during the 1990s could be an attempt by households to retain the same level of risk as previously in the face of declining output volatility, and suggested that further efforts to reduce risk could encourage households to again rebalance their risk profile. The author agreed with this, referring to it as the 'paradox of stability', and added that it may be one source of the 'conundrum' of declining long-term interest rates of late.

Finally, a few participants questioned the sensitivity of the author's results to institutional settings. For example, a participant wondered whether the results depend on the default framework by noting that in a country such as Australia, it is less attractive for borrowers in distress to 'walk away from' their properties than, say, in the US. In this case, it is less likely that there would be a significant transfer of property on to banks' balance sheets during periods of widespread financial distress. Similarly, another participant questioned what impact the practice of banks selling mortgages overseas would have on the paper's results, while someone else asked whether it mattered whether it is mortgages or houses that are marked to market. The author responded by saying that the results are invariant to this latter point, but agreed that the former points would be important considerations for a more nuanced analysis.

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Dan Andrews is currently studying for a Masters of Public Adminstration at Harvard University. Prior to commencing his degree, he was a Senior Economist in the Financial and Monetary Conditions section of the Reserve Bank of Australia. Mr Andrews has also worked in the Reserve Bank's economic forecasting unit, and in its Research Department, where he studied the impact of the spatial structure of Australia's urban population on dwelling prices. He has also published on the role of neighbourhood effects in the Australian youth labour market. He holds a Bachelors of Economics with Honours and a Bachelors of Arts from the University of Queensland.

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