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Macroeconomic Volatility and Terms of Trade Shocks

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Abstract

This paper explores the effect of terms of trade volatility on macroeconomic volatility using a panel of 71 countries from 1971–2005. It finds that terms of trade volatility has a statistically significant and positive impact on the volatility of output growth and inflation, although the magnitudes of these effects depend on the policy framework and the structure of markets. Specifically, adopting a more flexible exchange rate tends to ameliorate the effect of terms of trade shocks on macroeconomic volatility. The paper also finds some evidence that a monetary policy regime that focuses on low inflation helps to moderate the volatility of output and inflation in the face of a volatile terms of trade. The same is true of financial market development in the case of output volatility. Using data on the expenditure components of GDP, the channels through which terms of trade shocks affect output are examined. The results suggest that terms of trade volatility has its largest effect on the volatility of consumption, exports and imports. There is evidence to suggest that greater financial market development helps to mitigate the effect of terms of trade volatility on consumption volatility, while monetary policy that focuses on low inflation is associated with lower volatility of imports.

JEL Classification Numbers: E20, F41
Keywords: terms of trade shocks, growth, inflation, structural reform

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Dan Andrews and Daniel Rees

1. Introduction

The Australian economy has historically been subject to large swings in its terms of trade (Table 1), with these swings having a significant effect on both output and inflation. Over time, however, the impact of these swings on the economy appears to have lessened somewhat (see Figure 1 and the discussion in Gruen 2006), apparently reflecting changes to the overall policy framework and the structure of markets. By drawing on cross-country data, this paper formally examines the idea that the nature of the policy framework and the flexibility of markets have a significant effect on how economies respond to changes in their terms of trade.

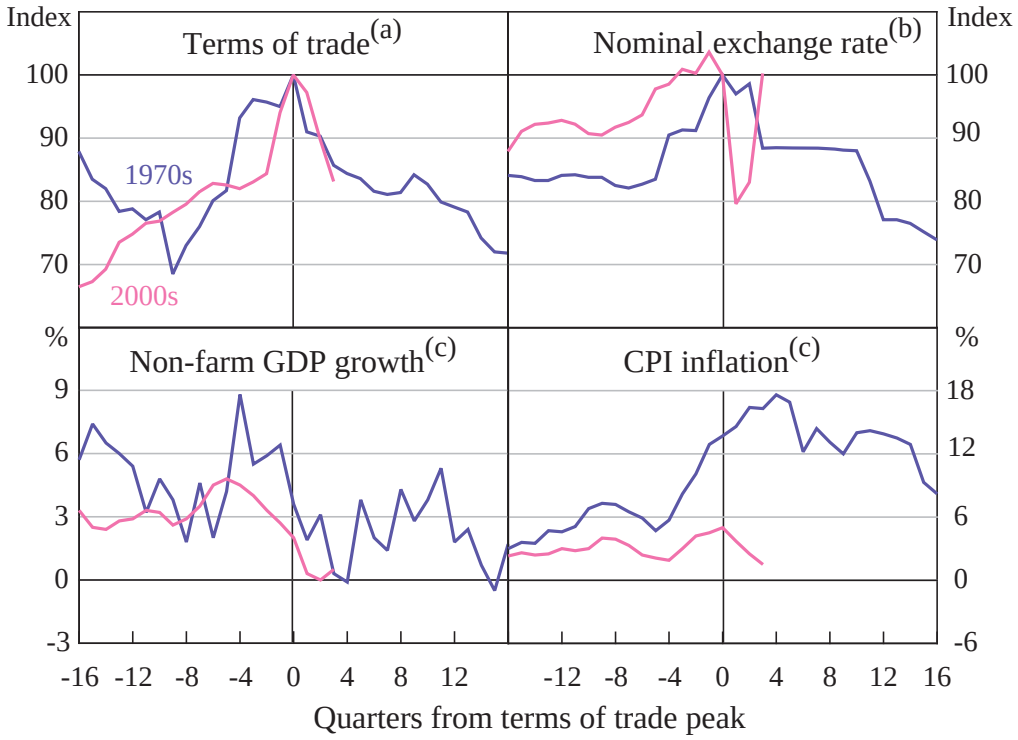
Table 1: Terms of Trade Volatility
Standard deviation of terms of trade growth

	Australia	Industrialised economies	Developing economies
1971–1980	8.5	5.6	16.2
1981–1990	6.3	5.0	13.6
1991–2000	4.8	3.5	9.9
2001–2009	7.9	3.1	6.7[(a)]

Note: (a) Data for developing economies only for period 2001–2005
Sources: see Appendix A. Data for 2009 are forecasts, sourced from the OECD *Economic Outlook* No 85.

We adopt an atheoretic approach based on cross-country panel data models, where the volatility of output and inflation (the dependent variables) are initially regressed on the volatility of terms of trade shocks – to account for the size of the shock – and a host of control variables. We then interact the terms of trade with a number of the control variables intended to represent the policy frameworks and the structure of financial and labour markets that are likely to be relevant for the propagation of terms of trade shocks.

Figure 1: Australia – Terms of Trade Booms and the Macroeconomy



Notes: (a) Peak = 100

(b) Nominal exchange rate is the trade-weighted index, peak in terms of trade = 100

(c) Year-ended

Sources: ABS; RBA

In our sample of 71 countries for the period 1971 to 2005, we find that shocks to the terms of trade are an important source of output and inflation volatility.[1] While monetary policy regimes that focus on low inflation reduce macroeconomic volatility in general (particularly with respect to output),[2] floating exchange rates appear to provide the key macroeconomic stabilisation tool for economies that are subject to sizeable terms of trade shocks. Our results provide some evidence to suggest that in the presence of terms of trade volatility other structural features of

1 Our sample concludes in 2005 due to data constraints. Accordingly, our analysis does not cover the most recent period of heightened volatility associated with the sharp rise in commodity prices up to 2008 and the Global Financial Crisis.

2 See Section 3 for a detailed discussion on how monetary policy is measured. While we find that monetary policy frameworks that focus on low inflation reduce output volatility in general, the effect on inflation volatility is more sensitive to the econometric specification chosen. However, the role that monetary policy plays in reducing inflation volatility could occur through other channels – for example, by keeping the average rate of inflation low and thereby providing an anchor for inflation expectations (see Section 4).

an economy affect output volatility; there is weaker evidence for an effect of these structural features on inflation volatility. To obtain a better understanding of the effect on output, we adopt a disaggregated approach, estimating how terms of trade shocks and structural features affect the volatility of the various expenditure components of GDP. These results suggest that terms of trade volatility has its largest effect on the volatility of consumption, exports and imports. We also find that greater financial market development reduces the impact of terms of trade shocks on macroeconomic volatility, but that this effect occurs primarily through household consumption.

The rest of the paper is structured as follows. A brief review of the literature, and a discussion of how this paper extends existing research, is provided in Section 2. The data and methodological issues are discussed in Section 3. Estimates of the effect of the volatility of terms of trade shocks on output and inflation volatility, and the extent to which institutional arrangements condition these relationships are presented in Section 4. The analysis is extended in Section 5 to consider the effect of terms of trade volatility on the expenditure components of output growth. The sensitivity of the results to alternative econometric specifications is considered in Section 6, while conclusions are drawn in Section 7.

2. Literature

Terms of trade shocks have been found to be an important source of macroeconomic volatility. Using a small open economy real business cycle model, Mendoza (1995) estimates that roughly one-half of the variation in aggregate output in a sample of the G7 and 23 developing economies can be attributed to terms of trade shocks. Kose (2002) applies a similar framework and finds that terms of trade shocks can explain almost all of the variance in output in small open developing economies. Changes in the terms of trade affect output to the extent that they alter the volume of imports that can be purchased for a given volume of exports and hence the economy's real domestic income.[3] The resulting fluctuations in domestic spending may well be reflected in inflation, both directly through the

3 From the perspective of a firm in the export sector, a rise in export prices relative to import prices raises real producer returns (relative to consumer prices) for a given level of inputs, which could stimulate business investment and output (Grimes 2006).

shock's impact on domestic prices and wages, and indirectly through its effect on output.

While terms of trade shocks have the potential to affect macroeconomic stability, the transmission of such shocks to the broader economy varies across countries. For instance, terms of trade shocks are likely to have a greater effect on macroeconomic volatility in countries more open to international trade, as terms of trade shocks will have their most direct effects on the tradable sector of an economy (Beck, Lundberg and Majnoni 2006). The effect of shocks can also vary across countries due to differences in national economic institutions (Blanchard and Wolfers 2000), including the nature of an economy's exchange rate and monetary policy regime, the level of financial sector development and labour market flexibility.

Economies with more flexible exchange rates are likely to be better able to accommodate terms of trade shocks than those with fixed exchange rates. Broda (2004) and Edwards and Levy Yeyati (2005), for example, using cross-country panel data find that the cumulative reduction in real GDP following a decline in the terms of trade is much larger in economies with fixed exchange rates than economies with floating exchange rates. This is consistent with the idea that, given an adverse terms of trade shock, a country with a flexible exchange rate will adjust through a currency depreciation, which tends to offset the shock's negative effects on output via a boost in external competitiveness. Moreover, if nominal wages are sticky, the depreciation of the exchange rate can reduce real wages at a time when labour demand is likely to be weak (Meade 1951). By contrast, the equilibrium real exchange rate under a fixed exchange rate regime has to adjust through changes in domestic nominal prices and wages. In the presence of nominal rigidities, this process can imply particularly large output costs. Flexible exchange rates also have the potential to ameliorate the impact of terms of trade shocks on inflation. For the case of Australia, Gruen and Dwyer (1995) concluded that a sufficiently large appreciation of the real exchange rate can offset the inflationary impact of a positive terms of trade shock.

Our paper builds on the existing literature in a number of ways. Specifically, we focus on the impact of *unanticipated* volatility in the terms of trade – that is, terms of trade shocks – on macroeconomic volatility (see Section 3). In contrast,

Edwards and Levy Yeyati (2005) focus on the rate of change in the terms of trade which does not allow for the potentially different macroeconomic effects of anticipated and unanticipated movements. While Broda (2004) also identifies unanticipated changes in the terms of trade by employing a VAR framework, our paper also controls for other institutional characteristics that are likely to affect the propagation of terms of trade shocks, including the nature of a country's monetary policy regime. The latter is potentially important to the extent that while flexible exchange rate regimes enable countries to pursue an independent monetary policy, discretionary monetary policy can also serve as a source of shocks, as well as a stabilising tool (Clark and van Wincoop 2001).

While Kent, Smith and Holloway (2005) also find a role for the conduct of monetary policy in explaining the trend decline in OECD output volatility, their analysis does not distinguish between the role of the monetary policy framework in the propagation of shocks and the size of these shocks. In this paper, we allow for the possibility that the monetary policy framework affects the propagation of terms of trade shocks. For example, if a rising terms of trade warrants tighter monetary policy in order to stabilise inflation, countries with a monetary policy regime that focuses on low inflation are more likely to deliver this policy adjustment. Alternatively, if the shock is perceived to be short-lived, there is some scope for monetary policy to look through the stimulus if inflation expectations are well-anchored (Stevens 2008),[4] otherwise the shock has the potential to fuel wage and price inflation.

The nature of the financial system will also matter if more developed financial markets allow agents to better smooth their expenditure decisions and deal with fluctuations in the exchange rate and other prices in the face of terms of trade shocks. However, the overall effect of financial market development on macroeconomic volatility is ambiguous to the extent that more developed financial markets can amplify shocks, such as to banks' balance sheets, implying greater output volatility (Beck *et al* 2006). While Beck *et al* find only weak evidence that financial development dampens the effects of terms of trade volatility on output volatility, we test this hypothesis more directly by investigating the impact of terms of trade shocks on the volatility of expenditure components of GDP, including

4 The anchoring of inflation expectations might occur through a well-understood inflation target.

consumption and investment. To the best of our knowledge, this disaggregated approach to analyse how economic institutions affect the propagation of terms of trade shocks distinguishes our paper from most others in the literature.

Kent *et al* (2005) also find a role for labour and product market reform in explaining the decline in OECD output volatility over recent decades (at least up until 2003). Reforms to factor markets can reduce output volatility by encouraging productive resources to shift more readily in response to differential shocks across firms and sectors. Accordingly, an economy's adjustment to terms of trade shocks might also depend on the relative flexibility of its labour market. If real wages are inflexible, the ability of floating exchange rates to temper the effect of terms of trade shocks on macroeconomic volatility becomes limited (Meade 1951; Edwards and Levy Yeyati 2005). Real wage inflexibility can arise directly from wage indexation, or be a product of high levels of unionisation and strict employment protection legislation (Clar, Dreger and Ramos 2007).

In a paper drafted contemporaneously with this one, Rumler and Scharler (2009) find that in a panel of 20 OECD countries, the effect of fluctuations in the terms of trade on output volatility is amplified in economies where trade union density is high. However, they also find that more co-ordinated labour markets (that is, where the level of communication between labour unions representing different groups is high) can have a stabilising effect.[5] Given that the volatility in Australia's terms of trade often lies between that of a typical industrialised and typical developing economy (Table 1), it makes sense for us to extend this analysis to also include non-OECD economies.

3. Data and Methodology

We use a sample of 71 countries/economies with data for the period 1971 to 2005. As is common in the literature, we transform our data into five-year averages, with

5 It is possible that unions internalise the macroeconomic consequences of their actions in economies with a high degree of labour market co-ordination (Calmfors and Driffill 1988). If unions care about the employment of existing members as well as the real wage, they will have an incentive to moderate wage demands in response to adverse macroeconomic shocks (Cukierman and Lippi 1999).

the first period including the years 1971 to 1975 and the final period including the years 2001 to 2005. Detailed data descriptions and sources are provided in Appendix A and a list of countries is provided in Appendix B.

In order to examine the effect of terms of trade shocks, it is first necessary to define these shocks. While a common approach in the literature is to use the standard deviation of terms of trade growth to measure terms of trade volatility (Beck *et al* 2006), some terms of trade movements are likely to be predictable. If so, changes in the terms of trade will be imperfect proxies for terms of trade shocks. In particular, to the extent that firms and households act in a forward-looking manner, failing to take account of predictable terms of trade movements could bias our estimates of the effects of terms of trade volatility towards zero.

To control for anticipated terms of trade movements, we follow Kent and Cashin (2003), and estimate equations of the form:

$$\Delta TOT_{i,s} = c_i + \varphi_i \Delta TOT_{i,s-1} + \upsilon_{i,s} \tag{1}$$

where $\Delta TOT_{i,s}$ is the growth rate of the terms of trade in country i at time s and c_i is a constant term for country i.[6] It is important to emphasise that we allow the slope coefficient in Equation (1), ϕ_i, to vary across countries. This allows the persistence of terms of trade movements to differ across economies. The residual from Equation (1), $\upsilon_{i,s}$, represents the terms of trade shock to country i at time s. Our measure of the volatility of terms of trade shocks is the log of the standard deviation of $\upsilon_{i,s}$ over each five-year block (henceforth σ_{it}^{TOT}), where t identifies the date of the five-year block.

The dependent variables in our regressions are the volatilities of output growth, CPI inflation and the expenditure components of output – household consumption, gross fixed capital formation, public consumption expenditure, exports and imports. All output variables are measured in real *per capita* terms. As was the case for the terms of trade, we first extract the unexpected component of each variable by regressing its annual change on a constant and a single lag, and then

6 As is standard, our measure of the terms of trade is the ratio of a price index of an economy's exports of goods and services to a price index of its imports of goods and services.

calculate volatility as the log of the standard deviation of the residuals from this equation within each five-year block, *t*.

We estimate fixed-effects panel regressions to examine the effect of the volatility of terms of trade shocks on the volatility of output and inflation. Each regression takes the form:

$$\sigma_{it}^{Y} = \delta\sigma_{it}^{TOT} + \theta\sigma_{it}^{TOT}V_{it-1} + \gamma V_{it-1} + \psi Z_{it} + \mu_i + \tau_t + \eta_{it} \qquad (2)$$

where: σ_{it}^{Y} is the log of the standard deviation of the dependent variable of interest for country *i*, σ_{it}^{TOT} is the log of the standard deviation of the terms of trade shock, V_{it} is a vector of structural variables and Z_{it} is a vector of control variables. To capture the likely lagged effect of structural change and to ensure that the structural indicators are exogenous, we follow Kent *et al* (2005) and include the structural variables in our regressions with a lag. That is, we match the volatility of annual GDP over a given five-year block at time *t*, 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 1975 is matched with the level of financial market development in 1970). We also include country-specific fixed effects (μ_i) to control for time-invariant factors that affect σ_{it}^{Y}, including country size, as well as time-fixed effects (τ_t) to control for common shocks.

This empirical framework allows us to estimate how different structural characteristics affect the propagation of terms of trade shocks ($\theta\sigma_{it}^{TOT}V_{it-1}$), as well as to control for the magnitude of terms of trade shocks ($\delta\sigma_{it}^{TOT}$) explicitly. The estimated coefficient γV_{it-1} captures how the various structural characteristics condition the responsiveness of the economy to all other shocks, as well as the size of these shocks.

We interact the terms of trade with several variables intended to represent policy frameworks and other structural features of the economy relevant to the propagation of terms of trade shocks. Our measure of exchange rate flexibility is a dummy variable that takes a value of one if an economy has a floating or managed floating exchange rate according to the *de facto* exchange rate classification system

of Reinhart and Rogoff (2004), and zero otherwise.[7] We prefer this measure of exchange rate flexibility to alternative *de jure* classification schemes (as used in Ghosh *et al* 1997) as it is actual exchange rate flexibility, rather than the formal exchange rate regime, that is likely to influence an economy's adjustment to terms of trade shocks.[8]

To account for the role of monetary policy as a determinant of macroeconomic volatility, we construct a dummy variable intended to capture the extent to which the monetary policy framework focuses on low inflation, hereafter referred to simply as 'strict' monetary policy. Similar to Kent *et al* (2005), we assume that Germany, Japan and Switzerland had strict monetary regimes throughout the sample period. Monetary policy in the United States is deemed to have had strict monetary policy from 1981 – corresponding to the first complete five-year block of the Volcker chairmanship – while monetary policy in other European countries is assumed to have become strict when they joined the euro area. Finally, an economy's monetary policy is assumed to have become strict in the year in which it adopted a formal inflation target (IMF 2006).

It is worth noting that this variable could well underestimate the number of 'strict' monetary policy observations in our sample. In particular, it omits economies that import effective monetary policy by pegging their nominal exchange rate to the currency of an economy whose central bank is strict on inflation. We excluded this type of monetary policy regime for two reasons. First, it is difficult to differentiate between economies that adopt an inflexible nominal exchange rate regime to stabilise inflation from those that do so for other reasons, including strategic trade policy. Second, the benefits of a pegged exchange rate for macroeconomic stability are better captured by our exchange rate dummy variable. Excluding countries which adopt a pegged exchange rate in order to help stabilise inflation (and output) will tend to bias the estimated coefficients on our strict monetary policy variable, and its interaction terms, towards zero.

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7 The Reinhart and Rogoff classification system orders exchange rate regimes into four categories from the most rigid to the most flexible: fixed, pegged, managed float and float.

8 We also considered the alternative Levy Yeyati and Sturzenegger (2002) *de facto* classification system. However, we preferred the Reinhart and Rogoff classification because it is available for a much larger number of countries, and over a longer sample.

We measure financial development in terms of the level of domestic credit provided to the private sector (as a share of GDP). This is a widely used measure of financial development (Levine, Loayza and Beck 2000; Beck *et al* 2006), which indicates the extent to which a country's financial system channels funds from savers to private sector investors. We interpret higher levels of private credit as an indication of a more developed financial system.

We consider two measures of labour market flexibility. The first is constructed using the index of labour market regulations component of the *Economic Freedom of the World* report, published by the Fraser Institute (Gwartney and Lawson 2008).[9] This index takes a value between one and ten, with a higher number indicating a less regulated labour market. The index value depends on a number of factors, including: the value of a country's mandated minimum wage relative to average value added per worker; regulations concerning the hiring and firing of workers; and the degree of wage decentralisation. For estimation purposes, we use this index to construct three dummy variables: low labour market flexibility, medium labour market flexibility and high labour market flexibility, which correspond to the bottom, middle and top thirds of the distribution respectively. We adopt this approach for both ease of interpretation and to allow for the possible hump-shaped relationship between labour market flexibility and macroeconomic outcomes (Calmfors and Driffill 1988).

While this measure of labour market flexibility is available for a large number of countries and the relative values of the index between countries and over time appear to correspond broadly with known periods of labour market deregulation, it has limitations. For instance, it is only able to capture a limited set of factors that determine how the labour market operates and tends to rely heavily on subjective interpretations of the legal framework. With this in mind, we also follow Andrews and Kohler (2005) and include union density to proxy the degree of labour market flexibility, although this reduces the number of countries in our sample by roughly one-fifth to 56 countries.

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9 Kent *et al* (2005) also used the number of days lost in labour disputes as a proxy for the extent of labour market regulation. While this measure can capture labour market outcomes more directly, and captures a broader range of factors that determine how the labour market operates than the data on the labour market regulations we use, it is not widely available for the larger number of countries in our sample.

For this empirical framework to reliably identify the macroeconomic effects of terms of trade shocks, we need to assume that terms of trade shocks are exogenous with respect to output volatility. This is potentially problematic for large economies or countries that have a sizeable market share in a particular good (Broda 2004; Edwards and Levy Yeyati 2005).[10] Given the lack of suitable instruments for the terms of trade, the standard approach in the literature has been to exclude those economies from the analysis where the exogeneity assumption is likely to be problematic. Using a sample of countries similar to ours, Edwards and Levy Yeyati (2005) found their results to be robust to such an approach, leading them to conclude that their results are unlikely to be driven by terms of trade endogeneity. In Section 5 we show that our results are also broadly robust to the exclusion of specific groups of economies where the exogeneity assumption is likely to be more of a concern.

We also include a number of control variables in our regressions. Consistent with the related literature, all regressions contain a measure of openness to international trade (proxied by the ratio of exports plus imports to GDP). The inflation volatility regressions also include the log of the average annual rate of inflation in the five years prior to the start of each window as well as a dummy variable that takes a value of one if an economy experiences a currency crisis during a five-year window.[11] All regressions include time-fixed effects to control for the general decline in macroeconomic volatility through our sample. Throughout the paper, we calculate robust standard errors that allow for heteroskedasticity of unknown form.

Table 2 shows the key summary statistics for our variables. As to be expected, the shocks to household consumption are considerably less volatile than the shocks to other expenditure components. While the estimated shocks contained in Table 2 also imply that consumption is more volatile than output, this result is driven by

10 Even for small economies, such as Australia, long-run terms of trade movements could be endogenous to the extent that the composition of imports and exports changes over time (Gillitzer and Kearns 2005). However, over any given five-year window, exogeneity is still likely to be a reasonable assumption.

11 The currency crisis dummy takes a value of one if a country experienced a free-falling exchange rate regime, as defined by Reinhart and Rogoff (2004), at any time during a five-year window. These episodes tend to be associated with the abandonment of fixed exchange rate regimes.

the numerous commodity producers in our sample.[12] Table C1 shows correlations across these different variables, while further information on the construction of our variables is presented in Appendix A.

Table 2: Descriptive Statistics

	Mean	Standard deviation	Min	Max
Dependent variables[(a)]				
SD real GDP shocks	2.68	2.01	0.36	12.19
SD consumption shocks	3.70	3.40	0.20	22.72
SD investment shocks	9.46	7.28	1.23	46.97
SD government consumption shocks	4.59	4.67	0.21	32.64
SD export shocks	7.50	5.33	0.68	45.52
SD import shocks	9.56	6.07	1.03	35.91
SD inflation shocks	31.42	300	0.19	5 087
Independent variables				
SD terms of trade shocks[(a)]	8.25	7.45	0.55	42.48
Private credit (share of GDP)[(b)]	49	38	2	222
Floating exchange rate dummy[(c)]	0.30	0.46	0.00	1.00
Strict monetary policy dummy[(d)]	0.13	0.33	0.00	1.00
Openness (total trade as a share of GDP) [(e)]	63	36	8	291

Notes: All descriptive statistics are based on a sample of 71 countries and 411 observations.
(a) Standard deviation (SD) of the annual shocks (that is, the residual from Equation (1), estimated over a five-year window. Note that the regression analysis later in the paper is based on the natural log of the standard deviation of these shocks over the same five-year window.
(b) Total private credit as a per cent of nominal GDP; annual average observed at five-year intervals.
(c) Dummy variable that takes a value of one if an economy has a floating or managed floating exchange rate according to the *de facto* exchange rate classification system of Reinhart and Rogoff (2004), and zero otherwise.
(d) Dummy variable that takes a value of one if an economy's monetary authorities are deemed to have been strict on inflation, and zero otherwise. See Section 3 for more detail.
(e) The value of total trade as a per cent to nominal GDP; annual average observed at five-year intervals.

12 In the G7 economies, for example, the volatility of the shocks to consumption are lower than the volatility of the shocks to output.

4. The Impact of Terms of Trade Volatility on Macroeconomic Volatility

To understand the effect of terms of trade volatility on macroeconomic volatility, we first estimate Equation (2) without the interactive terms. The results in Table 3 suggest that terms of trade volatility has a statistically significant positive effect on the volatility of output growth and inflation. The point estimates imply that if the volatility of annual terms of trade growth was greater by one standard deviation, the volatility of shocks to annual GDP growth would be 1.1 percentage points greater and the volatility of annual inflation shocks would be 1.2 percentage points greater.[13]

The estimated effects of the control variables on output volatility generally accord with our prior expectations. In particular, adopting a strict monetary policy regime reduces the volatility of shocks to annual output growth in the next five years by around 0.24 percentage points. This finding is consistent with Kent *et al* (2005), and demonstrates the stabilising role that credible monetary policy plays in general.

As in Easterly, Islam and Stiglitz (2000), the point estimates in our regressions suggest that (other things equal) floating exchange rates are associated with higher output volatility, although this effect is not statistically significant. More trade openness is associated with less output volatility while more developed financial institutions are positively associated with output volatility, although neither effect is statistically significant. The insignificance of the credit term is not unexpected given that the theoretical relationship between financial market development and output volatility is ambiguous, and is contingent on the nature of the shocks (Beck *et al* 2006).

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13 A one standard deviation increase in the volatility of annual terms of trade shocks is equivalent to 0.90 log points (based on the result shown in Table 2), while the coefficient on the terms of trade term is 0.13 in the output volatility regression and 0.21 in the inflation volatility regression (Table 3). Given that these regressions are estimated in logarithmic form, a one standard deviation increase in terms of trade volatility increases output volatility and inflation volatility by $e^{0.9x0.13}$=1.1 percentage points and $e^{0.9x0.21}$=1.2 percentage points, respectively.

Table 3: Panel Regression Results

Fixed-effects estimation, five-year blocks, the first ending in 1975, the last in 2005

	Regression				
	Dependent variable				
	Output volatility		Inflation volatility		
	[3.1]	[3.2]	[3.3]	[3.4]	[3.5]
Terms of trade variables					
σ Terms of trade $_t$		0.13**		0.21**	0.19***
Control variables					
Openness $_{t-1}$	–0.05	0.00	–0.29	–0.21	–0.25
Credit $_{t-1}$	0.13	0.12	–0.07	–0.07	
Floating exchange rate $_{t-1}$	0.12*	0.13*	–0.15	–0.14	–0.16
Strict monetary policy $_{t-1}$	–0.25*	–0.27**	–0.08	–0.11	–0.30
Inflation $_{t-1}$			0.24**	0.24*	
Currency crisis $_t$			1.51***	1.47***	1.56***
Number of countries/observations	71/411	71/411	71/402	71/402	71/402
R^2 within	0.21	0.23	0.50	0.51	0.47

Notes: ***, **, and * indicate that coefficients are significant at the 1, 5 and 10 per cent levels, respectively, using robust standard errors. All regressions include country- and time-fixed effects.

In the inflation volatility equations, we find that economies with higher rates of inflation also tend to experience more inflation volatility, a standard result in the literature. The coefficient on the currency crisis dummy is also positive and significant, illustrating the disruptive effect of large exchange rate depreciations (often associated with the abandonment of a fixed exchange rate regime) on domestic prices. The other control variables have negative coefficients, but these are not statistically significant. In the case of strict monetary policy, this result is surprising in light of existing evidence that inflation targeting reduces the volatility of inflation (Calderon and Schmidt-Hebbel 2009, for example). While this result could partly reflect the relative crudeness of our measure of strict monetary policy, the problem of multi-collinearity could also be a factor, given the relatively strong correlation between strict monetary policy and the credit to GDP variable (the correlation coefficient is 0.60; see Table C1). Moreover, to the extent that strict monetary policy stabilises inflation volatility by reducing the average rate of inflation, the lagged CPI inflation term – which is highly significant in Regression [3.4] – could well be a proxy for the impact of strict monetary policy. Indeed, when we exclude the credit and lagged inflation terms (Regression [3.5]),

the size of the strict monetary policy coefficient almost triples and becomes marginally significant (with a p-value of 0.11), with only a minor reduction in explanatory power overall (the R^2 within falls from 0.51 to 0.47).[14]

Having determined that variation in terms of trade shocks matters for output and inflation volatility, we now ask how policies affect stability in the face of such terms of trade volatility. To do this, we interact our measure of terms of trade volatility with the structural indicators described in Section 3.

Table 4 shows how our various structural variables affect the relationship between terms of trade volatility and output volatility. The main result is that adopting a floating exchange rate regime helps to stabilise an economy subject to a more volatile terms of trade (Regression [4.2]). The estimates imply that given a one standard deviation increase in the volatility of terms of trade shocks, other things equal, annual output volatility will be around 0.15 percentage points lower in economies with floating exchange rates than in economies with fixed exchange rate regimes.[15] Indeed, given that the non-interacted floating exchange rate coefficient is positive and significant in this regression, it appears that offsetting terms of trade shocks are the main way in which a floating exchange rate helps to stabilise output volatility.

The coefficients on both the strict monetary policy and financial market development interaction terms are also negative, although insignificant. The strict monetary policy interaction term, however, is jointly significant and negative when considered with the non-interaction strict monetary policy term. The credit result is broadly consistent with Beck *et al* (2006), who find only weak evidence for the idea that greater financial development dampens the impact of terms of trade

14 Note that the strict monetary policy coefficient becomes significant at the 5 per cent level when we include interaction terms (see Regression [6.5]).

15 In Regression [4.2], the coefficient on σTerms of trade $_t$ is 0.17 while the coefficient on σTerms of trade $_t$*Floating exchange rate $_{t-1}$ is –0.15. Accordingly, a one standard deviation increase in terms of trade volatility raises output volatility by $e^{0.9x0.17}$=1.17 percentage points in a fixed exchange rate regime, and by $e^{(0.9*0.17)+(0.9*-0.15)}$=1.02 percentage points in a floating exchange rate regime. Therefore, given a one standard deviation increase in the volatility of the terms of trade, annual output volatility is 0.15 percentage points lower in a floating exchange rate regime, compared with a fixed regime. In conducting this thought experiment, we abstract from the non-interacted floating exchange rate coefficient in Regression [4.2] to the extent that it captures how floating exchange rate regimes condition the responsiveness of the economy to all other (non terms of trade-related) shocks.

volatility on output volatility. In all equations, the coefficient on the terms of trade volatility variable is larger than in the model with no interaction terms. The results for the regression with all of the interactive terms included together are broadly similar to the regressions with each interactive term by itself. However, a Wald test for the significance of all of the institutional terms (both interacted and non-interacted in Regression [4.4]) suggests that these variables jointly have a significant moderating influence on the effect of terms of trade volatility on output volatility. Overall, we interpret these results as providing evidence that terms of trade shocks can increase the volatility of output, but that institutional settings can help to diminish the impact of these shocks.

Table 4: Panel Regression Results – Output Volatility

Fixed-effects estimation, five-year blocks, the first ending in 1975, the last in 2005

	Regression				
	[3.2]	[4.1]	[4.2]	[4.3]	[4.4]
Terms of trade variables					
σ Terms of trade $_{t}$	0.13**	0.39*	0.17***	0.15***	0.37
σ Terms of trade $_{t}$ * Credit $_{t-1}$		–0.07			–0.05
σ Terms of trade $_{t}$ * Floating exchange rate $_{t-1}$			–0.15**		–0.14*
σ Terms of trade $_{t}$ * Strict monetary policy $_{t-1}$				–0.17	–0.06
Control variables					
Openness $_{t-1}$	0.00	0.02	–0.03	0.01	–0.01
Credit $_{t-1}$	0.12	0.26*	0.14	0.12	0.25
Floating exchange rate $_{t-1}$	0.13*	0.14**	0.41**	0.13*	0.39***
Strict monetary policy $_{t-1}$	–0.27**	–0.33***	–0.31**	–0.17	–0.31*
Wald tests (p-values)					
H0: terms of trade coefficients (jointly) = 0		0.02	0.01	0.03	0.02
H0: institutional coefficients (jointly) = 0		0.24	0.02	0.02	0.00
H0: institution interaction coefficients (jointly) = 0					0.10
Number of countries/observations	71/411	71/411	71/411	71/411	71/411
R^2 within	0.23	0.23	0.24	0.23	0.24

Notes: ***, **, and * indicate that coefficients are significant at the 1, 5 and 10 per cent levels, respectively, using robust standard errors. All regressions include country- and time-fixed effects.

Table 5 considers the impact of labour market flexibility on output volatility. Overall, the results are fairly weak. In the specification that employs the Economic

Freedom of the World Index, the interaction terms suggest that high labour market flexibility tempers the impact of terms of trade shocks on output volatility, though this effect is not statistically significant. When we use union density to proxy labour market flexibility, the interaction term is also statistically insignificant, though the effect goes the other way (that is, higher union density is associated with lower output volatility in the presence of terms of trade shocks). The only statistically significant coefficient of interest is the (non-interacted) union density term, which implies that more regulated labour markets – as proxied by higher union density – tend to raise output volatility. It is important to note, however, that this effect jointly captures the extent to which labour market flexibility affects the responsiveness of the economy to all other shocks (unrelated to the terms of trade), as well as the size of these shocks. This result is broadly consistent with Kent *et al* (2005), although they use a different measure of labour market flexibility – the number of days lost to labour disputes.

Table 5: Panel Regression Results – Output Volatility

Fixed-effects estimation, five-year blocks, the first ending in 1975, the last in 2005

	Regression	
	[5.1]	[5.2]
Terms of trade variables		
σ Terms of trade $_{t}$	0.15*	0.42
σ Terms of trade $_{t}$ * Medium labour market flexibility $_{t-1}$	–0.01	
σ Terms of trade $_{t}$ * High labour market flexibility $_{t-1}$	–0.09	
σ Terms of trade $_{t}$ * Union density $_{t-1}$		–0.11
Control variables		
Openness $_{t-1}$	–0.01	–0.34
Credit $_{t-1}$	0.00	0.31**
Floating exchange rate $_{t-1}$	0.15**	0.16*
Strict monetary policy $_{t-1}$	–0.30**	–0.34**
Medium labour market flexibility $_{t-1}$	0.02	
High labour market flexibility $_{t-1}$	0.19	
Union density $_{t-1}$		0.40*
Number of countries/observations	71/394	56/251
R^2 within	0.23	0.31

Notes: ***, **, and * indicate that coefficients are significant at the 1, 5 and 10 per cent levels, respectively, using robust standard errors. All regressions include country- and time-fixed effects.

Table 6 presents the results when we interact our structural variables with terms of trade volatility in regressions whose dependent variable is inflation volatility. Once again, we find that adopting a flexible exchange rate helps to moderate the effect of terms of trade volatility. The estimates imply that given a one standard deviation increase in the volatility of terms of trade shocks, other things equal, annual inflation volatility will be around 0.22 percentage points lower in economies with floating exchange rates than fixed exchange rate regimes (see Regression [6.2]). Coefficients on interactions between terms of trade volatility and private credit, and terms of trade volatility and strict monetary policy both produced positive – though insignificant – coefficients.[16] To further investigate the role of monetary policy regimes and to abstract from the multi-collinearity concerns raised above, Regression [6.5] excludes the credit and lagged inflation terms. While the coefficient on the interaction between terms of trade volatility and strict monetary policy remains insignificant, the strict monetary policy term by itself is negative and significant at the 5 per cent level. This suggests that monetary policy regimes that have become relatively more strict on inflation have played a role in reducing the volatility of inflation, as well as output.

Overall then, we interpret these results as suggesting that adopting a floating exchange rate regime reduces the influence of terms of trade volatility on macroeconomic volatility. While the results for the other institutional variables are less robust, and depend somewhat on the specification, the point estimates suggest a more obvious role in moderating output volatility, rather than inflation. To obtain a better understanding of how these output effects operate, we adopt a disaggregated approach, and estimate how terms of trade shocks and economic institutions affect the volatility of the various expenditure components of GDP.

16 We also estimated models containing the various measures of labour market flexibility from Table 5, though none of these variables turned out to be significant explanators of inflation volatility.

Table 6: Panel Regression Results – Inflation Volatility

Fixed-effects estimation, five-year blocks, the first ending in 1975, the last in 2005

	Regression					
	[3.4]	[6.1]	[6.2]	[6.3]	[6.4]	[6.5]
Terms of trade variables						
σ Terms of trade $_{t}$	0.21***	0.20	0.26***	0.21***	0.23	0.23***
σ Terms of trade $_{t}$ * Credit $_{t-1}$		0.01			0.01	
σ Terms of trade $_{t}$ * Floating exchange rate $_{t-1}$			–0.21**		–0.22**	–0.21*
σ Terms of trade $_{t}$ * Strict monetary policy $_{t-1}$				0.08	0.11	0.18
Control variables						
Openness $_{t-1}$	–0.21	–0.21	–0.26	–0.22	–0.27	–0.29
Credit $_{t-1}$	–0.07	–0.08	–0.04	–0.07	–0.06	
Floating exchange rate $_{t-1}$	–0.14	–0.14	0.24	–0.14	0.25	0.21
Strict monetary policy $_{t-1}$	–0.11	–0.11	–0.16	–0.17	–0.24	–0.48**
Inflation $_{t-1}$	0.24**	0.25***	0.25***	0.24**	0.25**	
Currency crisis $_{t}$	1.47***	1.47***	1.51***	1.47***	1.52***	1.61***
Wald tests (p-values)						
H0: terms of trade coefficients (jointly) = 0		0.00	0.00	0.00	0.00	0.00
H0: institutional coefficients (jointly) = 0		0.71	0.07	0.70	0.31	0.01
H0: institution interaction coefficients (jointly) = 0					0.25	0.14
Number of countries/observations	71/402	71/402	71/402	71/402	71/402	71/402
R^2 within	0.51	0.51	0.51	0.51	0.51	0.48

Notes: ***, **, and * indicate that coefficients are significant at the 1, 5 and 10 per cent levels, respectively, using robust standard errors. All regressions include country- and time-fixed effects.

5. The Transmission of Terms of Trade Shocks

5.1 Terms of Trade Shocks and Expenditure Volatility

In this section we extend our analysis to consider how structural features of the economy affect the transmission of terms of trade shocks to the different components of expenditure. We start by estimating Equation (2) with no interaction terms, using various expenditure components of output as the dependent variables. Table 7 shows the result of this exercise.

Table 7: Panel Regression Results – Output Volatility
Fixed-effects estimation, five-year blocks, the first ending in 1975, the last in 2005

	Regression					
	Dependent variable					
	Household consumption	Gross fixed capital formation	Government consumption	Gross national expenditure	Exports	Imports
	[7.1]	[7.2]	[7.3]	[7.4]	[7.5]	[7.6]
Terms of trade variables						
σ Terms of trade $_t$	0.22***	0.02	0.15*	0.16***	0.21***	0.14***
Control variables						
Openness $_{t-1}$	0.45***	0.01	0.19	–0.05	0.20*	–0.02
Credit $_{t-1}$	0.05	0.16*	–0.15	0.16**	0.01	0.05
Floating exchange rate $_{t-1}$	0.05	0.08	0.15	–0.03	0.17**	0.05
Strict monetary policy $_{t-1}$	–0.45***	–0.22*	0.22*	–0.28**	–0.19*	–0.25*
Number of countries/observations	71/411	71/411	71/411	71/411	71/411	71/411
R^2 within	0.24	0.10	0.22	0.22	0.18	0.25

Notes: ***, **, and * indicate that coefficients are significant at the 1, 5 and 10 per cent levels, respectively, using robust standard errors. All regressions include country- and time-fixed effects.

Focusing first on the domestic components, we find that an increase in the volatility of terms of trade shocks has a statistically significant positive effect on the volatility of (private and public) consumption, as well as the volatility of overall gross national expenditure (GNE).

While terms of trade movements are commonly thought to have a noticeable effect on investment, we find a small positive but statistically insignificant effect. One possible explanation for this finding is that the impact of terms of trade shocks on investment will depend upon the expected persistence of those shocks (Kent and Cashin 2003). Longer-lasting shocks, which affect expected returns to domestic production, are more likely to alter investment intentions; a purely temporary shock will affect current domestic income, but not future returns to domestic production. Since our sample contains a mixture of permanent and temporary shocks, it is quite plausible that, in aggregate, the volatility of these shocks will have little impact on investment volatility. The small impact of terms of trade volatility on investment volatility could also reflect the fact that our measure of gross fixed capital investment also includes dwelling and government investment, which are possibly less sensitive to terms of trade shocks.

Table 7 also suggests that terms of trade volatility has a positive and significant impact on the volatility of imports and exports. This is as expected since volatility in the relative prices of exports and imports is likely to reflect changes in global demand and supply, and influence domestic production. Among the control variables, the results also suggest that strict monetary policy reduces the volatility of most categories of domestic spending and exports. In particular, the negative relationship between strict monetary policy and consumption volatility could imply that better-anchored inflation expectations promote inter-temporal consumption smoothing or that strict monetary policy stabilises consumption to the extent that it results in less volatile nominal incomes. This term could also be picking up the impact of lower nominal interest rates, which are likely to have eased borrowing constraints on households (Kent, Ossolinski and Willard 2007) – at least in the second half of the sample (which concludes in 2005, before the onset of the Global Financial Crisis).

5.2 Stabilising Expenditure Volatility

Table 8 shows the results when we interact our institutional variables with terms of trade volatility in regressions including the various expenditure components of GDP. As in the output volatility regressions above, we find that the coefficient on the terms of trade term (by itself) remains positive (and significant) in most of these regressions.

Table 8: Panel Regression Results – Volatility of Output Components

Fixed-effects estimation, five-year blocks, the first ending in 1975, the last in 2005

(continued next page)

Dependent variable: Consumption				
σ Terms of trade $_t$	0.61***	0.24***	0.23***	0.60***
σ Terms of trade $_t$ * Credit $_{t-1}$	–0.11**			–0.10*
σ Terms of trade $_t$ * Floating exchange rate $_{t-1}$		–0.09		–0.07
σ Terms of trade $_t$ * Strict monetary policy $_{t-1}$			–0.14	0.02
Wald tests (p-values)				
H0: terms of trade coefficients (jointly) = 0	0.00	0.00	0.00	0.00
H0: institutional coefficients (jointly) = 0	0.07	0.41	0.00	0.00
Dependent variable: Gross fixed capital formation				
σ Terms of trade $_t$	0.13	0.05	0.04	0.07
σ Terms of trade $_t$ * Credit $_{t-1}$	–0.03			–0.00
σ Terms of trade $_t$ * Floating exchange rate $_{t-1}$		–0.13		–0.12
σ Terms of trade $_t$ * Strict monetary policy $_{t-1}$			–0.17	–0.15
Wald tests (p-values)				
H0: terms of trade coefficients (jointly) = 0	0.80	0.28	0.28	0.17
H0: institutional coefficients (jointly) = 0	0.11	0.15	0.08	0.05
Dependent variable: Government consumption expenditure				
σ Terms of trade $_t$	0.32	0.17**	0.17**	0.27
σ Terms of trade $_t$ * Credit $_{t-1}$	–0.05			–0.02
σ Terms of trade $_t$ * Floating exchange rate $_{t-1}$		–0.09		–0.08
σ Terms of trade $_t$ * Strict monetary policy $_{t-1}$			–0.18*	–0.15
Wald tests (p-values)				
H0: terms of trade coefficients (jointly) = 0	0.07	0.06	0.03	0.09
H0: institutional coefficients (jointly) = 0	0.65	0.12	0.11	0.18
Dependent variable: Gross national expenditure				
σ Terms of trade $_t$	0.41**	0.17***	0.18**	0.37**
σ Terms of trade $_t$ * Credit $_{t-1}$	–0.07			–0.05
σ Terms of trade $_t$ * Floating exchange rate $_{t-1}$		–0.05		–0.03
σ Terms of trade $_t$ * Strict monetary policy $_{t-1}$			–0.17	–0.11
Wald tests (p-values)				
H0: terms of trade coefficients (jointly) = 0	0.00	0.00	0.00	0.00
H0: institutional coefficients (jointly) = 0	0.05	0.77	0.02	0.02

Table 8: Panel Regression Results – Volatility of Output Components
Fixed-effects estimation, five-year blocks, the first ending in 1975, the last in 2005
(continued)

Dependent variable: Exports				
σ Terms of trade $_t$	0.28	0.20***	0.22***	0.26
σ Terms of trade $_t$ * Credit $_{t-1}$	–0.02			–0.01
σ Terms of trade $_t$ * Floating exchange rate $_{t-1}$		0.03		0.04
σ Terms of trade $_t$ * Strict monetary policy $_{t-1}$			–0.07	–0.07
Wald tests (p-values)				
H0: terms of trade coefficients (jointly) = 0	0.00	0.00	0.00	0.01
H0: institutional coefficients (jointly) = 0	0.91	0.09	0.08	0.26
Dependent variable: Imports				
σ Terms of trade $_t$	0.11	0.16***	0.16***	0.02
σ Terms of trade $_t$ * Credit $_{t-1}$	0.01			0.05
σ Terms of trade $_t$ * Floating exchange rate $_{t-1}$		–0.09		–0.08
σ Terms of trade $_t$ * Strict monetary policy $_{t-1}$			–0.21**	–0.24**
Wald tests (p-values)				
H0: terms of trade coefficients (jointly) = 0	0.00	0.00	0.00	0.00
H0: institutional coefficients (jointly) = 0	0.47	0.18	0.01	0.02

Notes: ***, **, and * indicate that coefficients are significant at the 1, 5 and 10 per cent levels, respectively, using robust standard errors. Control variables not shown for sake of brevity. All regressions include country- and time-fixed effects

Our results suggest that financial market development reduces the impact of terms of trade volatility on consumption volatility, and that this effect is statistically significant. The obvious interpretation of this result is that greater access to financial markets allows households to smooth their consumption in response to income volatility resulting from terms of trade shocks. When households are unable to save or borrow to smooth income fluctuations, consumption growth is more volatile. This is an interesting finding because previous studies (such as Beck *et al* 2006) have tended to downplay the extent to which financial market development stabilises output volatility in the presence of terms of trade shocks. It is also possible that the financial market development term – proxied by the ratio of credit to GDP – is also capturing the effects of access to business credit, or more generally, a broader set of economic reforms.

Among the other components of domestic spending, the coefficients on the strict monetary policy and flexible exchange rate interaction variables are usually negative, but rarely statistically significant. One exception is the strict monetary policy interaction term in the government consumption volatility regression, which is significant. Also, the strict monetary policy interaction term is almost significant at the 10 per cent level in the GNE and investment regressions, while the floating exchange rate interaction term is marginally significant in the investment volatility equation (with a p-value of 0.13). Overall, these results provide weak evidence that adopting a monetary policy regime that is strict on inflation and a flexible exchange rate regime can help to stabilise the domestic components of demand in the face of terms of trade shocks.

Turning to the external variables, our results suggest that strict monetary policy helps to reduce the volatility of imports growth in the presence of terms of trade shocks. The same is true of a floating exchange rate regime, though this result is on the margin of being significant (with a p-value of 0.14). Given that demand for imports is likely to be closely tied to domestic demand, this result provides evidence for our suggestion that these institutions help to mitigate the effect of terms of trade shocks on domestic economic conditions. None of the institutional variables has a statistically significant impact on the volatility of export growth in the presence of terms of trade shocks, although a floating exchange rate in particular is likely to stabilise income flows in response to terms of trade shocks.

6. Robustness Checks

To test the robustness of our results, we considered a number of alternative specifications of our terms of trade and control variables, none of which substantively affects our conclusions.[17] Our key findings are also robust to the exclusion of various groups of countries (to control for endogeneity bias),

17 These included: adding the average level of inflation over the previous five-year block to the output volatility regressions to control for monetary shocks, including exchange rate volatility (measured in SDR or nominal effective exchange rate terms) as an additional variable and multiplying terms of trade volatility by an economy's trade share to control for the possibility that terms of trade volatility has a larger effect on more open economies. Results of these robustness tests are available from the authors on request.

alternative sample periods, and the inclusion of additional variables to control for other types of shocks.

While assuming that terms of trade shocks are exogenous is probably reasonable for small economies, it is not strictly true for very large countries or for countries that exert substantial pricing power in the markets for certain commodities. To explore this issue, we re-estimated our model excluding two groups of countries – the G7 economies and non-commodity producers – whose terms of trade have some chance of being influenced by domestic economic developments.[18] The motivation for the latter test is that, because commodities tend to be homogeneous goods, terms of trade shocks for most of these countries are likely to be exogenous with respect to domestic economic conditions.[19]

The results of these exercises, shown in Tables C2 and C3, are similar to our baseline regressions. Indeed, the only noticeable difference is that the coefficient on terms of trade volatility is often slightly larger, suggesting that terms of trade shocks are more disruptive for smaller economies and for commodity exporters. While excluding OPEC oil producers from our sample also produced qualitatively similar results, the floating exchange rate interaction term became significant at the 13 per cent level.[20] However, to the extent that Australia's terms of trade is reasonably correlated with that of oil exporters (reflecting Australia's status as a major exporter of coal and iron ore), we are inclined to retain this OPEC variation in our central specification.

Although the inclusion of time-fixed effects controlled for the existence of common shocks, it is still interesting to examine the extent to which the large amount of macroeconomic and terms of trade volatility that many economies experienced in the 1970s affects our sample. To do this, we re-estimate our equations over the period 1980–2005, which was a time of comparative

18 The economic significance of some of the G7 economies has declined in recent years relative to some of the larger developing economies, including China, India and Brazil. However, as our sample includes the period 1971–2005, the G7 probably reflects the most economically significant economies over this sample.

19 We classified commodity producers as those countries for whom manufactured goods account for less than 50 per cent of export revenue.

20 However, this change in significance mainly reflects a larger standard error – associated with the smaller sample size – as opposed to a meaningful reduction in the point estimate.

macroeconomic stability for many economies in our sample.[21] As Table C4 shows, the interaction term on strict monetary policy becomes highly significant in the output volatility regressions, while our finding that floating exchange rate regimes cushion the impact of terms of trade shocks remains intact. The results from the post-1980 period suggest that the results based on the longer sample understate the role of strict monetary policy in helping to moderate the effects of terms of trade shocks.

Finally, despite our focus on the terms of trade shocks, there are likely to be other external factors that influence macroeconomic volatility (see Lui 2008, for example). While the time-fixed effects in our regressions will control for shocks that are common across countries (such as to productivity or technology), it is possible that our terms of trade variable is at least partly proxying for other external influences that directly affect domestic output volatility through trade and/or confidence channels. To control for this possibility, we included a measure of trading partner output volatility in our regressions. We construct this variable by aggregating the output volatility of each country's ten largest trading partners, using bilateral export weights at five-year intervals (for instance, output volatility for the period 1981–1985 is weighted by the 1980 export share; see Appendix A for more details). While we weight this variable on the basis of the top ten trading partners to ease the computational burden of this exercise, it provides a reasonably comprehensive coverage.[22]

Table C5 shows the results from the post-1980 regression controlling for trading partner output volatility (*tpvol*).[23] Most of the key results from Table C4 remain intact. While the terms of trade coefficient is positive but less consistently significant, the floating exchange rate and strict monetary policy interaction terms remain negative and are significant (by themselves) at the 5 per cent level. Interestingly, *tpvol* enters the model with a negative sign, although this term is generally insignificant. Further analysis revealed that while *tpvol* was statistically significant and positively related to output volatility in a simple regression with

21 Of course, even this period was not free of macroeconomic volatility in particular regions, most notably the 'Peso Crisis' in Latin America in the early 1990s, and the 'Asian Financial Crisis' of the late 1990s.

22 For instance, we are able to capture at least to two-thirds to three-quarters of the value of exports for most countries in our sample.

23 Comprehensive bilateral export weights are only available from 1980.

country-fixed effects, it became insignificant (and in some cases negative) once time-fixed effects were included. We also re-estimated our models with *tpvol* instead of time-fixed effects to control for global shocks, but the explanatory power of these models were somewhat lower. The results suggest that, to the extent that *tpvol* captures external influences relevant to macroeconomic volatility, these tend to be common across countries.

7. Conclusion

This paper explores the effect of terms of trade shocks on macroeconomic volatility using a panel of 71 countries from 1971–2005. We find that the volatility of terms of trade shocks has a statistically significant and positive impact on the volatility of output growth and inflation. We also explore how different policy frameworks and the structure of markets influence the transmission of terms of trade shocks. While there is evidence that monetary policy frameworks that focus on low inflation tend to reduce macroeconomic volatility in general, floating exchange rates seem to be the key to lower macroeconomic volatility for economies that are subject to sizeable terms of trade shocks.

We also examined how the volatility of terms of trade shocks affects the volatility of the main expenditure components of GDP. Our results suggest that terms of trade volatility primarily affects the volatility of the growth of household consumption, exports and imports. Perhaps surprisingly, investment volatility appears less affected by terms of trade shocks, although this could reflect the influence of the persistence of terms of trade shocks, or the inclusion of government and dwelling investment – dealing with these would be an interesting avenue for further research. Financial market development appears to dampen the effect of terms of trade shocks on the volatility of consumption growth. Monetary policy that focuses on low inflation and a flexible exchange rate regime help to stabilise imports in response to terms of trade volatility.

These results are broadly robust to alternative specifications, including the omission of large economies and non-commodity producers. When we re-estimated our models over a shorter sample from 1980 – a period of relative macroeconomic stability – we find a role for monetary policy, as well as flexible

exchange rates, in reducing the volatility of output in the presence of large terms of trade shocks.

Overall, our results suggest that even though global movements in relative prices are beyond the control of policy-makers in small economies, policy-makers can still influence how those movements affect the economy.

Appendix A: Data Descriptions and Sources

Real GDP per capita and its expenditure components in constant 2000 US dollars (World Bank, *World Development Indicators*).

Inflation: Year-ended percentage change in the consumer price index (*World Development Indicators*).

Terms of trade: Export price index divided by import price index. Where possible, these data have been sourced from the *World Development Indicators*. Where these data are unavailable, we have spliced data from the Penn World Tables (Heston, Summers and Aten 2002). Data for 2006–2008 for industrialised economies (including Australia) are sourced from the OECD. Data for 2009 are forecasts, sourced from the OECD *Economic Outlook* No 85.

Private credit: Ratio of domestic credit claims on the private sector to GDP (*World Development Indicators*).

Exchange rate flexibility: Dummy variable taking a value of one if an economy's exchange rate regime is classified as either floating or managed floating according to Reinhart and Rogoff (2004), and zero otherwise.

Strict monetary policy regime: Dummy variable indicating if an economy has a formal inflation targeting regime or if it behaved as if it had a formal inflation target. Formal inflation targeters are sourced from IMF (2006). In addition, Germany, Japan and Switzerland are assigned a value of one throughout the sample, while the United States is assigned a value of one from 1981. All economies that are part of the euro area are assumed to have a strict monetary policy.

Openness: The sum of exports and imports of goods and services divided by gross domestic product. All data are in current price local currency terms (*World Development Indicators*).

Labour market flexibility: The index of labour market regulations component of the Economic Freedom of the World Index published by the Fraser Institute. The index assigns economies a labour market flexibility index rating between one (least flexible) and ten (most flexible). The index is based on an economy's mandated minimum wage as a proportion of average value added per worker, the extent of regulations impeding the hiring and firing of workers, the extent of centralised wage bargaining, the mandated cost of hiring workers (including social security and payroll taxes), the mandated cost of worker dismissal, and the use and duration of conscription (Gwartney and Lawson 2008).

Union density: The log of the ratio of trade union members to the total workforce (Rama and Artecona 2002).

Trading partner output volatility: The log of the output volatility of each country's ten largest trading partners, aggregated using bilateral nominal export shares sourced from the IMF's *Direction of Trade Statistics*. A country's top ten trading partners is initially determined on the basis of *average* bilateral trade flows between 1980 to 2005. The export shares of each country's top ten trading partners are normalised to one in order to construct export weights, and these export weights are allowed to vary at five-year intervals.

Appendix B: List of Countries

Table B1: List of Countries

Algeria[c]	France	Malawi[c]	Syria[c]
Australia[c]	Gabon[c]	Malaysia[c]	Tanzania[c]
Austria	Germany	Mauritius	Thailand[c]
Bangladesh	Ghana[c]	Mexico[c]	Tunisia[c]
Belgium	Greece[c]	Morocco[c]	Turkey[c]
Bolivia[c]	Guatemala[c]	Netherlands[c]	Uganda[c]
Botswana[c]	Honduras[c]	New Zealand	United Kingdom
Brazil[c]	Hong Kong	Niger[c]	United States
Cameroon[c]	Hungary	Norway[c]	Uruguay[c]
Canada[c]	Iceland[c]	Pakistan[c]	Venezuela[c]
Chile[c]	India	Panama[c]	Zambia[c]
China	Indonesia[c]	Paraguay[c]	
Costa Rica[c]	Iran[c]	Peru[c]	
Côte d'Ivoire[c]	Ireland	Philippines[c]	
Denmark[c]	Italy	Portugal	
Dominican Republic[c]	Japan	Senegal[c]	
Ecuador[c]	Jordan[c]	South Africa[c]	
Egypt[c]	Kenya[c]	Spain	
El Salvador[c]	Korea, Republic of	Sweden	
Finland	Madagascar[c]	Switzerland	

Note: c = commodity producer

Appendix C: Additional Results

Table C1: Correlations –

	SD terms of trade shocks	SD real GDP shocks	SD consumption shocks	SD investment shocks
SD real GDP shocks	0.39			
SD consumption shocks	0.44	0.63		
SD investment shocks	0.36	0.62	0.57	
SD government consumption shocks	0.53	0.47	0.56	0.52
SD exports shocks	0.47	0.46	0.44	0.40
SD imports shocks	0.53	0.59	0.64	0.62
SD inflation shocks	0.50	0.49	0.45	0.48
Credit (share of GDP)	–0.43	–0.27	–0.39	–0.37
Floating exchange rate	0.01	–0.02	–0.11	–0.07
Strict monetary policy	–0.29	–0.30	–0.42	–0.35
Openness (share of GDP)	–0.33	–0.01	0.07	0.04

Notes: Correlations based on a sample of 71 countries and 411 observations. All variables specified in
Sources: see Appendix A

Five-year Block Data

SD government consumption shocks	SD exports shocks	SD imports shocks	SD inflation shocks	Credit (share of GDP)	Floating exchange rate	Strict monetary policy
0.52						
0.52	0.51					
0.50	0.42	0.50				
–0.49	–0.36	–0.38	–0.48			
–0.08	–0.05	–0.06	–0.05	0.17		
–0.34	–0.28	–0.37	–0.36	0.60	0.29	
–0.03	–0.07	–0.15	–0.28	0.25	–0.13	–0.04

logarithmic form except for the floating exchange rate and strict monetary policy dummies.

Table C2: Panel Regression Results – Output Volatility Excluding G7

Fixed-effects estimation, five-year blocks, the first ending in 1975, the last in 2005

Terms of trade variables				
σ Terms of trade $_t$	0.44**	0.17***	0.15**	0.44**
σ Terms of trade $_t$ * Credit $_{t-1}$	–0.09			–0.08
σ Terms of trade $_t$ * Floating exchange rate $_{t-1}$		–0.15*		–0.13*
σ Terms of trade $_t$ * Strict monetary policy $_{t-1}$			–0.15	–0.07
Wald tests (p-values)				
H0: terms of trade coefficients (jointly) = 0	0.02	0.01	0.05	0.02
H0: institutional coefficients (jointly) = 0	0.27	0.01	0.07	0.01
H0: institution interaction coefficients (jointly) = 0				0.05
Number of countries/observations	64/348	64/348	64/348	64/348
R^2 within	0.22	0.22	0.21	0.23

Notes: ***, **, and * indicate that coefficients are significant at the 1, 5 and 10 per cent levels, respectively, using robust standard errors. Control variables not shown for sake of brevity. All regressions include country- and time-fixed effects.

Table C3: Panel Regression Results – Output Volatility Excluding Non-commodity Exporters

Fixed-effects estimation, five-year blocks, the first ending in 1975, the last in 2005

Terms of trade variables				
σ Terms of trade $_t$	0.46*	0.18**	0.14*	0.45*
σ Terms of trade $_t$ * Credit $_{t-1}$	–0.10			–0.08
σ Terms of trade $_t$ * Floating exchange rate $_{t-1}$		–0.16*		–0.14*
σ Terms of trade $_t$ * Strict monetary policy $_{t-1}$			–0.15	–0.07
Wald tests (p-values)				
H0: terms of trade coefficients (jointly) = 0	0.06	0.04	0.15	0.07
H0: institutional coefficients (jointly) = 0	0.46	0.07	0.20	0.05
H0: institution interaction coefficients (jointly) = 0				0.19
Number of countries/observations	48/260	48/260	48/260	48/260
R^2 within	0.19	0.19	0.19	0.20

Notes: ***, **, and * indicate that coefficients are significant at the 1, 5 and 10 per cent levels, respectively, using robust standard errors. Control variables not shown for sake of brevity. All regressions include country- and time-fixed effects.

Table C4: Panel Regression Results – Output Volatility Estimation Beginning in 1981

Fixed-effects estimation, five-year blocks, the first ending in 1985, the last in 2005

Terms of trade variables					
σ Terms of trade $_{t}$	0.12*	0.38*	0.18**	0.16**	0.31
σ Terms of trade $_{t}$ * Credit $_{t-1}$		–0.07			–0.03
σ Terms of trade $_{t}$ * Floating exchange rate $_{t-1}$			–0.21**		–0.19*
σ Terms of trade $_{t}$ * Strict monetary policy $_{t-1}$				–0.25***	–0.18
Control variables					
Openness $_{t-1}$	0.05	0.07	–0.01	0.08	0.03
Credit $_{t-1}$	0.21*	0.35**	0.27**	0.21*	0.33*
Floating exchange rate $_{t-1}$	0.21**	0.23***	0.58***	0.22**	0.55***
Strict monetary policy $_{t-1}$	–0.26**	–0.31**	–0.28**	–0.08	–0.18
Wald tests (p-values)					
H0: terms of trade coefficients (jointly) = 0		0.09	0.05	0.02	0.03
H0: institutional coefficients (jointly) = 0		0.13	0.00	0.00	0.00
H0: institution interaction coefficients (jointly) = 0					0.02
Number of countries/observations	71/273	71/273	71/273	71/273	71/273
R^2 within	0.20	0.20	0.21	0.21	0.22

Notes: ***, **, and * indicate that coefficients are significant at the 1, 5 and 10 per cent levels, respectively, using robust standard errors. All regressions include country- and time-fixed effects.

Table C5: Panel Regression Results – Output Volatility Controlling for Trading Partner Volatility

Fixed-effects estimation, five-year blocks, the first ending in 1985, the last in 2005

Terms of trade variables					
σ Terms of trade $_{t}$	0.10	0.33	0.17*	0.14*	0.23
σ Terms of trade $_{t}$ * Credit $_{t-1}$		–0.06			–0.01
σ Terms of trade $_{t}$ * Floating exchange rate $_{t-1}$			–0.24**		–0.22**
σ Terms of trade $_{t}$ * Strict monetary policy $_{t-1}$				–0.23**	–0.17
Control variables					
Openness $_{t-1}$	–0.02	0.01	–0.06	0.02	–0.02
Credit $_{t-1}$	0.20	0.32	0.28**	0.21	0.30
Floating exchange rate $_{t-1}$	0.24**	0.26***	0.64***	0.25***	0.61***
Strict monetary policy $_{t-1}$	–0.30**	–0.34**	–0.34**	–0.14	–0.22
Trading partner output volatility $_{t-1}$	–0.16	–0.17*	–0.15	–0.15	–0.15
Wald tests (p-values)					
H0: terms of trade coefficients (jointly) = 0		0.27	0.07	0.08	0.10
H0: institutional coefficients (jointly) = 0		0.27	0.00	0.00	0.00
H0: institution interaction coefficients (jointly) = 0					0.05
Number of countries/observations	64/246	64/246	64/246	64/246	64/246
R^2 within	0.20	0.20	0.22	0.20	0.22

Notes: ***, **, and * indicate that coefficients are significant at the 1, 5 and 10 per cent levels, respectively, using robust standard errors. All regressions include country- and time-fixed effects.

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