TOWARDS AN UNDERSTANDING OF AUSTRALIA'S CO-MOVEMENT WITH FOREIGN BUSINESS CYCLES

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Research Discussion Paper
9607

November 1996

Economic Research Department

Reserve Bank of Australia

We would like to especially thank Lynne Cockerell, Gordon de Brouwer, Jacqui Dwyer, David Gruen, Jo Paisley, and Alison Tarditi for their helpful comments and suggestions. Views expressed in this paper are those of the authors and not necessarily those of the Reserve Bank of Australia.

Abstract

This paper identifies two transmission mechanisms which might contribute to explaining the well-documented correlation between Australian and foreign business cycles. The first is through exports. We find that the US and Japan have a high output elasticity of demand for Australia's exports. Consequently, their business cycles have a larger impact on Australia's exports than that suggested by their market shares. The second mechanism is through the share market. Both the US and Australian share markets appear to have a significant impact on Australian activity. Evidence is also found that the responses of investment to the share market in the two countries are remarkably similar. Given that the share markets are highly correlated, the similarity in response lags may help to explain the correlation in business cycles.

JEL Classification Numbers E32, F14, F41, G15, O56

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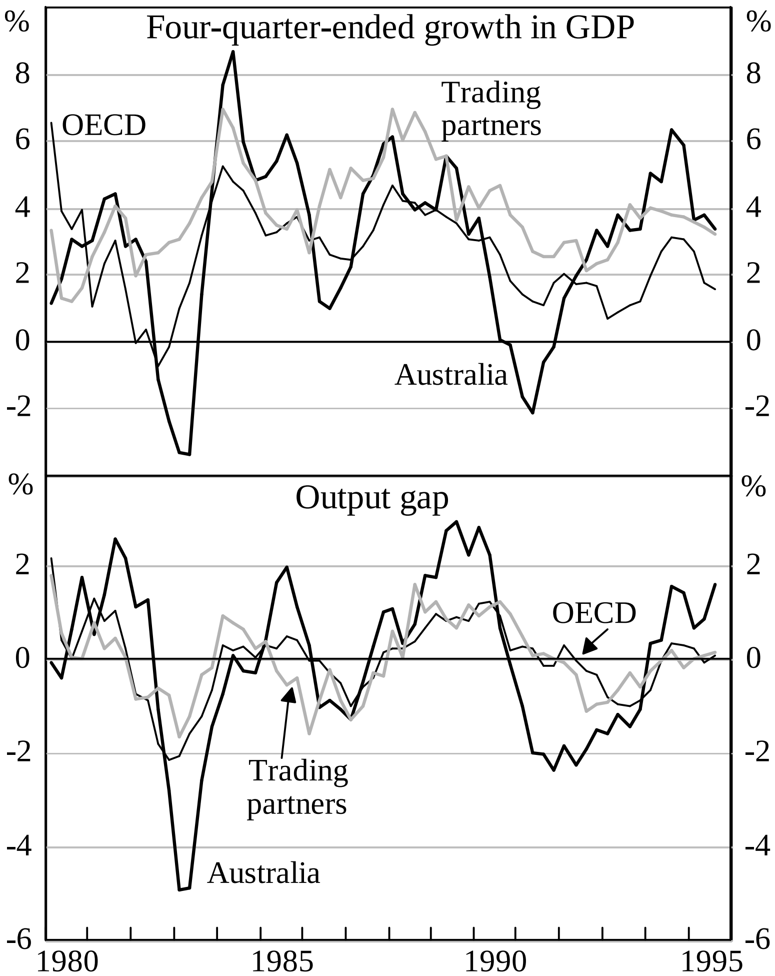
1. Introduction

The strong correlation between the Australian and foreign business cycles both before and after the floating of the Australian dollar is well documented. Two graphical representations of this correlation are shown in Figure 1.

Figure 1: Australian and Foreign Business Cycles: 1980-1995



Notes: Export-markets GDP is calculated using a weighted average of the growth in GDP of Australia's trading partners where the weights are the respective countries' shares in Australia's exports. Output gaps are the difference between actual GDP and Hodrick and Prescott (1981) filtered GDP, using λ = 1600.

In the top panel, the year-ended growth in Australia's GDP is compared with that in Australia's export markets, and in the OECD. In the lower panel, corresponding output gaps are compared. The contemporaneous nature of the business cycles is clear in both representations, but is dealt with more formally in Table 1, which reports the correlation coefficients between the Australian and foreign business cycles.

Gruen and Shuetrim (1994) use a cointegration framework to examine more closely the relationship between the Australian and foreign business cycles. They show that the impact of foreign activity on the Australian economy is large and immediate. They also show that a long-run relationship exists between Australian GDP and various measures of foreign activity. The purpose of this paper is to examine some of the linkages which underlie the relationship between the Australian and foreign business cycles since the early 1980s.

Table 1: Correlation Between the Australian and Foreign Business Cycles (1980:Q1-1995:Q3)

	Four-quarter-ended growth rate			GDP gap		
Lag in foreign cycle	US	OECD	Export markets	US	OECD	Export markets
0	0.69	0.57	0.45	0.72	0.69	0.52
1	0.74	0.58	0.44	0.78	0.67	0.53
2	0.71	0.52	0.38	0.79	0.60	0.48
3	0.57	0.37	0.32	0.70	0.45	0.41
4	0.36	0.18	0.23	0.48	0.21	0.28

Notes: GDP gap is the difference between actual GDP and GDP 'smoothed' by a Hodrick Prescott filter. The shading identifies the lag with the highest correlation.

We begin in Section 2 by briefly reviewing the empirical literature on the correlation in business cycles and explanations of this correlation. Two explanations appear particularly relevant. They are the impact of foreign activity on Australia's exports and the influence of foreign share markets on Australian investment and activity. Given Australia's increased openness to trade and integration with foreign financial markets, these explanations merit attention and are, in turn, dealt with in more detail.

Existing empirical work on exports has been less than convincing. In part, this is because the influence of domestic activity on exports has not been adequately modelled. Section 3 of this paper models separately the influence of domestic and foreign activity on exports. In doing so, we find that foreign activity has a large and significant impact on Australia's exports. At times, this channel of foreign influence has had a sizeable impact on Australian GDP.

Section 4 considers the explanation for the business cycle co-movement based on the concept of integrated world financial markets. This section follows the work of Fama (1990) and Canova and De Nicolo (1995) to see if foreign share markets influence Australian activity. Using a variant of the Gruen and Shuetrim (1994) model of Australian GDP, US and domestic share market variables are introduced to find that they have a large impact on Australian activity.

This result in itself does not explain the close correlation in business cycles. If developments in the US share market impact quickly on the Australian share market then, for the business cycles to be highly correlated, both economies must respond to their share markets in similar ways. Section 5 looks at how the influences of the US share market propagate through the US and Australian economies. We find evidence that the propagation is through investment and not consumption and that the response of investment to the sharemarket in each country is remarkably similar. Finally, Section 6 concludes.

Before we look more closely at the interaction between the Australian and foreign business cycles, we should question the cause of the correlation in business cycles. Australia may cycle with foreign activity because of direct foreign influences on the domestic economy. Several possibilities come to mind: direct effects on either the demand or price of Australian exports, or perhaps the direct influence of foreign asset markets on Australian asset markets. If effects like these are the dominant foreign influences on the domestic business cycle, then one may have success in a search for the channels of influence.

Alternatively, countries may cycle together primarily because they are subject to similar 'underlying influences', like similarly evolving technologies and capital stocks, or similar responses to common shocks. In this case, it would be misleading to think foreign business cycles are 'transmitted' to the domestic cycle and any identifiable interaction between business cycles will appear too weak to be responsible for the cycle in each country. At best, all that can be explained is the component of the correlation in business cycles that is *not* due to the common 'underlying influences'. Given this limitation, we now turn to the literature which identified the correlation and provided explanations for its existence.

2. The Australian and Foreign Business Cycles

Barry and Guille (1976) demonstrated correlation between the Australian and foreign business cycles.[1] They suggested that transmission was through the balance of payments. More recently, McTaggart and Hall (1993) and Gruen and Shuetrim (1994) have employed cointegration techniques to investigate the relationship between the domestic and foreign economic cycles to determine the long-run relationship between domestic and foreign activity. Gruen and Shuetrim (1994) provide the best empirical description of the correlation in business cycles when they estimate the following model of the Australian business cycle:

$$\Delta y_t = a + \sum_{j=2}^{6} b_j R_{t-j} + \sum_{j=1}^{2} g_j SOI_{t-j} + \sum_{j=0}^{7} d_j \Delta tot_{t-j} + \sum_{j=0}^{7} k_j \Delta rtwi_{t-j} + f y_{t-1} + q y^f{}_{t-1} + p \Delta y^f{}_t + e_t \tag{1}$$

where y is Australian GDP, R is the real 'cash' interest rate, SOI is the Southern Oscillation Index to capture the effect of weather patterns on farm output, tot is the terms of trade, $rtwi$ is the real trade weighted index of the exchange rate and y^f is foreign GDP. The lower case variables are in logs and Δ is the change in the variable.

The Gruen and Shuetrim results are reproduced in Table 2. For our purposes, three results are important. First, the contemporaneous growth in foreign output is highly significant and large (0.4 or greater) in all the error-correction models of Australian GDP (2 through 7). Second, in the models which also incorporate the terms of trade and real exchange rate, the level of Australian and foreign GDP appear to be cointegrated. That is, a stable long-run relationship between the level of Australian and foreign GDP exists in the data. However, in two of the models (2 and 4), the terms of trade and real exchange rate do not have the expected signs and the probability of cointegration is reduced considerably if the terms of trade and real exchange rate are excluded.

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1 Appendix A provides a synopsis of recent empirical work on the impact of foreign business cycle on the Australian economy.

Table 2: Australian GDP Growth Regressions[(a)#]
(1980:Q1 to 1993:Q4)
Dependent variable: Change in log Australian GDP

	OECD			US		Export markets	
Variable model:	1	2	3	4	5	6	7
Constant	1.61** (3.70)	-27.25** (-3.90)	-15.42** (-2.86)	-31.71** (-4.01)	-17.32** (-3.24)	15.20 (1.91)	9.75 (1.11)
Real cash rate[(b)]	-0.027 {0.00}	-0.057 {0.00}	-0.035 {0.00}	-0.033 {0.00}	-0.021 {0.01}	-0.035 {0.00}	-0.037 {0.00}
SOI[(b)(c)]	0.011 {0.04}	0.017 {0.08}	0.011 {0.04}	0.010 {0.19}	0.007 {0.05}	0.017 {0.05}	0.012 {0.01}
Terms of trade[(b)] % change	0.030 {0.17}	-0.060 {0.10}		-0.069 {0.06}		0.004 {0.82}	
Real TWI[(b)] % change	-0.023 {0.07}	0.022 {0.03}		0.047 {0.03}		-0.012 {0.30}	
Lagged Australian GDP log level		-0.29** (-3.69)	-0.20* (-2.31)	-0.31** (-4.12)	-0.19** (-2.58)	-0.19* (-2.49)	-0.14 (-1.53)
Lagged foreign GDP log level		0.35** (3.84)	0.24* (2.43)	0.38** (4.21)	0.23** (2.76)	0.16** (2.65)	0.12 (1.67)
Foreign GDP % change		1.22** (5.16)	0.84** (4.90)	0.60** (5.22)	0.40** (4.96)	0.50* (2.55)	0.55** (4.27)
R^2	0.47	0.65	0.56	0.67	0.56	0.53	0.47
$\bar{R}^2$	0.09	0.34	0.46	0.37	0.47	0.10	0.35
Joint significance of terms of trade and real TWI	85.24 {0.00}	45.58 {0.00}		86.68 {0.00}		39.94 {0.00}	
Autocorrelation test AR(4)	6.79 {0.15}	11.80 {0.02}	3.50 {0.48}	15.07 {0.00}	9.91 {0.04}	10.34 {0.04}	3.02 {0.55}
ARCH test ARCH(4)	16.92 {0.00}	18.85 {0.00}	22.26 {0.00}	17.32 {0.00}	23.71 {0.00}	17.25 {0.00}	20.02 {0.00}
Jarque Bera test (Normality)	0.16 {0.93}	0.28 {0.87}	2.44 {0.29}	0.59 {0.74}	3.26 {0.20}	0.17 {0.92}	0.46 {0.80}

Notes: (a) Numbers in parentheses () are t-statistics. Numbers in brackets {} are p-values. Individual coefficients marked with *(**) imply that the coefficient is significantly different from zero at the 5%(1%) level. Standard errors are estimated using a Newey-West correction allowing for fourth order residual correlation. All variables in log levels and their differences are multiplied by 100 (so growth rates are in percentages).

(b) The mean coefficient is reported for the real cash rate, the Southern Oscillation Index, the terms of trade and the real TWI to summarise the coefficients on these variables. The p-values are derived from chi-squared tests of the joint significance of the lags.

(c) The SOI (Southern Oscillation Index) measures the sea level barometric pressure differential between Darwin and Tahiti. If the index is positive, trade winds are stronger and rainfall in Australia is more plentiful. If the index is negative, the trade winds are weaker and less rain occurs. The quarterly figures are the average daily value of the index throughout that quarter.

Reproduced from Table 2 in Gruen and Shuetrim (1994).

Finally, it appears the US-based model performs as well as or better than the OECD model, and substantially better than the model based on export-markets' GDP.

The striking feature of these results is not that foreign activity affects the Australian economy but how large and immediate the impact is.[2] Two further results support this finding. First, a simple unrestricted error-correction model of US and Australian GDP indicates that deviations from the long-run relationship between US and Australian GDP do not affect US GDP. This implies, as would be expected, that it is Australian and not US GDP which adjusts to remove the disequilibrium from the long-run relationship. The Gruen and Shuetrim relationship, therefore, reflects causation and not simply correlation. Second, if we abstract from the trending nature of the GDP variables by defining the business cycle with reference to an output gap, the results, reported in Appendix B, are very similar.

At odds with the 'correlation implies causation' view outlined above, are two papers which argue that foreign activity does not have large direct effects on domestic activity. Smith and Murphy (1994) find that foreign activity has little impact on Australian activity. Instead, they argue that variation in Australian GDP growth has been driven by domestic factors, namely real wage shocks and domestic demand. Downs, Louis and Lay (1994), using a single equation model of GDP growth, also conclude the direct effect of US activity on the Australian business cycle is small. However, they do acknowledge that the impact is larger and more significant since 1983. This period coincides with significant trade and financial market liberalisation, a fact which may point to likely explanations of the correlation in business cycles.

Explanations offered for the correlation in business cycles can be characterised by two schools of thought.[3] The first school focuses on the output and/or income effects of foreign business cycles. These affect activity either indirectly, through the terms of trade, or directly through Australia's exports.[4] The terms of trade

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2 Gruen and Shuetrim estimate the contemporaneous impact of US GDP growth on the growth in Australian GDP to be between 0.4 and 0.6, depending on the model, which is consistent with McTaggart and Hall's (1993) estimate of 0.5.

3 A summary of the literature on possible transmission mechanisms is provided in Appendix C.

4 For example, see Pitchford (1992, 1993), Gruen and Shuetrim (1994), and Debelle and

mechanism in turn operates through two channels: an export supply response to changing export prices, and an income effect which leads to changes in domestic demand. The impact of the terms of trade on domestic activity through these channels may however have been blunted since the floating of the Australian dollar, since currency fluctuations have tended to be positively correlated with the terms of trade.[5] This leads to higher export prices being offset by the exchange rate and some of the increased demand being satisfied by imports rather than domestic output. As a consequence, while there is some evidence that the terms of trade affect Australian GDP, the effect does not appear to be large.[6]

Evidence concerning direct effects of foreign activity on exports is also unclear. Gruen and Shuetrim (1994) argue that because Australia's business cycle is better explained by US or OECD activity than by activity in Australia's trading partners, the transmission mechanism is not through exports. Debelle and Preston (1995) reach a similar conclusion using a disaggregated approach which fails to find a significant direct effect of foreign GDP on exports. A criticism of this approach is that, while a long-run relationship between Australian and foreign GDP may be expected, there is no obvious reason to expect the relationship between the components of domestic GDP and foreign GDP in aggregate to be stable. This is especially true if the export share of GDP is undergoing a structural shift.

The second school of thought seeks explanations based on common factors which affect different countries simultaneously. A number of possible explanations come within this general approach. One group of these focuses on the integration of domestic and foreign financial markets. Events which affect the large foreign financial markets (such as changes in monetary policy and expectations for growth, profitability and inflation), might flow through onto the financial markets of smaller countries; in this way, the smaller country would 'adopt' the business

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Preston (1995).

5 See Blundell-Wignall and Thomas (1987), Gruen and Wilkinson (1991) and Tarditi (1996).

6 Downes, Louis and Lay (1994) and Gruen and Shuetrim (1994) model the impact of the terms of trade on gross national expenditure and GDP. They conclude that the terms of trade has a large and significant impact on gross national expenditure but an insignificant impact on GDP. By implication, these results suggest any increase in exports due to a rise in the terms of trade is offset by a reduction in Australian output for domestic purposes. The increased domestic demand is then satisfied by imports.

cycle of the country with the larger financial market.[7] Alternatively, foreign share markets might affect Australian activity through their direct impact on the cost of raising funds, which may depend, in part, on the performance of foreign share markets. This link could be strengthened by foreign ownership of Australian companies, since domestic subsidiaries may have greater access to low cost internal funds or equity finance when the parent company is highly profitable and its share price is high.[8]

Another explanation which centres on common causal factors is the impact of worldwide supply shocks. Examples include the positive oil price shocks of the 1970s, the negative oil price shock in 1986, and shocks to technology. Partly due to the difficulty in comprehensively identifying the shocks, this explanation has received little attention. Finally, Debelle and Preston (1995) suggest an influence through the effect of foreign business cycles on Australian business confidence. However, they acknowledge that an explicit role for business confidence in determining Australian investment is more difficult to identify.

Two of the linkages between the foreign and domestic business cycles appear particularly relevant from this review of the literature and are investigated further below. The first linkage is through exports, commonly regarded as the main channel through which business cycles are transmitted internationally. Given the dominance of this view and the increased openness to trade of the Australian economy, the next section considers the relationship between foreign activity and exports in detail. The second linkage, through share markets, is relevant due to the increasing integration of the Australian and foreign markets, and is considered in Section 4.

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7 Fama (1981), Geske and Roll (1983), Kaul (1987) and Barro (1990) find that stock returns help predict future real activity. Furthermore, Canova and De Nicolo (1995) find expected US GNP growth helps predict European stock returns which in turn helps to explain future European GNP growth.

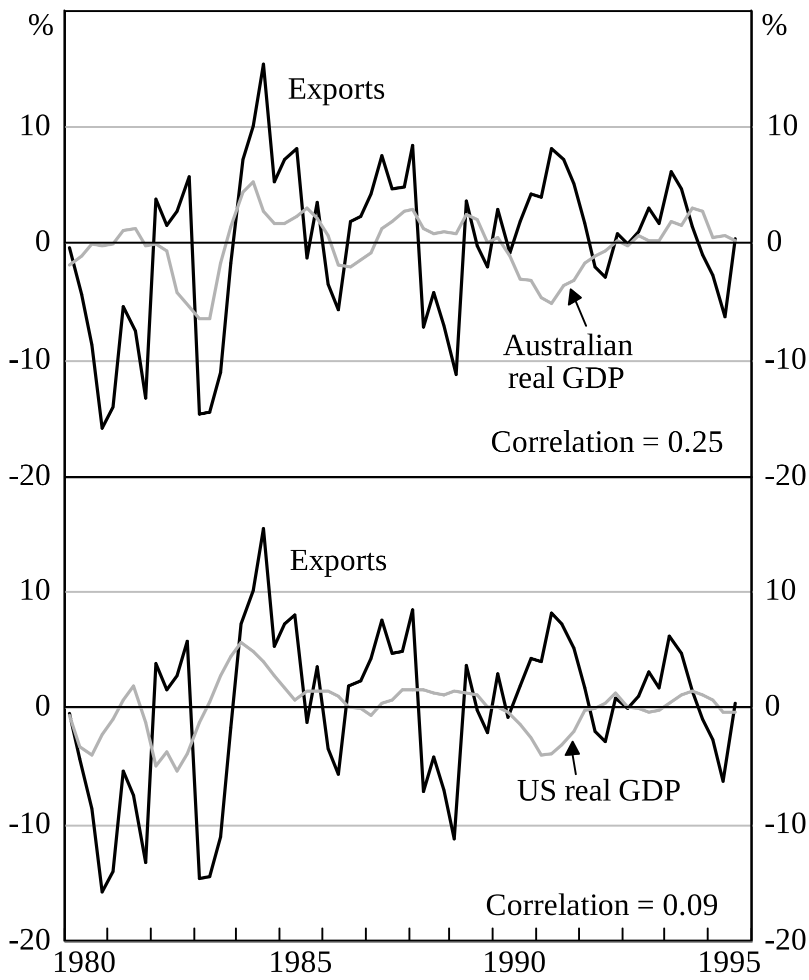
8 Fazzari, Hubbard and Petersen (1988) and Froot and Stein (1991) argue that the cost of internal funds is less than external finance and show investment is sensitive to the availability of internal funds. Froot and Stein (1991) also argue that companies with higher relative wealth are more likely to engage in foreign direct investment.

3. The Foreign Business Cycle and Australian Exports

This section looks at the impact of foreign activity on Australian exports. Figure 2 shows the cycles in exports, Australian GDP and US GDP. The correlations between Australian exports and the two countries' GDPs are low, at 0.25 and 0.09 respectively. At first sight these low correlations seem to imply that foreign activity is not important for Australia's exports and that exports, in turn, are not determining Australian activity. However, this analysis ignores the fact that exports may be driven by movements in both foreign and domestic demand. By recognising this, the following 'exports' mechanism for the transmission of business cycles can be posited. Suppose that a high level of world activity increases the demand for Australian exports and, furthermore, that a high level of domestic activity reduces exports. The latter assumption follows because Australian producers divert exports to satisfy domestic demand. As a result, the

Figure 2: Cycles in Exports, and Domestic and Foreign Activity

Four-quarter-ended percentage change



Notes: The figures show the deviation from the sample average four-quarter-ended growth in each series.

net effect on exports of an increase in domestic and foreign activity may be small. Consequently, the correlation between exports and either domestic or foreign activity will appear low, *even though Australia's exports are in part dependent on foreign activity*.

While the idea that increased foreign activity increases exports is straightforward, the idea that domestic demand *decreases* exports is less so. Menzies and Heenan (1993) argue that producers switch in the short run between foreign and domestic markets depending on domestic activity. However, domestic activity also affects the level of exports in the long run for the following reason. As a first approximation, the trend growth in output for an economy is determined by supply factors such as capital accumulation, growth in the workforce and changes in technology. If technological progress is largely independent of export growth, then faster growth in exports must be at the expense of slower growth in that part of output which is consumed domestically.[9] In the short run this is also true but possibly less clear cut if there are idle resources.[10] However, in general, a surge in domestic demand will be satisfied partly by increased production and imports, but also partly by reduced exports. It is for this reason that we argue that there may be a long-run relationship between exports, domestic output consumed domestically, and foreign output.

9 This is not as bleak as it sounds. All else equal, increased exports may have little effect on Australia's total output but still improve the standard of living. If we sell exports and buy imports we reveal that we value the imports more than the exports.

10 The correlation between four-quarter-ended growth in exports and domestically consumed GDP (ie GDP less exports) is -0.16.

Having characterised the long-run determinants of Australian exports in this way, the following unrestricted error-correction model of exports is estimated:

$$\begin{aligned}\Delta x_t &= a + \sum d_j \Delta tot_{t-j} + \sum k_j \Delta rer_{t-j} + \sum h_j \Delta x_{t-j} + \sum g_j \Delta y^{dc}_{t-j} + \sum c_j \Delta y^{f}_{t-j} \\ &\quad + b x_{t-1} + f y^{dc}_{t-1} + q y^{f}_{t-1} + y \ \text{TREND} + e_t\end{aligned} \tag{2}$$

where the level of exports x is determined in the long run by the level of domestically consumed output y^{dc} (equivalent to GDP less exports), the level of foreign output y^f, and a time trend to capture differences in domestic and foreign output trends and structural shifts towards exports in the Australian economy. Short-run influences on exports include changes in the terms of trade tot and the real exchange rate rer.[11]

Two alternative measures of export prices were also investigated. The first was the relative price of exportable to non-traded goods. The second was the ratio of the terms of trade to the real exchange rate.[12] Both measures were incorporated in a general dynamic structure and found to be either insignificant or, as above, did not display the expected sign and so were not reported.

Before estimating the models, the time series properties of the data were investigated.[13] We find that domestically consumed output and foreign output are best characterised as I(1) variables while first differences of these variables and the remaining explanatory variables are best described as stationary, I(0) series. There is some evidence that exports are trend-stationary. However, we proceed under the assumption that exports are non-stationary.[14]

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11 See Appendix D for details of the data series.

12 The ratio of the terms of trade (TOT) to the real exchange rate (RER) is: $TOT/RER = \frac{P_x}{P_m}\left(\frac{P_f}{P_d\, e}\right) = \frac{P_x}{P_d}\left(\frac{P_f}{P_m\, e}\right)$ where P_i is the price index and $i = x, m, f, d$ represents exports, imports, and foreign and domestic consumption. The ratio, therefore, reflects changes in the relative price of exports to domestic prices compared with changes in the relative price of imports to foreign prices.

13 See Appendix E for tests of the time series characteristics of the data.

14 Interpretations of the results differ somewhat under the alternative characterisations of exports. If exports are non-stationary, equation (2) specifies the adjustment of exports to deviations from the cointegrating relationship between exports, domestically consumed

The results of estimating equation 2 are reported in Table 3.[15] Model (1) uses US GDP as the measure of foreign output, models (2) and (3) use OECD GDP, and models (4) and (5) use export-markets' GDP. Model (1´) will be discussed later. Exports, domestically consumed output and foreign output are cointegrated only in the model using US GDP. In the OECD and export-markets models (2 and 4), domestically consumed output does not enter the long-run relationship. Excluding this variable fails to improve either of these models (3 and 5). While not reported, a strong cointegrating relationship can be found between exports and either OECD or export-markets' GDP if the trend is also excluded. However, the models have less than half the explanatory power of the US based models as measured by $\bar{R}^2$.

The relative performance of these models is counter-intuitive. In an exports equation it would be expected that the export market and OECD models would outperform the US model, because the US only accounts for around 10 per cent of Australia's export market. However, the cycle in Australia's exports will depend not only on a country's export share, but also on its output elasticity of demand for Australia's exports, e_f^x. When $e_f^x = 0$, Australia's exports are insensitive to the business cycle in that country. For $e_f^x > 0$, Australia's exports and that country's business cycle will be positively correlated. Countries with a high elasticity of demand will have a large impact on Australia's exports over their business cycle. Conversely, countries with a low or negative elasticity of demand will have little or even a 'perverse' negative impact on Australia's exports over their business cycle.

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output and foreign output. Alternatively, if exports exhibit trend growth, deviations from trend growth will be determined by deviations from the cointegrating relationship between the activity variables.

15 In the model, it is assumed that y^{dc} and y^f are weakly exogenous. This assumption is supported by single equation error-correction models where deviations from the long-run relationship between x, and y^{dc} y^f impact only on exports.

Table 3: Models of Australian Exports [(a)]
(1980:Q2-1995:Q3)
Dependent variable: Log change in exports

	Lag	United States		OECD		Export markets	
		(1)	(1´)	(2)	(3)	(4)	(5)
Constant		5.935 (3.36)	7.86 (4.20)	-3.704 (-2.85)	1.788 (0.69)	3.187 (1.87)	3.008 (2.12)
Exports	1	-0.566 (-6.13)	-0.556 (-6.31)	-0.295 (-3.22)	-0.398 (-4.42)	-0.378 (-4.25)	-0.387 (-4.39)
Domestically consumed GDP	1	-1.007 (-3.52)	-1.183 (-4.19)	-0.286 (-1.22)		-0.292 (-1.54)	
Foreign GDP	1	1.207 (3.64)	1.197 (3.79)	1.019 (2.88)	0.189 (0.66)	0.817 (4.01)	0.106 (0.33)
Trend		0.008 (4.65)	0.009 (5.34)		0.006 (2.70)		0.006 (1.70)
Domestically consumed GDP (log change)	0 to 2	0.952 {0.000}	1.068 {0.000}	0.883 {0.019}		1.244 {0.005}	
Foreign GDP (log change)	1	-1.740 (-2.99)	-1.909 (-3.42)				
Japanese GDP (log change)	0		1.397 (2.35)				
Terms of trade (log change)	1 to 4	-0.717 {0.060}	-0.693 {0.034}	-0.753 {0.142}	-0.688 {0.107}	-1.055 {0.073}	-0.693 {0.114}
Real exchange rate (log change)	1 to 4	0.396 {0.043}	0.380 {0.020}	0.118 {0.147}	0.282 {0.188}	0.237 {0.136}	0.297 {0.195}
Long-run relationship							
Australian GDP less exports		-1.779	-2.129	-0.972		-0.773	
Foreign GDP		2.133	2.152	3.458	0.475	2.164	0.275
Trend		0.013	0.015		0.015		0.015
Joint significance of terms of trade and real exchange rate		1.746 {0.114}	2.051 {0.062}	1.352 {0.242}	1.218 {0.308}	1.592 {0.153}	1.197 {0.320}
Diagnostics of residuals							
$\bar{R}^2$		0.499	0.545	0.271	0.262	0.360	0.257
LM (1)[(b)]		0.115 {0.735}	0.289 {0.591}	0.306 {0.580}	0.271 {0.603}	0.097 {0.755}	0.257 {0.612}
Standard error of equation		0.027	0.025	0.032	0.032	0.030	0.032
DW		1.90	2.05	1.85	1.99	1.98	2.00

Notes: (a) Each model was initially estimated with 4 lags of the short-run variables. Insignificant variables were then eliminated following individual exclusion tests. Finally, all the eliminated variables were tested for joint significance and rejected. Numbers in parentheses () are t-statistics and numbers in brackets {} are probability values for the joint test that all the lags can be excluded. The distribution of the t-statistics on the level variables in the model lie between a N(0, 1) and a Dickey Fuller distribution (See Kremers *et al*. 1992). **, *, and # denote significance at the 1%, 5%, and 10% levels respectively.

(b) LM (1) is a Lagrange multiplier test for first order autocorrelation.

Table 4 shows, for some of our major trading partners, the correlation between Australian exports to a particular country and its business cycle. A large positive correlation indicates a high output elasticity of demand for Australia's exports. Among the countries with the highest positive correlations are Japan and the US; Australia's two largest export partners. These results may reflect Australia's role as a major supplier of inputs for the Japanese economy, and that the US economy is relatively open. A reasonably high correlation is also found with the NIEs. In contrast, among the lowest correlations are those with countries within Europe, which may reflect less open markets. The impact of changes in activity in these countries on Australia's exports will, on average, be much lower. This helps to explain why the OECD-based model does worse than the US-based model, as the OECD-wide measure of foreign activity contains countries which have low or negative output elasticity of demand for Australia's exports. As a result, demand for Australia's exports will depend not only on OECD activity, but also on the composition of that activity. A similar argument applies to the export-markets model, since this gives weight to countries with a high average share of Australia's exports rather than to those whose demand for Australian exports is highly responsive to the business cycle.

Table 4: Correlation Between Australian Exports by Destination and Foreign Activity (1980-1994)

	Japan	US	NZ	South Korea	UK	Singapore	Taiwan
Correlation coefficient	0.69	0.72	0.44	0.23	0.18	0.69	0.57
Average export share (%)	26.50	10.40	5.20	4.70	3.90	3.60	3.30
	Hong Kong	Germany	Italy	France	Canada	EU	NIEs
Correlation coefficient	0.70	-0.63	0.74	0.14	0.23	0.32	0.60
Average export share (%)	3.00	2.40	2.00	1.9	1.60	13.90	14.50

Notes: Data are for the period 1982-1994 for NZ and for the period 1981-1994 for Taiwan and the NIEs. The logarithms of the series are detrended using linear trends. The exports series were detrended to remove structural reasons for the change in exports over the past 14 years and to ensure the series are stationary. The NIEs are Hong Kong, South Korea, Singapore, and Taiwan.

Given that Table 4 suggests that Japan's output elasticity of demand for Australian exports is high, the US-based model was re-estimated using US and Japanese GDP. While the level of Japanese GDP is insignificant in the long-run relationship, the contemporaneous change in Japanese GDP has a positive and significant impact on Australia's exports. These estimates are reported as Model (1´) in Table 3, which is now referred to as the 'preferred' model.

Turning to the short-run specification of the preferred model, we find that the terms of trade has little effect on exports and its sign is opposite to that expected. This may be because the industries which respond to the prices which drive the cycle in Australia's terms of trade are agricultural and resource based which are constrained by the weather or long-term contracts. The impact of the terms of trade on exports, therefore, is more diffuse and long-term. A higher terms of trade may well lead to higher investment and exports, but the lead time varies and depends, in part, on the perceived permanence of the change in export prices. In contrast, it has been shown that the terms of trade appears to have a large, positive and relatively rapid impact on domestic demand.[16] The model, therefore, may not be able to distinguish between the more rapid negative impact on exports through domestic demand, and the more long-term positive price effect. A similar explanation can be invoked to explain the persistent unexpected sign to the real exchange rate variable.

To look at the short-run impact of domestically consumed output and foreign activity on exports, we can use impulse response functions generated from the preferred model. The effects on exports of permanent shocks to domestically consumed output, US and Japanese GDP are shown in Figure 3:[17] higher foreign activity raises the level of exports while higher domestically consumed output reduces it. The net effect of a simultaneous shock to both variables is minimal change in the level of exports in the long run.[18] However, in the short run, the net impact generally increases exports. The impulse response functions imply that if the shocks to foreign and domestic activity are not highly correlated then the impact on exports and GDP will be large. However, if the shocks are highly

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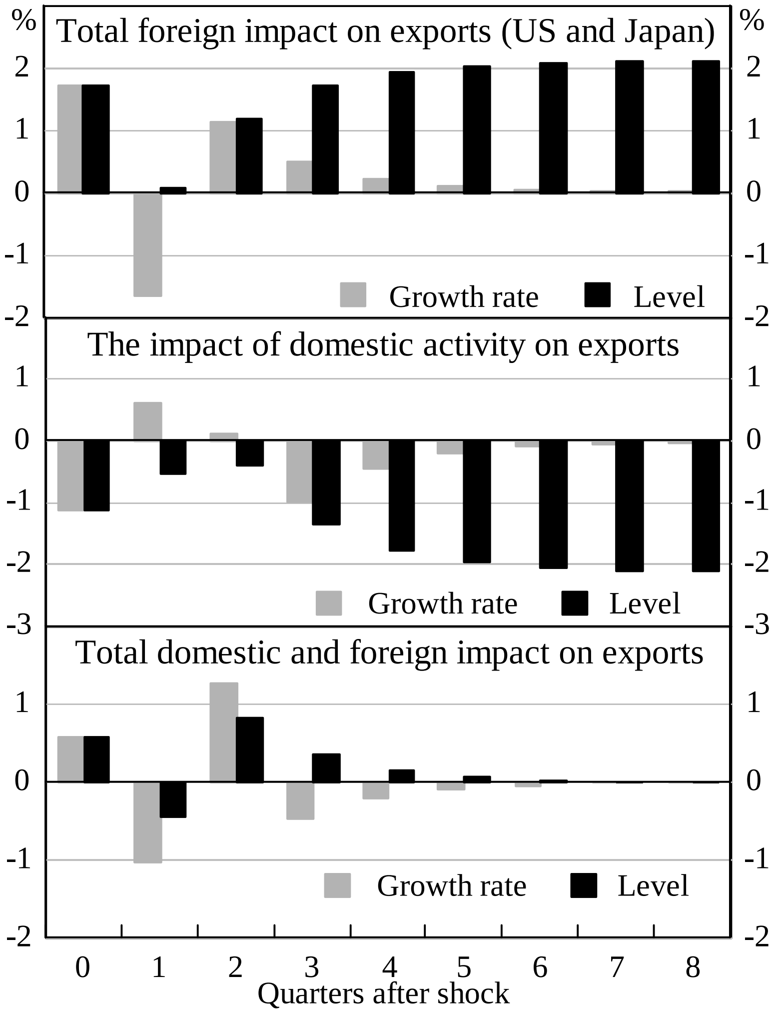
16 See Downes *et al.* (1994) and Gruen and Shuetrim (1994).

17 The impulse response is for a 1 per cent permanent shock to the level of domestically consumed GDP. The shocks to the levels of foreign GDP are in the ratio of their respective average growth rates of GDP to that of Australia's growth in domestically consumed GDP.

18 This may be considered a visual 'test' of the long-run condition that domestic and foreign economic cycles have no impact on the level of exports in the long run. That is, trend growth in exports is the result of 'supply' factors alone and captured by the linear time trend.

correlated, then the net impact on exports and GDP, although positive, will be considerably reduced.

Figure 3: Exports Impulse Response Functions for a Permanent Shock to the Level of Domestic Foreign Activity

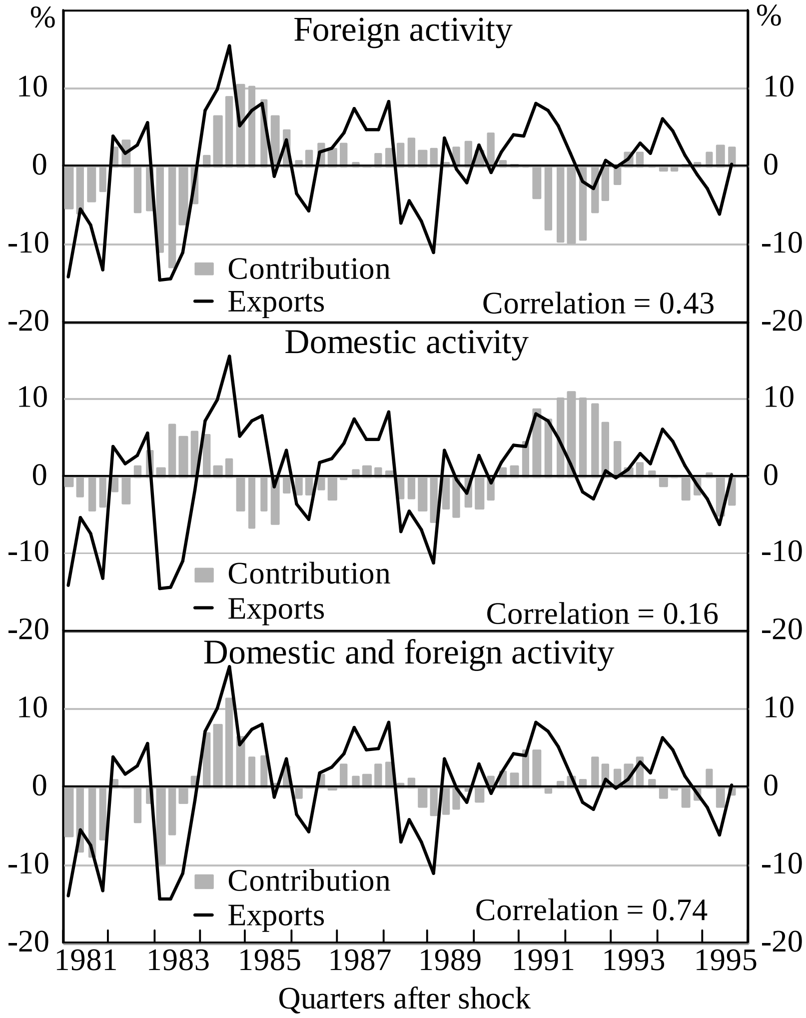


Note: The shocks to the level of domestically consumed GDP, US GDP and Japanese GDP are 1%, 0.98% and 1.23% respectively.

Using the preferred model we can also disentangle the historical impact of the foreign and domestic business cycles on exports. The top panel of Figure 4 shows the impact that deviations from the average growth in foreign GDP (US and Japanese) has had on exports over the sample. The impact is large and persistent. Similarly, the second panel shows the estimated impact of deviations from average growth in domestically consumed output on exports. Periods of high domestic activity serve to reduce exports. The third panel combines the effects of both the domestic and foreign business cycles on Australian exports. A large part of the cycle in exports can now be explained by the combination of these activity variables.[19]

Figure 4: The Impact of Domestic and Foreign Activity on Exports

Four-quarter-ended percentage change



Note: The export growth rate is the de-meaned four-quarter-ended growth in exports. The contributions are calculated as follows. Predicted values for export growth are calculated using the actual values of the exogenous variables and the predicted level of exports. Predicted values are also calculated holding a particular exogenous variable to its sample average growth rate or level over the entire sample. The contribution of that exogenous variable is then the difference between these predicted values.

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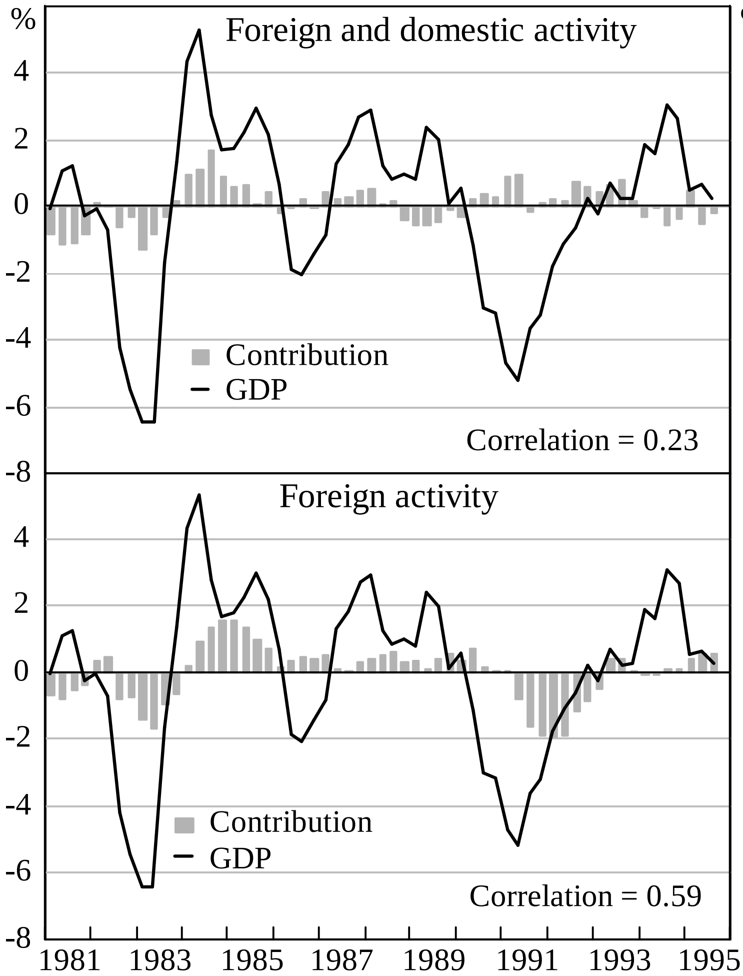
19 Closer inspection of Figure 4 reveals that the explanatory power of the model may have diminished after the mid 1980s. However, if we re-estimate equation (2) over a more recent sample (say 1985:Q4 to 1995:Q3), the results are qualitatively similar. Results are not reported as the sample is too short to generate meaningful long-run parameter estimates.

At the beginning of this section it was argued that because both domestic and foreign activity affect exports, the correlation between domestic activity alone and exports is likely to be low. The top panel of Figure 5 shows the total direct

Figure 5: Impact of Business Cycles Through Exports on GDP

Four-quarter-ended percentage change



Notes: The export growth rate is the de-meaned four-quarter-ended growth in exports. Contributions to GDP growth are calculated by multiplying the contributions to export growth by the share of exports in GDP.

contribution to the growth in Australian GDP from domestic and foreign activity through the export channel.[20] The correlation is low, and it does not appear to explain the cycle in Australian GDP. Therefore, the export cycle, when driven by shocks to foreign and domestic activity, is a poor explanator of domestic activity. However, it was also argued above that this does not imply that foreign activity

20 The contribution of exports to the growth in GDP is calculated by multiplying the export growth due to activity by the export share in GDP in the period before.

does not influence Australian activity through exports. The lower panel shows the direct contribution to domestic activity of that component of exports which is the result of the cycle in foreign activity alone. This is equivalent to removing from exports the feedback from domestic activity. Now the explanation of domestic activity is more substantial. We conclude, therefore, that foreign activity does influence domestic activity via an exports channel.

4. The Impact of Foreign Share Markets on Australian Activity

We now turn to the second area of investigation, that of the share market. The increasing integration of world financial markets allows the rapid propagation of foreign financial prices to domestic financial prices. If capital markets are imperfect, as many authors argue, these shocks to financial prices may lead to changes in real output.[21] Australia's share market is highly correlated with foreign share markets. Table 5a shows the correlation between the quarterly percentage change in the Australian share price accumulation index and similar indexes for the US, Japan, Europe, Australia's export markets, and the 'world'. McNelis (1993) reports similarly high correlation coefficients for volatility measures of share price indexes for a number of countries. His results are reported in Table 5b. Using Granger causality tests within a VAR model of share price volatilities, McNelis (1993) also shows that the Australian share price index does not help predict a number of the major foreign indexes (reproduced in Table 6). In contrast the share indexes of Germany, Japan, Singapore, UK and the US all 'Granger cause' movements in the Australian index. In particular, McNelis identifies the UK as the 'most significant' index for predicting the Australian index.

21 Under conditions of imperfect information, firms with higher net worth will, other things equal, have easier access to external funding. For example, see Gertler (1988) for a survey of the influences of financial factors on activity. See also Lowe and Rohling (1993) Mills, Morling and Tease (1994).

Table 5a: Correlation Between Australian and Foreign Nominal Share Market Returns

	US	Japan	Europe	Export markets	World
Correlation	0.62	0.42	0.65	0.61	0.69

Notes: Correlation between the quarterly percentage change in the share market accumulation indexes. Export markets index is calculated as the export weighted average of the accumulation indexes for Japan, US, NZ, South Korea, UK, Singapore, Taiwan and Hong Kong.

Table 5b: Correlation Coefficients of Australian and Foreign Stock-Price Volatility Measures

	Germany	Japan	Singapore	US	UK
Correlation	0.31	0.27	0.58	0.68	0.54

Notes: Correlation coefficients of the Schwert Indexes of volatility are reproduced from Panel A of Table 1 in McNelis (1993). Data are end month share price indexes for the period January 1982 to March 1992. Schwert (1988) measures stock market volatility as follows. A 12th order autoregression is estimated for average monthly returns using seasonal dummies. A 12th order autoregression is then estimated for the absolute values of the errors again using seasonal dummies. The predicted values from this regression provide an estimate of the conditional standard deviation of the monthly returns given prior information.

Table 6: VAR Model of Stock-Price Volatilities

Dependent variable: Schwert share price volatility index

	Australia	*Germany*	*Japan*	*Singapore*	*UK*	*US*
Australia	2.91	1.37	0.66	1.40	1.38	1.10
Germany	3.88	2.91	2.41	6.04	2.96	2.79
Japan	2.53	2.23	3.05	5.76	1.70	1.62
Singapore	3.37	1.31	4.22	3.56	2.82	1.54
UK	4.40	3.91	2.73	3.44	2.54	3.34
US	2.64	1.43	3.36	1.58	3.19	2.98

Notes: Reproduced from Panel B of Table 1 in McNelis (1993). Data is end month share price indexes over the period, January 1982 to March 1992. The VAR model regresses the volatility measure for each country on 6 lags of itself and 6 lags of the other countries' measure. If the joint significance of the 6 lags of a country are insignificant then the conclusion is that past values of that country do not contain significant information about predicting the dependent variable. The F-test statistic is reported in the table above: Critical Values on Zero Restrictions: F(6/56) = 2.27(5%); 3.08(1%).

If foreign share markets influence Australian share markets then they can also influence Australian activity directly and/or indirectly through their effect on investment in Australia.[22] The direct effect is through the investment by foreign-owned domestic companies or subsidiaries operating in Australia. If the share price of the parent company is high because of high profits then the subsidiary may have greater access to low cost retained earnings of the parent company.[23]

The indirect effect of the foreign share market is via its influence on the Australian share market. This effect contains at least three inter-related transmission mechanisms. The first mechanism follows from Tobin's investment theory or 'q' theory.[24] This predicts that firms will invest if the replacement cost of the capital stock is less than the value of the firm. The second is a cost of funds argument. Domestic firms find the cost of equity falls with higher general share prices leading to an expansion in investment and output. The third is an expectations argument. Expectations of greater world activity increase the valuation of domestic companies and share prices. Coincident with the expectation of greater activity is the need for greater investment to meet the expected higher demand.

Using a 'benchmark' model based on the Gruen and Shuetrim (1994) model of Australian GDP, we introduce domestic and foreign share market variables to investigate their impact on the model. The appropriate share market variable to include depends on the transmission mechanism which it represents. Share market variables reflecting the first two transmission mechanisms set out above are similar but not identical. Barro (1990) argues the ratio of the share price index to the private investment deflator is a good measure of Tobin's 'q' for an economy. By contrast, Fama (1990) uses share market returns deflated by the consumer price index to predict output growth. Similar to Fama's approach, we construct the accumulation share price index (which incorporates dividends), deflated by the GDP deflator. The GDP deflator was chosen because it allows the share price of the firm to be expressed in terms of the firm's output price. The real share market price variable was found to be a trend stationary process and was therefore detrended. The detrending is theoretically appealing as it is expected that the cycle in the real share price and not its trend level will affect the cycle in activity.

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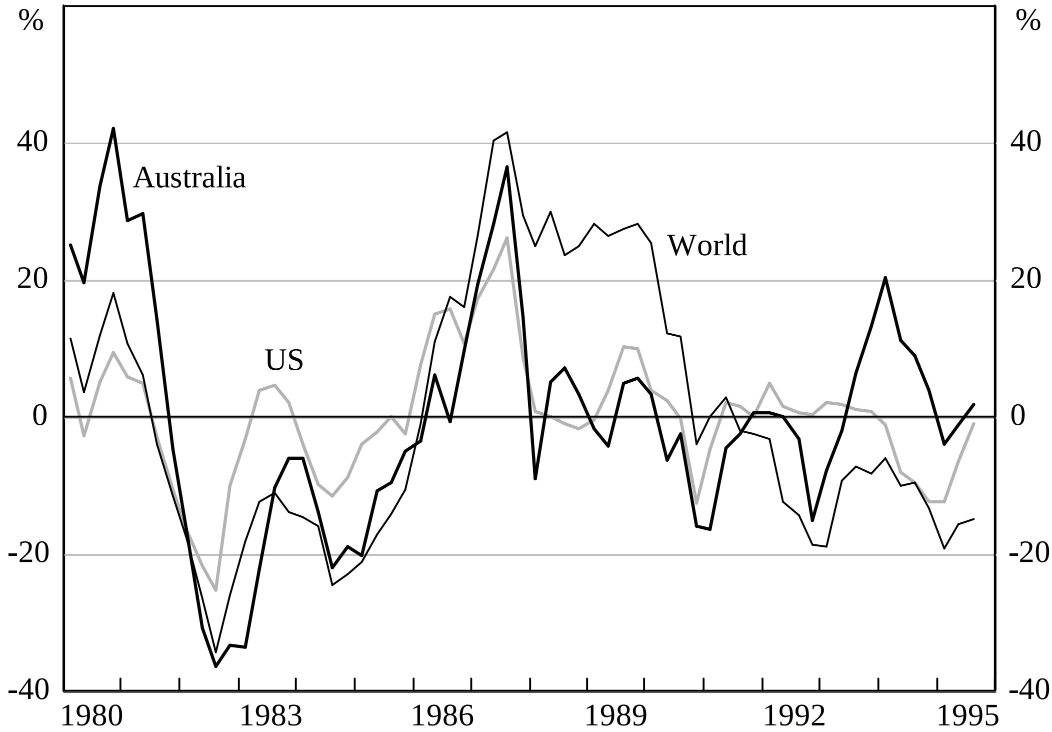
22 While there may well be other avenues for share prices to effect domestic activity, such as a wealth effect on consumption, these other avenues appear minor and are not pursued.

23 See Fazzari, Hubbard and Petersen (1988) and Froot and Stein (1991).

24 See Tobin (1969).

Figure 6 shows the detrended real share price for Australia, the US and a composite world index. We see that the three series move closely together. However, the world series deviates substantially from the Australian and US series following the 1987 sell-off in share prices due to the long lag before the Japanese share market was also sold-off in January 1990.

Figure 6: Detrended Real Share Prices



Note: The world real share price is the nominal world accumulation share price index deflated by the G7 deflator.

The benchmark model is reported in Table 7 using US GDP as the measure of foreign activity.[25] The US model was chosen over the OECD or export-market models as it performs substantially better. Models 1 to 3 add to the benchmark

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25 Over the longer sample, the 'benchmark' model differs slightly from that in Gruen and Shuetrim (1994). The Southern Oscillation Index is now insignificant. After testing for individual and joint significance, the terms of trade and real exchange rate were also eliminated from the benchmark model in a stepwise fashion. Consistent with the Gruen and Shuetrim model, a trend variable is also insignificant.

Table 7: The Real Share Price and Australian Activity[(a)]
(1981:Q3-1995:Q3)
Dependent variable: Log change in Australian GDP

	Lag	Benchmark model	(1)	(2)	(3)
Constant		0.286* (2.18)	0.331** (2.73)	0.149 (1.11)	0.303# (1.90)
Australian GDP	1	-0.287** (-4.21)	-0.257** (-4.07)	-0.205** (-2.87)	-0.246** (-3.33)
US GDP	1	0.345** (4.44)	0.300** (4.13)	0.254** (3.12)	0.289** (3.52)
Real cash rate[(b)]	2 to 6	-0.157** {0.009}	-0.149** {0.006}	-0.193** {0.001}	-0.156* {0.034}
US GDP (log change)	0	0.452** (3.17)	0.440** (3.36)	0.375** (2.72)	0.428** (3.09)
Real share price					
Australia	1		0.019** (3.17)		0.017# (1.74)
United States	1			0.030* (2.58)	0.005 (0.283)
Long-run relationship					
Foreign GDP		1.203	1.169	1.237	1.177
Joint significance of US and Australian share markets variables					4.97* {0.011}
Diagnostics of residuals					
$\bar{R}^2$		0.527	0.603	0.577	0.595
LM (1) [(c)]		2.61 {0.106}	0.253 {0.615}	0.101 {0.750}	0.194 {0.659}
Standard error of equation		0.006	0.006	0.006	0.006
DW		1.59	1.85	1.90	1.87

Notes: (a) Each model was initially estimated with 4 lags of the short-run variables. Insignificant variables were then eliminated following individual exclusion tests. Finally, all the eliminated variables were tested for joint significance and rejected. Numbers in parentheses () are t-statistics and numbers in brackets {} are probability values for the joint test that all the lags can be excluded. The distribution of the t-statistics on the level variables in the models lies between a N(0, 1) and a Dickey Fuller distribution (see Kremers *et al*. 1992). **, *, and # denote significance at the 1%, 5%, and 10% levels respectively.

(b) Real cash rate reported as the sum of the coefficients multiplied by 100.

(c) LM (1) is a Lagrange multiplier test for first order autocorrelation.

model the share market variables for Australia and the US. The models all perform better than the benchmark model in terms of increasing the explanatory power as measured by $\bar{R}^2$. In model 1 we add the Australian real share price and find it has a significant and large, positive impact on Australian activity. A permanent 1 standard deviation increase in the real share price (around

17 per cent), increases GDP in the short run by around 0.32 of a percentage point and by around 1.26 percentage points in the long run. The addition to the benchmark model of the US real share price in model 2 provides similar results.[26] However, the long-run relationship between Australian and US GDP is less well defined.

Models 1 and 2 cannot separately identify the influence of the Australian and US share markets on output. In model 3 both share market variables are included. Evident from their joint significance, the US and Australian real share price variables contain information concerning Australian activity. Once the Australian share market variable is included, the US share market variable becomes insignificant. This suggests that the Australian variable contains all the relevant information present in the US variable plus some additional information. This result, along with the McNelis (1993) finding of 'causality' between the US and Australian share markets, is intuitively appealing. It is consistent with the idea that the US share market influences the Australian share market and, thereby, Australian activity, and that the Australian share market contains information not present in the US market which is uniquely relevant to Australian activity.

From models 2 and 3 we can determine the influence of the US share market on Australian activity. Model 3 could be used to identify the direct impact of the US share market on activity. However, the indirect effect via its influence on the Australian share market cannot be identified. Model 2 provides an estimate of the sum of the direct and indirect US influences.

The contributions to Australia's cycle in GDP from the US share market, the real cash rate and foreign activity using model 2 are shown in Figures 7a and 7b. We see that at times the foreign share market has a sizeable impact on GDP growth; up to 2 percentage points on a four-quarter-ended basis. In the bottom panel, a slightly larger impact stems from the real cash rate. The top panel of Figure 7b shows the contribution due to foreign growth. It is evident that while the contribution of the US share market to the cycle in Australian GDP has been smaller than that of the real cash rate or foreign activity, the contribution has been large at times and often leads the cycle.

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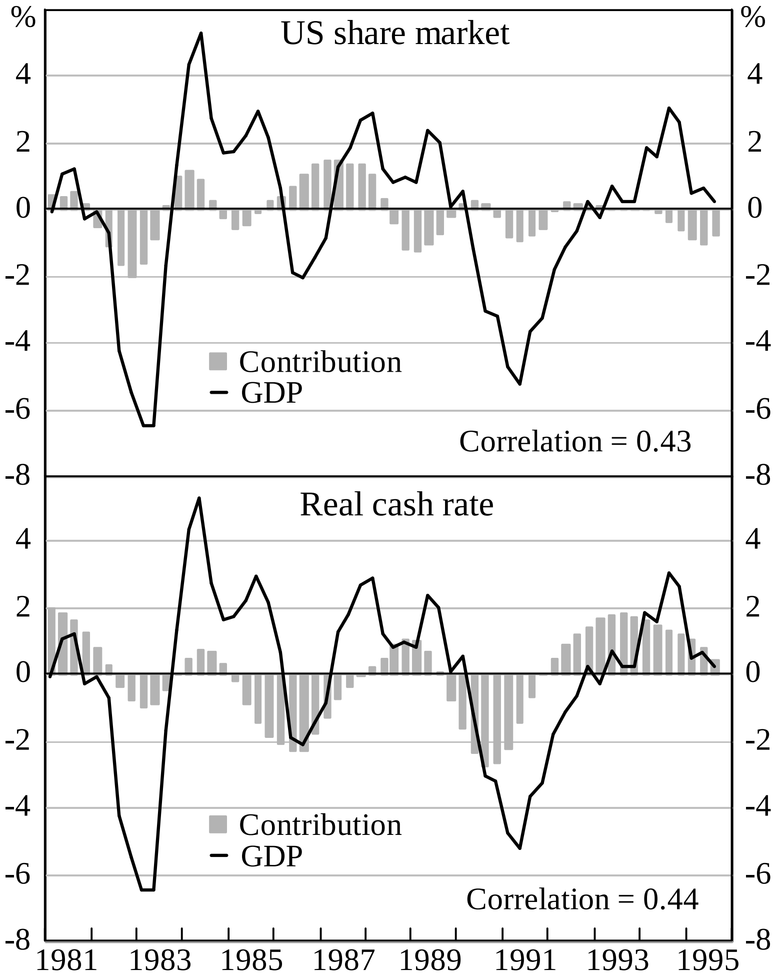
26 The short and long-run impact on the level of Australian GDP of a permanent 1 standard deviation increase (around 9 per cent) in the US real share price are 0.27 and 1.31 percentage points.

Figure 7a: Contributions to Australian Activity

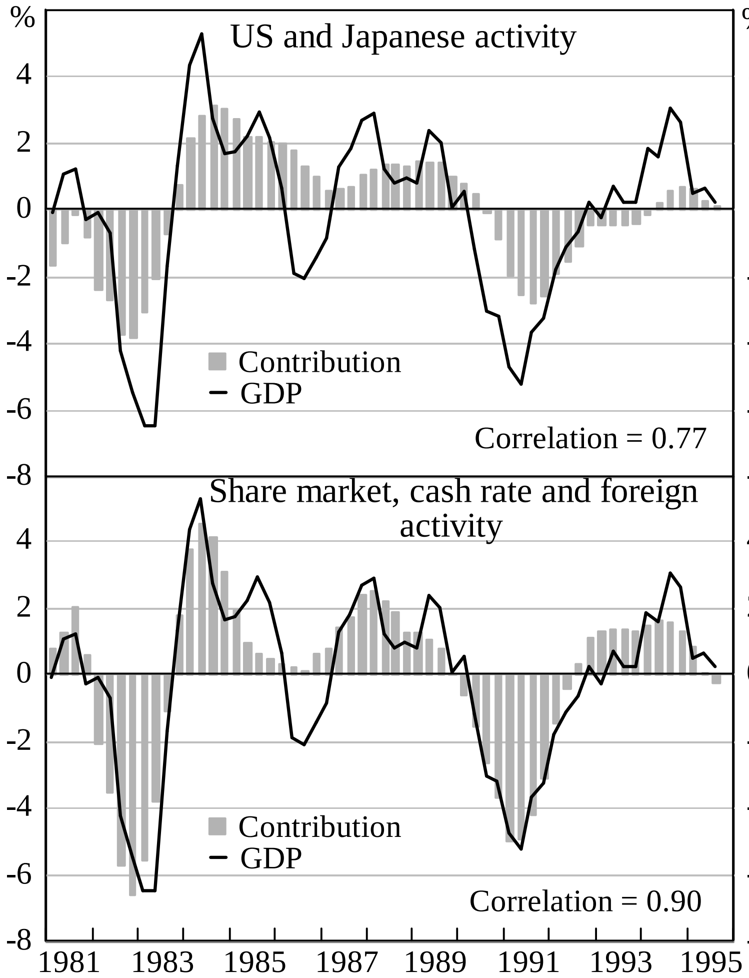
Four-quarter-ended percentage change



Notes: The GDP growth rate is the de-meaned four-quarter-ended growth in GDP. The contributions are calculated as follows. Predicted values for GDP growth are calculated using the actual values of the exogenous variables and the predicted level of GDP. Predicted values are also calculated holding a particular exogenous variable to its sample average growth rate or level over the entire sample. The contribution of that exogenous variable is then the difference between these predicted values.

Figure 7b: Contributions to the Business Cycles

Four-quarter-ended percentage change



Notes: The GDP growth rate is the de-meaned four-quarter-ended growth in GDP. The contributions are calculated as follows. Predicted values for GDP growth are calculated using the actual values of the exogenous variables and the predicted level of GDP. Predicted values are also calculated holding a particular exogenous variable to its sample average growth rate or level over the entire sample. The contribution of that exogenous variable is then the difference between these predicted values.

Finally, we should notice that even though the inclusion of the share market variable increases the explanatory power of the benchmark model substantially, the short and long-run coefficients on foreign activity are not significantly reduced. It appears, therefore, that while the share market may help explain domestic activity, and may also help explain the correlation in business cycles, the foreign demand variable in the benchmark model is not simply a 'proxy' for a missing share market variable.

5. The Propagation of Business Cycles

It was argued above that the correlation between Australian and foreign business cycles may be partly explained by the correlation between share markets. But this explanation requires that foreign and domestic activity variables respond to their respective share markets in similar ways. This section looks at evidence for that proposition by looking at sharemarket correlations with three variables – investment, consumption and output – in Australia and the US.[27]

Table 8 shows the correlation between detrended Australian investment and lags in the detrended Australian real share price, at an aggregate level and for the

Table 8: Investment Gap and Real Share Prices for Australia and the US: Correlations and Associated Lags

	Australia					**United States**	
	Aggregate investment			*Mining*	*Manufact.*	*Aggregate investment*	
Lags in real share price	Total	Plant and equipment	Non-dwelling construction	Plant and equipment	Plant and equipment	Total	Plant and equipment
0	0.23	0.01	0.13	-0.20	0.37	0.15	0.06
1	0.40	0.18	0.22	-0.12	0.48	0.25	0.10
2	0.56	0.38	0.33	-0.04	0.58	0.27	0.14
3	0.62	0.45	0.41	0.06	0.57	0.25	0.17
4	0.62	0.48	0.45	0.19	0.60	0.19	0.16
5	0.55	0.44	0.46	0.32	0.59	0.03	0.09
6	0.45	0.39	0.44	0.38	0.53	-0.09	0.00
7	0.30	0.24	0.40	0.41	0.47	-0.17	-0.07
8	0.15	0.08	0.33	0.35	0.4	-0.22	-0.12
9	0.02	-0.05	0.24	0.28	0.32	-0.22	-0.17
10	-0.13	-0.17	0.09	0.24	0.29	-0.18	-0.17

Notes: Shading identifies the lag with the highest correlation. The 'gap' is the difference between the log level of the variable and a linear time trend. It is approximately the percentage deviation from trend of the variable. For Australia, the mining real share price index uses the 'All Mining' accumulation share price index deflated by the mining sector investment deflator. Similarly, the manufacturing real share price uses the 'All Industrials' accumulation share price index deflated by the manufacturing investment deflator.

[27] This analysis does not imply causation. Instead, it is a consistency check of our more general analysis which implies a particular pattern of correlations between a number of the variables.

mining and manufacturing sectors.[28] We see that investment lags the real share price with a peak in the correlation occurring with a lag of between three and seven quarters, depending on the industry and the level of aggregation in investment. Also in Table 8 are similar correlations for the US using aggregate investment. These show a similar pattern of correlations and lags to those found for Australia, except in two respects. First, the correlations are lower for the US; and second, the peak lags in Australia are 1 quarter longer. The low correlation may be because the US share market is a proxy for a 'world' share market and, therefore, focuses less on the US.

An alternative way to display the peak correlations is shown in Figures 8 to 11 where the peak correlation coefficients between the variables are shown with the number of lags at which that peak occurs. The arrows in the figures point to the lagging variable in the correlation.[29] We observe that the Australian and US real share prices are highly correlated, with the Australian share market lagging by 1 quarter. In Figures 8a and 8b we also see that lags between the real share price and investment, and between investment and GDP, are similar in the US and Australia. Therefore, if the real share price is influencing investment within each country, and if the Australian and US real share prices are closely related, then it is likely that the business cycles will be correlated.

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28 The consumption, investment and output variables in this section have all been logged and detrended using a linear trend. The 'gap' between the actual level and the linear trend is approximately the percentage deviation from trend of the variable.

29 For example, the maximum correlation of the Australian real share price and US real share price is 0.65 which occurs when the Australian real share price lags the US real share price by one quarter. When no arrow head is shown, the peak correlation occurs contemporaneously.

Figure 8a: Real Share Price, Total Investment Gap and GDP Gap

Peak correlations and associated lags

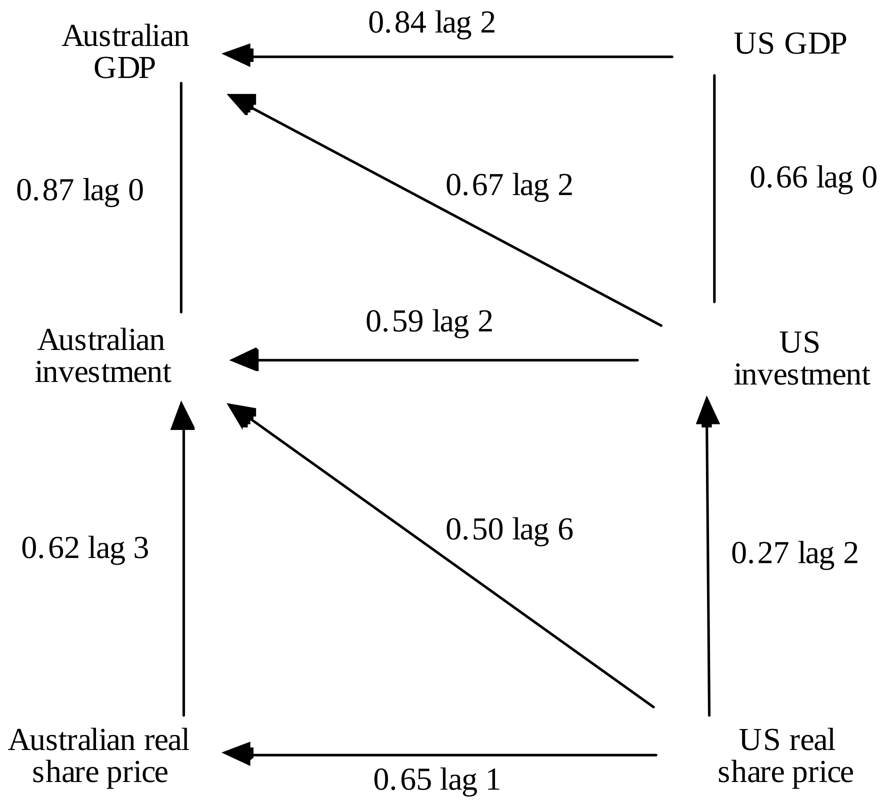
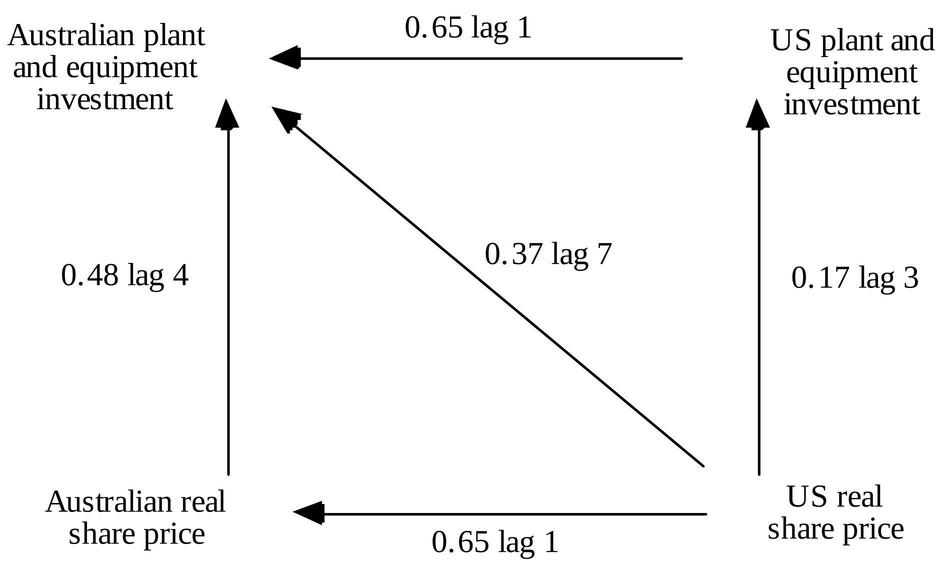


Figure 8b: Real Share Price and Plant Equipment Investment Gap

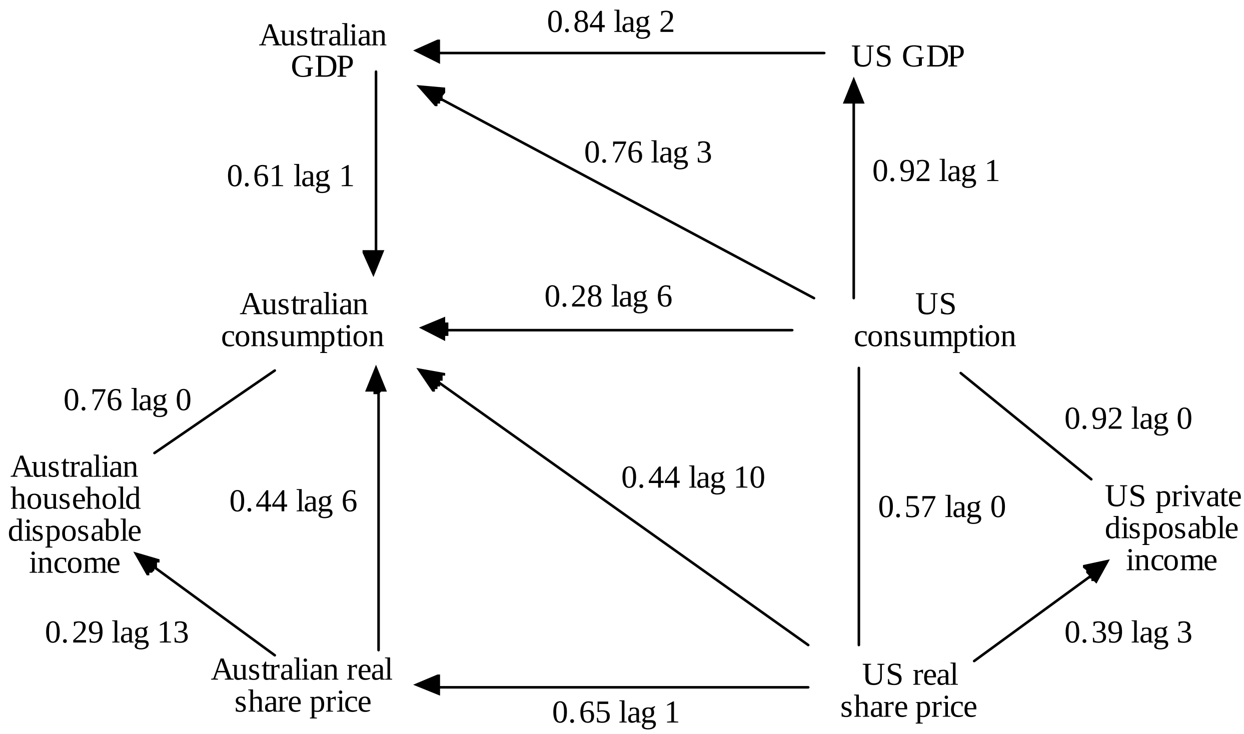
Peak correlations and associated lags



Similarly, Figure 9 shows the correlation between the real share price and consumption. This correlation diagram displays greater divergence between the correlation and lag structures of the two countries than was the case with the investment diagrams. The lags between the real share price and consumption are considerably longer in Australia than in the US. Consequently, US and Australian consumption are not highly correlated and there is a long lag in the peak correlation. It would appear that the interaction between the share market and consumption is not as well defined in Australia and is unlikely to explain a large proportion of the correlation in business cycles.

Figure 9: Real Share Price, Consumption Gap and GDP Gap

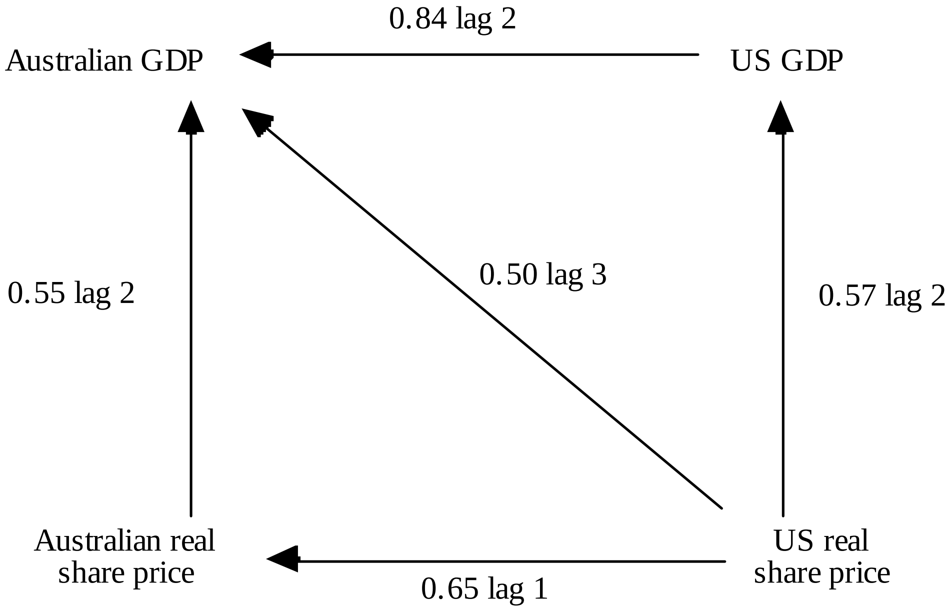
Peak correlations and associated lags



Finally, Figure 10 shows the correlation at the aggregate level between the real share price and GDP for the US and Australia. The peak lags between the respective share markets and GDP are the same, consistent with the high correlation between Australian and US GDP.

Figure 10: Real Share Price and GDP Gap

Peak correlations and associated lags



A common feature of these peak correlation diagrams is that the lags emanate from the US share market. If the correlation in business cycles was due to simultaneous world-wide shocks to the real economy, it would be unlikely for the share market to regularly lead the shocks by the number of periods shown in the figures. This casts doubt on the proposition that the correlation of business cycles is attributable to simultaneous world-wide shocks to the real economy. Even if the shocks impact on share markets first, we would expect contemporaneous correlations between the Australian and US share markets. It appears, therefore, that a case can be made that the US share market 'drives' the Australian share market and, because of the similar domestic responses, this contributes to the correlation in business cycles.

6. Conclusion

Previous studies have identified the extent of the correlation between Australian and foreign business cycles and at an aggregate level showed that foreign business cycles 'cause' the Australian business cycle. However, the transmission mechanisms which underpin the correlations have been more difficult to identify.

This paper has identified two large and significant transmission mechanisms. The first mechanism through exports is widely accepted even though it has been difficult to show empirically. By allowing for the effect of domestic activity on exports, we show in Section 3 that foreign activity has a large impact on exports as expected. Also shown was that after allowing for the feedback of domestic activity onto exports, Australia's exports are not only highly correlated with the cycle in foreign GDP but large enough to have a sizeable impact on Australian activity at times.

It was also argued that the effect on Australia's exports of the US and Japanese economic cycles is greater than indicated by their average shares of our export markets. This is because, as well as being Australia's two largest export markets, their output elasticities of demand for Australia's exports are relatively high. This explains why the export equations based on OECD or export-markets' GDP performed poorly relative to the US-based model. By implication, it may also explain why the US-based GDP model in Gruen and Shuetrim (1994) performs so well relative to the OECD and export markets based models.

The second transmission mechanism identified was through the impact of the US share market on the Australian share market. In Section 4 it was shown that the two countries' share markets are closely correlated and that the inclusion of share market variables substantially improves the explanatory power of the benchmark model of Australian GDP. This result does not necessarily imply that the cycles in the real economy will be correlated unless the within-country responses to share market movements in the US and Australia are similar. Section 5 provides some evidence that the responses of investment to the share market variables in the two countries are remarkably similar, while the responses of consumption are different. This implies that if the sharemarket is serving to correlate the US and Australian business cycles, it is likely to be through investment rather than consumption.

Appendix A: Empirical Estimates of Australia's Co-Movement With Foreign Business Cycles

Barry and Guille (1976)

Methodology Simple correlation between the Australian and world business cycles. Business cycle defined as deviation from trend through peaks in industrial production. Defined 'world' business cycle as trade-weighted industrial production. Sample: Quarterly, 1959-1974.

Results Australian business cycle lags by 2 – 3 quarters the world business cycle. Evidence that the lag has reduced over time.

Backus and Kehoe (1992)

Methodology Contemporaneous correlation of HP filtered logarithm of real output. Sample: Annual for more than 100 years.

Results Interwar years a high correlation (greater than 0.3) for Canada, Germany, Italy, Sweden, United Kingdom, and United States. Postwar a high correlation found only for Germany, Japan, Sweden, and United Kingdom.

Haslem, Hawkins, Heath and Tarditi (1993)

Methodology Test for 'common features' using Engle and Kozicki (1993) technique. Uses industrial production as the measure of the business cycle. Sample 1984:Q1 to 1993:Q1.

Results VAR(1) common feature between both the US and OECD business cycles and the Australian business cycle. A 1 percentage point increase in the OECD production growth leads to a 0.95 percentage point increase in the Australian industrial production.

McTaggart and Hall (1993)

Methodology 2 step error-correction model. First step between Australian and US GDP. Second step was to explain Australian GDP growth by the growth in US GDP and the error correction. Sample: 1967:Q1 to 1991:Q1.

Results Cointegration found between the level of Australian and US GDP. Coefficient on growth in US GDP is 0.5 and on the ECM -0.48.

Downs, Louis and Lay (1994)

Methodology Single equation GDP. Sample: 1972 to 1994.

Results Estimates US GDP growth has a larger and more significant (but still very small) impact on Australian GDP growth following 1983.

Gruen and Shuetrim (1994)

Methodology Single Equation Error-Correction Model. Sample: 1980:Q1-1993:Q4.

Results High contemporaneous impact of world output on domestic growth with a coefficient between 0.4 and 0.6 depending on the model and the measure of foreign activity. Coefficient on ECM is between -0.15 and -0.3. Finds small effect of terms of trade and real exchange rate on output growth.

Smith and Murphy (1994)

Methodology Johansen VAR. Sample: 1976:Q1 to 1990:Q1.

Results Attributes 2 per cent of the variance in GDP growth to international activity, 73 per cent to domestic demand and 15 per cent to real wage shocks.

Debelle and Preston (1995)

Methodology Unrestricted ECM between Australian GDP, OECD GDP and components of Australian GDP. Sample: 1971:Q2 to 1994:Q4.

Results Looks for cointegration. Finds little impact on components of GDP. Exports not cointegrated with OECD GDP. Some evidence of transmission through business confidence.

Appendix B: Estimates of the 'Gruen and Shuetrim Model Using Detrended Variables

While in this paper we characterise the domestic and foreign activity variables as I(1), there is some chance that the variables follow a trend stationary process.[30] Therefore, the Gruen and Shuetrim (1994) model was re-estimated using logged activity variables detrended using a linear trend. The results are reported in Table B1. Models (1), (2) and (3) are estimated using US, OECD and export-markets GDP. As in the original results reported in Table 2 and for the 'benchmark' model reported in Table 7, we find foreign activity has a large impact on the cycle in domestic GDP in the contemporaneous period. For example, in the US-based model (1), a 1 percentage point increase in US GDP is associated with a 0.57 of a percentage point increase in Australian GDP in the contemporaneous period and a 1.36 percentage point increase in the long run. These are similar to the short and long-run coefficients from the 'benchmark' model in Table 7 of 0.45 and 1.20.

Also reported in Table B1 as model (1´) is a US-based model which includes the Australian real share price variable. The results can be compared with model (1) in Table 7. The cash rate is now jointly insignificant, but otherwise the results are similar. The lag structure associated with US GDP has been altered but the total short-run impact on domestic activity remains largely unchanged. We also see that the impact of the share market is very similar. A permanent 1 standard deviation increase in the real share price (17 per cent) leads to a 0.34 percentage point increase in Australian GDP in the short-run and a 0.90 percentage point increase in GDP in the long-run. This compares with estimates of 0.32 and 1.26 percentage points for model (1) in Table 7.

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30 Nelson and Plosser (1982) argue that standard unit root tests have low power in rejecting the null hypothesis of non-stationarity. The Kwiatkowski, Phillips, Schmidt and Shin (1992) tests in Appendix E, based on the null hypothesis of stationarity, provide additional evidence that these series are non-stationary.

Table B1: The 'Gruen and Shuetrim Model' Using Detrended Variables[a] (1981:Q3-1995:Q3)

Dependent variable: Australian GDP gap

	Lag	United States (1)	United States (1´)	OECD (2)	Export markets (3)
Constant		0.004* (2.26)	0.006** (3.52)	0.008** (3.45)	0.004# (1.85)
Australian GDP	1	0.869** (6.22)	0.644** (9.59)	0.556** (6.30)	0.935** (6.04)
	2	-0.246# (-1.88)			-0.236 (-1.21)
	3				-0.221# (-1.74)
Foreign GDP	0	0.565** (3.81)	0.377** (5.04)	0.907** (4.70)	0.320 (1.53)
	1	-0.449# (-1.95)			-0.309 (-1.25)
	2	0.395* (2.39)			-0.171 (-0.68)
	3				0.719** (2.90)
Real cash rate[b]	2 to 6	-0.070 {0.335}	-0.097** {0.001}	-0.121** {0.010}	-0.051 {0.158}
Real share price	1		0.020** (2.98)		
Terms of trade log change	1 to 4			0.043 {0.366}	0.122* {0.027}
Real exchange rate log change	1 to 4			-0.085* {0.049}	-0.142** {0.002}
Joint significance of terms of trade and real exchange rate				{0.019}*	{0.002}**
Diagnostics of residuals					
$\bar{R}^2$		0.887	0.894	0.884	0.879
LM(1)[c]		1.323 {0.250}	0.773 {0.379}	3.299# {0.069}	1.878 {0.171}
Standard error of equation		0.006	0.006	0.006	0.006
DW		2.08	1.79	1.62	2.09

Notes: (a) With the exception of the real cash rate, all variables are detrended logged levels. Numbers in parentheses () are t-statistics; and numbers in brackets {} are probability values for the joint test that all the lags can be excluded. **, *, and # denote significance at the 1%, 5%, and 10% levels respectively.

(c) Real cash rate reported as the sum of the coefficients multiplied by 100.

(c) LM (1) is a Lagrange multiplier test for first order autocorrelation.

Appendix C: Channels of Transmission of Business Cycles

Existing empirical work	*Aims and theoretical implications*	*Actual results*
(1) Terms of trade		
Gruen and Shuetrim (1994)	Higher terms of trade increases exports through a supply response and increases demand through higher national income.	Some evidence that the terms of trade impacts on GDP but the impact appears small.
Downs, Louis and Lay (1994)	As above	Finds TOT impacts on GDP and GNE. Impact on GDP is smaller, particularly post 1993.
(2) Exports		
Menzies and Heenan (1993)	Considers hysteresis effects due to sunk costs of exporting.	Find some empirical support for the existence of sunk costs.
	Looks also at the effect of domestic activity on exports.	Finds evidence that the recession in 1989/90 increased exports.
Gruen and Shuetrim (1994)	Positive impact of world business cycle on exports	Finds that the US business cycle has greater impact on Australian business cycle than trading partners business cycle. Concludes that it is not exports which explains the correlation.
Downs, Louis and Lay (1994)	Same as above	Asserts no 'strong linkage between output and export volumes'. Concludes changes in world activity will also have little effect.
Debelle and Preston (1995)	Same as above	Little evidence that world business cycle impacts on exports (or any of the other components of GDP).

Existing empirical work	*Aims and theoretical implications*	*Actual results*
(3) Share market		
Canova and De Nicolo (1995)	Looks at linkages between European and US business cycles through stock markets. Lagged foreign share market returns help explain Australian GDP. Alternatively, foreign share markets impact on Australian share market which in turn impacts on Australian growth.	Shows European stock returns explain both US and European GNP growth.
(4) Confidence effects		
Debelle and Preston (1995)	Positive impact of foreign business cycle on business and/or consumer confidence.	Found US investment growth and real US Fed funds rate impact on Australian business confidence. However, they acknowledge that the impact of business confidence on investment is small.
(5) Foreign ownership of Australian companies		
Froot and Stein (1991)	Cost of internal funds less than external finance (a) The size of foreign business cycle on Australian business cycle is, in part, dependent on ownership. (b) Investment in Australia dependent on overseas share prices.	Finds high relative wealth of foreign companies induces increased foreign direct investment.

Existing empirical work	*Aims and theoretical implications*	*Actual results*
(6) Worldwide shocks		
Backus, Kehoe and Kydland (1993)	Based on business cycle models, when different countries are subjected to stochastic shocks (using historical correlations between productivity shocks), cross-country consumption correlation should be high and cross-country output correlations low or even negative. If productivity shocks are perfectly correlated across countries, then so too should be consumption and output.	Cross-country data reveals output correlations are higher than consumption correlations. This is inconsistent with the underlying model.
(7) World interest rates		
MacDonald (1988), Bernanke and Blinder (1992), Gagnon and Unferth (1993), and Pigott (1994).	'World' real interest rates determine cost of capital and therefore activity. Alternatively, foreign real interest rates influence domestic real interest rates which in turn determine the domestic business cycle.	Business cycles determined more by short rates than long rate. Interest parity tests tend to fail but are still consistent with close international interest rate linkages.
Blundell-Wignall, Brown and Tarditi (1995)	Negative impact on consumption.	Some evidence real interest rates reduce consumption in the US, UK and Australia.
Lowe (1992)	Positive impact of yield curve on activity.	Positive impact of the yield curve on GDP, consumption and investment

Appendix D: Data Sources and Description

Australian Data

Data	*Source*
GDP (Average)	ABS Cat. No. 5206, Table 48.
Exports of goods and services	ABS Cat. No. 5206, Table 52.
Terms of trade (goods and services)	ABS Cat. No. 5302, Table 9.
Real exchange rate	RBA 22 country real export weighted exchange rate.
Export shares	ABS Cat. No. 5410, Table 5. Prior to 1992/93, ABS Cat. No. 5424 used. Historical data taken from ABS Annual Yearbooks and ABS Overseas Trade publications.
GDP(E) implicit deflator	ABS Cat. No. 5206, Table 19.
Underlying Consumer Price Index	Treasury.
Real cash rate	Official cash rate (RBA *Bulletin*, Table F1) less four-quarter-ended percentage change in the Treasury underlying CPI.
Southern Oscillation Index	Bureau of Meteorology. Measures the sea level barometric pressure differential between Darwin and Tahiti.
Total private gross fixed capital expenditure	ABS Cat. No. 5206, Table 52.
Private gross fixed capital expenditure, equipment	ABS Cat. No. 5206, Table 52.
Private gross fixed capital expenditure, non-dwelling construction	ABS Cat. No. 5206, Table 52.
Private new capital expenditure, equipment – mining	Nominal values from ABS Cat. No. 5625, Table 3; deflators from ABS special data service.
Private new capital expenditure, equipment – manufacturing	Nominal values from ABS Cat. No. 5625, Table 3; deflators from ABS special data service.
Private consumption	ABS Cat. No. 5206, Table 52.

Australian Data *(contd)*

Data	*Source*

Real household disposable income	Household disposable income (ABS Cat. No. 5206, Table 28) deflated by the private consumption deflator (ABS Cat. No. 5206, Table 19).
Real share price	Accumulation index for total share market returns, incorporating dividend yields (Datastream, TOTMKAU(RI)) deflated by the GDP(E) deflator.

Foreign Data

Data	*Source*
Real Output	
US GDP	Datastream, USGDP...D.
Japan	Datastream, JPGDP...D.
OECD GDP	Datastream, OCDGDP...D.
Export-markets GDP	An export weighted average of quarterly percentage changes in the GDP of Australia's major trading partners is used to form a GDP index.
New Zealand GDP	Datastream, NZGDP...D.
South Korea GDP	Datastream, KOGDP...C, seasonally adjusted using EZ X-11.
UK GDP	Datastream, UKOCGDPDD.
Singapore GDP	Datastream, SP10073.D.
Taiwan GDP	Datastream, TWGDP...C, seasonally adjusted using EZ X-11.
Hong Kong GDP	Datastream, HKGDP...C, seasonally adjusted using EZ X-11.
European community GDP	Datastream, EECGDP..D.
Newly industrialised economies GDP	The sum of the GDP of Hong Kong, Singapore, South Korea and Taiwan, in 1985 exchange rates and US dollars.

Foreign Data *(contd)*

Data	*Source*
Nominal Share Prices	
US share price	Datastream, TOTMKUS(RI).
Japan share price	Datastream, TOTMKJP(RI).
World share price	Datastream, TOTMKWD(RI).
Export-markets share price	An export weighted average of accumulation indices for Australia's major trading partners. Accumulation indices obtained from Datastream.
Europe share price	Datastream, TOTMKER(RI).
Real Share Prices	Accumulation index for total share market returns, incorporating dividend yields, deflated by the GDP deflator. The G7 GDP deflator is used to deflate world share prices.
Deflators Used for Share Prices	
US GNP deflator	Datastream, USIPDGNPE.
Japan GDP deflator	Datastream, JPIPDGDPE.
G7 GDP deflator	GDP weighted implicit deflator for the G7 based on 1992 prices and exchange rates. GDP deflators obtained from Datastream.
Investment	
US gross private domestic investment	Datastream, USGDPRIND.
US nonresidential private fixed investment – producers' durable equipment	Datastream, USINVPDED.
Consumption	
US personal consumption expenditures	Datastream, USCONEXPD.
Household Disposable Income	
US personal disposable income	Datastream, USPDISPID.

Appendix E: Integration Tests of the Data

The following tables examine the time series properties of the real GDP and real share price data. Table E1 presents augmented Dickey Fuller (Said and Dickey 1984) (ADF) tests where the null hypothesis of a unit root is tested against the alternative of stationarity. Table E2 presents Kwiatkowski *et al*. (1992) (KPSS) tests where the null hypothesis of stationarity is tested against the alternative of a unit root.

Domestically consumed GDP, US GDP, OECD GDP, export-markets GDP and the world real share price all appear to be integrated of order 1. For all these variables, the null hypothesis of non-stationarity cannot be rejected using the ADF tests. In addition, the null of stationarity is rejected at the 10 per cent level for all these variables using the KPSS tests, with the possible exception of domestically consumed GDP.[31] The first differences of these series are found to be stationary under both tests.

Exports and the Australian real share price appear to be trend stationary. Using the ADF tests, the null of non-stationarity is rejected at the 10 per cent level in favour of the alternative of trend-stationarity. In addition, the KPSS tests cannot reject the null of trend-stationarity.

The time series characteristics of the US real share price are ambiguous. The ADF test rejects the null of non-stationarity in favour of trend-stationarity at the 10 per cent level. However, the KPSS test rejects the null of stationarity at the 10 per cent level. The series is characterised as trend-stationary in the paper. This interpretation is supported by graphical analysis.

[31] Using the KPSS test, the null of stationarity for domestically consumed GDP is accepted at the 10 per cent level when the lag length is 8 or greater. However, as Kwiatkowski *et al.* (1992) note, the power of the test is reduced as the lag length is increased.

Table E1: Augmented Dickey-Fuller Tests[(a)]

Variable	Lags [(b)]	Φ_1	Φ_3	$\hat{t}$	$\hat{t}_m$	$\hat{t}_t$
exports	4	6.33*	11.03**	3.28	0.99	-4.05*
domestically consumed GDP	3	2.69	4.39	2.02	-0.91	-2.81
D domestically consumed GDP	5	8.42**	8.41*	-2.80**	-3.85**	-3.79*
US GDP	3	3.41	3.30	2.51	-0.27	-2.44
D US GDP	4	10.13**	10.25**	-2.17*	-4.24**	-4.15*
OECD GDP	5	4.79#	1.60	2.71	-0.99	-1.45
D OECD GDP	4	5.09*	5.53	-1.22	-3.03*	-3.10
export-markets GDP	2	9.36**	1.65	4.17	-0.16	-1.74
D export-markets GDP	1	10.76**	10.75**	-1.46	-4.52**	-4.47**
Australian real share price	3	1.24	7.16*	-1.44	-1.00	-3.59*
US real share price	1	3.67	6.42*	-1.43	-0.44	-3.46#
world real share price	3	2.15	2.14	-1.84	-0.90	-1.95
D world real share price	1	11.55**	11.60**	-4.11**	-4.69**	-4.66**

Notes: (a) The likelihood ratio tests are:

$\Phi_1 : (a, r) = (0,1)$ in $Y_t = a + rY_{t-1} + e_t$

$\Phi_3 : (a, b, r) = (a, 0, 1)$ in $Y_t = a + bt + rY_{t-1} + e_t$

The 't-tests' are r=1 for

$\hat{t}$: in $Y_t = rY_{t-1} + e_t$

$\hat{t}_m$: in $Y_t = a + rY_{t-1} + e_t$

$\hat{t}_t$: in $Y_t = a + bt + rY_{t-1} + e_t$

**, *, and # denote significance at the 1%, 5%, and 10% levels respectively. The critical values for the likelihood ratio tests and the 't-tests' are from Dickey and Fuller (1981) and Fuller (1976) respectively. The shaded box indicates the form of the model used in testing for non-stationarity. In most cases, the sample is 1980:Q1-1995:Q3. The sample is truncated when more than 3 lags of the dependent variable are included in the test. All variables are in logs. *Æ* indicates the change in the variable.

(b) 'Lags' indicates the number of lags of the dependent variable included in the test to remove autocorrelation in the residuals.

Table E2: Kwiatkowski, Phillips, Schmidt and Shin Tests[(a)]

	Constant		Constant and trend	
Variable Lag length[(b)]:	4	8	4	8
exports	1.337**	0.795**	0.100	0.091
domestically consumed GDP	1.300**	0.787**	0.164*	0.117
Æ domestically consumed GDP	0.070	0.074	0.058	0.061
US GDP	1.324**	0.788**	0.201*	0.137#
Æ US GDP	0.095	0.096	0.099	0.100
OECD GDP	1.350**	0.798**	0.196*	0.130#
Æ OECD GDP	0.168	0.159	0.090	0.087
export-markets GDP	1.361**	0.808**	0.194*	0.127#
Æ export-markets GDP	0.173	0.142	0.174	0.143
Australian real share price	1.189**	0.719*	0.085	0.074
US real share price	1.338**	0.795**	0.136#	0.122#
Æ US real share price	0.040	0.084	0.041	0.086
world real share price	1.242**	0.735*	0.201*	0.132#
Æ world real share price	0.108	0.113	0.093	0.098

Notes: (a) The null hypothesis of stationarity is considered by testing $s_m^2 = 0$ in $Y_t = xt + r_t + e_t$, where $r_t = r_{t-1} + m_t$ and $m_t \sim (0, s_m^2)$. With the inclusion of a constant, the critical values at the 1%, 5%, and 10% levels of significance, are 0.739, 0.463, and 0.347 respectively. With the inclusion of a constant and trend, the critical values at the 1%, 5% and 10 % levels of significance, are 0.216, 0.146, and 0.119 respectively. **, *, and # denote significance at the 1%, 5%, and 10% levels respectively. In most cases, the sample is 1980:Q1-1995:Q3. The sample is truncated when more than 3 lags of the dependent variable are included in the test. All variables are in logs.

(b) The lag length refers to the value of *l* chosen when calculating the estimate of the error variance, $s^2(l) = T^{-1}\sum_{t=1}^{T} e_t^2 + 2T^{-1}\sum_{s=1}^{l} w(s,l)\sum_{t=s+1}^{T} e_t e_{t-s}$, used in the testing procedure.

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