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Research Discussion Paper

Exchange Rate Movements and the Australian Economy

Josef Manalo, Dilhan Perera and Daniel Rees

RDP 2014-11

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Abstract

We use a structural vector autoregression model to characterise the aggregate and industry effects of exchange rate movements on the Australian economy. We find that a temporary 10 per cent appreciation of the real exchange rate that is unrelated to the terms of trade or interest rate differentials lowers the level of real GDP over the subsequent one-to-two years by 0.3 per cent and year-ended inflation by 0.3 percentage points. The mining, manufacturing, personal services, construction and business services industries are the most exchange rate sensitive sectors of the economy. In the context of the boom in the terms of trade over the past decade, we use our model to explore how the Australian economy might have evolved under alternative scenarios. These suggest that real exchange rate movements over the past decade have had a broadly stabilising effect on the domestic economy and can largely be explained by economic fundamentals.

JEL Classification Numbers: C32, F31, F41

Keywords: structural vector autoregression, exchange rates

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Exchange Rate Movements and the Australian Economy

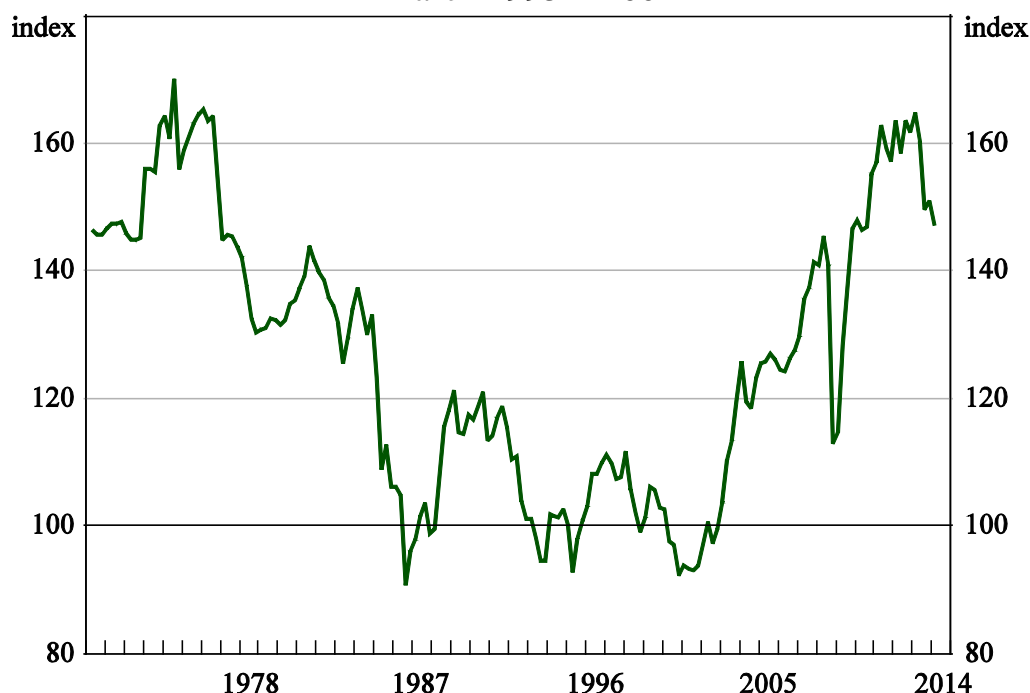
Josef Manalo, Dilhan Perera and Daniel Rees

1. Introduction

Over recent decades, the Australian economy has experienced significant swings in the value of its real exchange rate (Figure 1). Economic theory would suggest that these exchange rate movements, by altering the relative prices of domestic- and foreign-produced goods and services, should lead to changes in production, inflation and interest rates. To the extent that industries differ in their trade exposure and in their price sensitivity of demand and supply, exchange rate movements will also have compositional effects, causing some industries to expand and others to contract.

Figure 1: Real Exchange Rate

March 1995 = 100



Source: RBA

But to what extent do these effects depend on the economic factors that have driven movements in the exchange rate? Which sectors are most sensitive to exchange rate movements? And how would the real exchange rate and the broader

Australian economy have behaved if Australia's economic environment had evolved differently? In this paper we present some answers to these questions.

To do so, we estimate a structural vector autoregression model of the Australian economy. We identify exchange rate shocks as any movement in the exchange rate not explained by other economic factors, such as interest rates or the terms of trade. At an aggregate level, our model allows us to quantify the macroeconomic effects of exchange rate shocks. Our results suggest that a temporary 10 per cent appreciation of the exchange rate that is unrelated to the terms of trade or interest rate differentials reduces the level of real GDP by 0.3 per cent and year-ended inflation by around 0.3 percentage points over the subsequent eighteen months and is typically followed by a decrease in the cash rate of around 40 basis points.

At an industry level, we find that the most trade-exposed industries, including the mining and manufacturing industries, are the most responsive to exchange rate movements. But large responses are not confined to industries that export or compete with imports. Some industries, such as business services, have little direct trade exposure but produce inputs into the production processes of trade-exposed firms. We find that these industries also respond to exchange rate movements. In contrast, the responses of industries with little direct or indirect exposure to foreign trade, such as social services, are generally smaller.

Our model indicates that foreign sector variables, including the terms of trade, are the major cause of movements in the real exchange rate. In contrast, exchange rate shocks themselves are a minor contributor to the volatility of domestic economic variables. This is consistent with the idea that exchange rate movements typically serve as a shock absorber for the Australian economy, rather than acting as a source of shocks in their own right.

To investigate the role of the exchange rate further, we analyse two scenarios. In the first, we ask how the Australian economy might have evolved over the past decade if it had experienced the same macroeconomic shocks but the nominal exchange rate had not appreciated. We find that, even if the nominal exchange rate had remained constant in an environment in which the terms of trade was increasing rapidly, the real exchange rate would still have appreciated. However, this real exchange rate appreciation would have been accompanied by a large

increase in domestic inflation and higher nominal interest rates. Moreover, output growth is largely unaffected by this scenario because real activity ultimately depends upon the real, not the nominal, exchange rate. This scenario provides a practical illustration of how exchange rate flexibility helps to cushion the Australian economy from foreign shocks.

In the second scenario, we examine the contribution of international economic developments to the level of the real exchange rate and Australia's economic performance more broadly over the past decade. Our model suggests that, without a rising terms of trade and strong growth in overseas economies, the real exchange rate would not have appreciated. But a weaker real exchange rate would not have resulted in faster economic growth, as it would merely have reflected a weaker external environment. This scenario emphasises the point that what causes exchange rate movements determines their effect on the Australian economy.

This paper contributes to two strands of the existing literature. First, it is related to papers that examine the sectoral and industry implications of macroeconomic shocks on the Australian economy. Examples of this include Lawson and Rees (2008), who examine the effects of monetary policy shocks, and Cagliarini and McKibbin (2009), who describe the impacts of foreign shocks. In a similar spirit, Battersby, Kouparitsas and Munro (2013) decompose variation in sectoral employment growth into sector-specific shocks and common economy-wide shocks. Our contribution to this literature is to document the industry-level effects of exchange rate shocks, which are an important source of macroeconomic volatility for small open economies. Second, our paper complements other papers that describe the effect of exchange rate movements on open economies. Examples of this include Karagedikli *et al* (2013), who examine the sectoral impacts of exchange rate shocks in New Zealand, and Hahn (2007), who investigates how exchange rate shocks affect sectoral activity and prices in the euro area. Voss and Willard (2009) also include an exchange rate shock in a vector autoregression (VAR) model of the Australian economy, although they do not quantify the effects of this shock on output or inflation. Finally, Kohler, Manalo and Perera (2014) summarise the impact of exchange rate movements on economic activity across a range of Australian economic models, including the one in this paper.

The rest of the paper is structured as follows: Section 2 describes our empirical model and data; Section 3 outlines our core results; Section 4 uses our model to present a number of counterfactual scenarios of how the Australian economy might have evolved if the exchange rate or global economy had behaved differently; Section 5 provides robustness checks; and Section 6 concludes.

2. Model and Data

This section outlines the statistical model that we use to examine exchange rate shocks and describes the data.

2.1 The VAR Model

We use the following VAR framework throughout our analysis. Let $Y_t \equiv [F_t' \ D_t']'$ be a vector of foreign (F_t) and Australian (D_t) economic variables. We are interested in analysing the structural VAR:

$$\mathbf{A}Y_t = \tilde{\mathbf{A}}(\mathbf{L})Y_{t-1} + \varepsilon_t \quad (1)$$

Where the matrix \mathbf{A} summarises the contemporaneous relationships between the variables, $\tilde{\mathbf{A}}(\mathbf{L})$ is an autoregressive lag polynomial of order L and ε_t is a vector of independently and identically distributed structural shocks with a variance-covariance matrix Ω . Consistent with the small open economy assumption typically used in studies of the Australian economy, we restrict the parameters of \mathbf{A} and $\tilde{\mathbf{A}}(\mathbf{L})$ so that Australian economic developments do not affect foreign variables either contemporaneously or with a lag.

We identify exchange rate shocks using a recursive ordering approach. Specifically, we identify an exchange rate shock as any movement in the real exchange rate that is not explained by changes in other macroeconomic variables.¹

1 More formally, we identify exchange rate shocks by taking a Choleski decomposition of the variance-covariance matrix of the reduced form representation of Equation (1). Appendix B contains the technical details of our econometric approach and identification strategy. This is the same identification strategy used by Karagedikli *et al* (2013).

This identification rests on two assumptions. First, that macroeconomic shocks affect the real exchange rate immediately. Second, that exchange rate shocks affect other macroeconomic variables with a lag. To justify the first assumption, we note that short-term movements in the real exchange rate largely reflect changes in nominal exchange rates. The Australian dollar floats freely and its nominal value is determined in highly liquid foreign exchange markets. Hence, its value can adjust rapidly to incorporate changes in macroeconomic fundamentals. The second assumption is consistent with the idea that it takes time for firms to alter pricing and production decisions in response to changed monetary conditions, including changes in exchange rate levels. At first glance, the case for a delayed monetary policy response to exchange rate movements might seem less plausible as movements in exchange rates are readily observable. However, numerous empirical studies have found that, in practice, exchange rate movements do not appear to have a large direct influence on monetary policy decisions in Australia (Lubik and Schorfheide 2007; Kam, Lees and Liu 2009).² In Section 5 we demonstrate that our results are insensitive to the ordering of the exchange rate and interest rate variables in the VAR.

2.2 The Data

We estimate the model using seasonally adjusted data at quarterly frequencies for the period 1985:Q1 to 2013:Q2. The model includes two foreign and five domestic variables. The foreign variables are US real GDP and the Australian terms of trade.³ The Australian variables are real GDP, a measure of sectoral production (for example, manufacturing gross value added), trimmed mean inflation, the cash rate and the real TWI.⁴ We estimate a separate VAR for each sector of the

2 Exchange rate movements may still have an indirect effect on monetary policy settings through their effect on inflation and output.

3 We treat the terms of trade as a foreign variable because Australia is a price-taker in most export markets. Consequently, movements in the terms of trade largely reflect global rather than Australian prices.

4 This choice of variables is similar to that of other Australian structural VARs, including Berkelmans (2005) and Lawson and Rees (2008). It is more parsimonious than Dungey and Pagan (2009), who include additional variables such as share prices. In the disaggregated models, our measure of aggregate output is real GDP less the gross value added of the industry that we include in each model.

Australian economy, as well as an aggregate model that excludes sectoral production measures.⁵

The inclusion of output, inflation, interest rates and the real exchange rate in the domestic block is standard. For the international block, there are many additional variables that one ideally might like to include, such as foreign interest rates and inflation. Our choice of variables reflects a trade-off between including a sufficient number of variables to account for the major foreign influences on the exchange rate and a need to construct a parsimonious model given the relatively small number of observations available to us.

In the model, US output is intended to capture the impact of economic conditions in advanced economies on Australia. For the first half of our sample the US and Australian business cycles moved together closely, although the relationship has become less pronounced over the past decade (Beechey *et al* 2000).⁶ As well as the demand-side effects of foreign economic growth, US output also has a strong relationship with US monetary conditions, which may influence the value of Australia's real exchange rate through an uncovered interest rate parity relationship. We later show that our results are little changed when US output is replaced with major trading partner GDP.

We include the terms of trade to capture the impact of the prices of commodities, which account for a large proportion of Australia's exports, on the Australian economy. In addition, this variable may also account for some of the influence of economic conditions in emerging economies, especially China, which are significant commodity importers, on demand for Australian exports. Historically, there has been a close relationship between the level of Australia's terms of trade and the real exchange rate (Blundell-Wignall, Fahrer and Heath 1993; Gruen and Wilkinson 1994; Chen and Rogoff 2003; Stevens 2013). Failing to control for this

5 We include a dummy variable in all equations for the period 1993:Q1 to 2013:Q2 to account for the structural break in the monetary policy regime in Australia associated with the start of inflation targeting. We also include dummy variables for each of the four quarters starting with 2008:Q4 to control for the unusual period of financial market volatility associated with the global financial crisis.

6 See Otto, Voss and Willard (2001) for a discussion of the causes and patterns of business cycle correlations amongst advanced economies.

relationship could lead us to mistakenly attribute the impact of commodity price movements to pure exchange rate shocks.

In the model, GDP and its components enter in log deviations from a quadratic trend.⁷ Inflation enters the model in quarterly percentage changes, the cash rate enters in levels, and the terms of trade and the real exchange rate enter in log levels. The specification of GDP and inflation are consistent with standard models in which monetary policymakers adjust interest rate settings in response to the output gap and deviations of inflation from its target level. Based on lag order selection tests, we include two lags of the endogenous variables in our VAR.

In Section 5 we demonstrate that our results are robust to alternative assumptions about VAR ordering, trends, lag lengths and dummy variables.

3. Results

3.1 Aggregate Model

We first discuss aggregate responses to an unanticipated exchange rate appreciation, shown in Figure 2, before moving to the sectoral implications. In all examples, we scale the initial shock so that it causes a 10 per cent appreciation of the real exchange rate.⁸ After the initial shock, the real exchange rate evolves endogenously, although we also show the effects of a more sustained exchange rate appreciation.

The appreciation causes a persistent contraction in GDP.⁹ The point estimates suggest that the maximum effect of the appreciation occurs around eighteen months after the shock, at which time the level of GDP is 0.3 per cent below its trend level. Although the confidence intervals around this response are wide, the

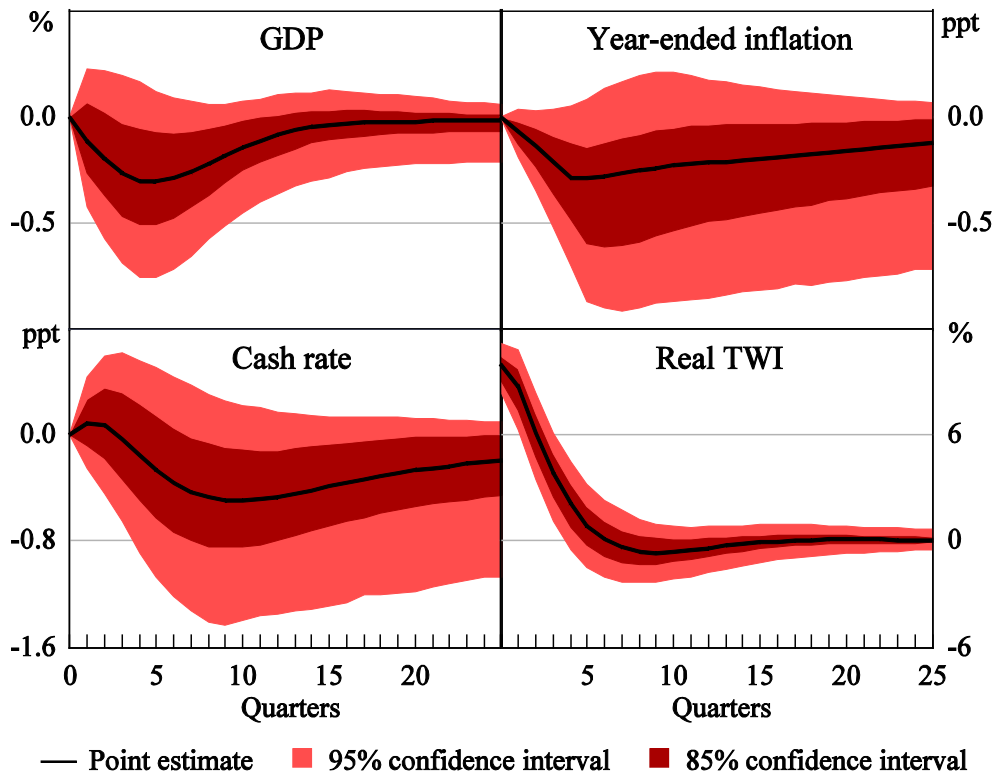
7 The quadratic trend helps to account for a decrease in the average pace of economic growth in the United States since the turn of the century. The results are almost identical if we use a linear trend for the GDP variables rather than a quadratic trend.

8 Since our model is linear, the impacts of an appreciation and a depreciation are symmetric. In reality, large exchange rate movements may have greater-than-proportional impacts due to their effects on firm entry and exit. In our aggregate model, a one standard deviation exchange rate shock causes a real exchange rate appreciation of around 3 per cent.

9 We generate confidence intervals using Killian's (1998) bias-adjusted bootstrap method.

decrease in GDP is statistically significant at a one standard deviation confidence level after three quarters. Subsequently, output returns to trend, which it reaches four years after the initial appreciation. The appreciation also triggers a fall in domestic inflation. In year-ended terms, the inflation rate is around 0.3 percentage points lower eighteen months after the initial appreciation before gradually returning to trend in subsequent quarters.¹⁰ The cash rate responds little to the shock in the first few quarters. This accords with existing empirical evidence that exchange rate movements have little direct effect on Australian monetary policy. Monetary policy responds to the decreases in output and inflation, however, and the cash rate is slightly more than 40 basis points lower than otherwise, before it returns to its initial level.

Figure 2: Impulse Response Functions – Exchange Rate Shock

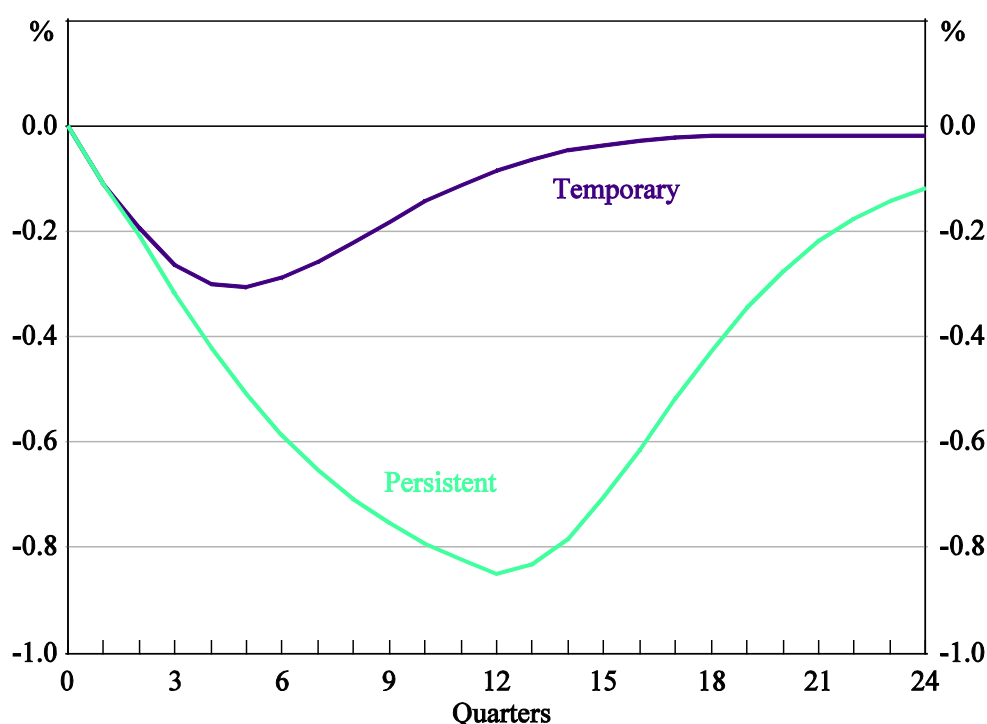


In our baseline results we allow the real exchange rate to evolve endogenously following the shock. In this case, the exchange rate appreciation is relatively short-lived, with the real exchange rate returning to its initial level within two years of the shock. To illustrate the implications of a more persistent appreciation,

¹⁰ Although we include quarterly inflation in the VAR, we present the results in year-ended terms for ease of interpretation.

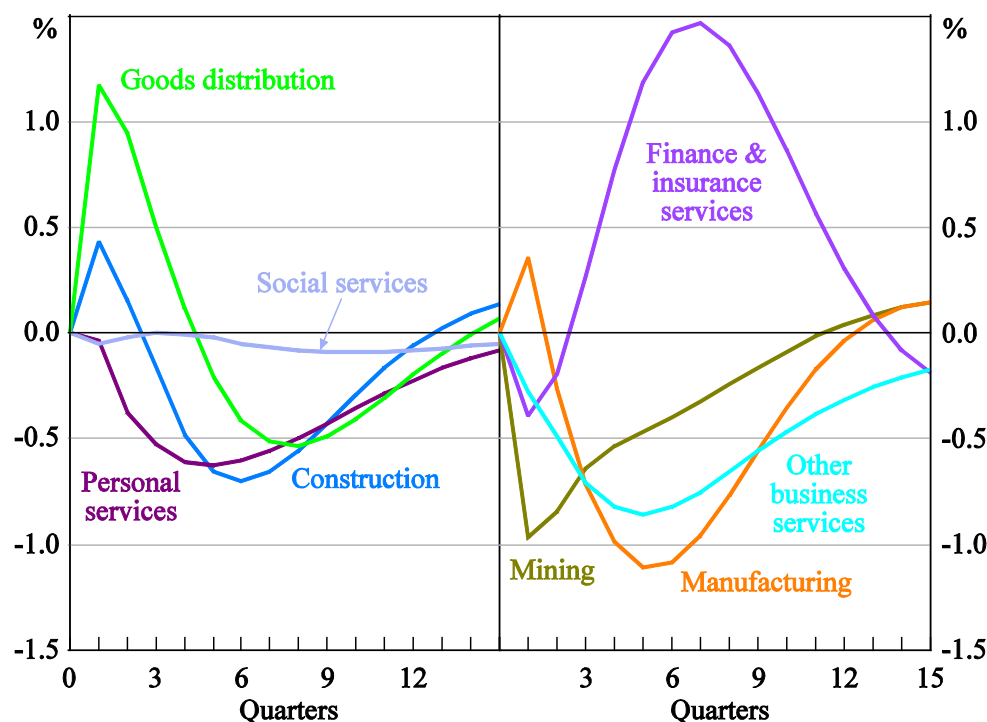
Figure 3 shows the response of GDP when we impose a sequence of exchange rate shocks so that the real exchange rate remains 10 per cent above its initial level for three years before returning endogenously to its initial level. In this case, the contraction in output is more prolonged; output troughs at around 0.8 per cent below its initial level, three years after the initial appreciation, before recovering gradually.

Figure 3: GDP Response to Temporary and Persistent Exchange Rate Shocks



3.2 Production Sectors

Figure 4 shows how the output of different industries responds to a temporary 10 per cent exchange rate appreciation. Consistent with the decrease in aggregate output following an exchange rate appreciation, most industries experience a reduction in activity. The mining and manufacturing industries experience much larger decreases in output than the economy as a whole. The response of mining occurs in the quarters immediately following the shock, while it takes three to four quarters before the manufacturing sector contracts substantially. Output in the personal services and other business services sectors also decrease substantially following the shock. In contrast, the model suggests that output in the construction and goods distribution sectors increases initially following an exchange rate appreciation, although these sectors contract later on.

Figure 4: Industry Gross Value Added

The appreciation appears to have a large positive impact on output in the finance & insurance services industry. We find it difficult to explain this last result and suspect that it may reflect measurement issues, such as the structural changes that occurred in this industry during the deregulation of Australian financial markets during the 1980s. Overall, the results illustrate how the aggregate effect of the exchange rate shock masks significant differences in responses across industries.

A number of factors might influence the magnitude of an industry's response to exchange rate shocks. Most directly, the trade exposure of the industry, either in terms of its reliance on foreign demand or the extent of import competition, is likely to matter. In industries that are more trade-exposed, an exchange rate appreciation is likely to cause a larger and more rapid decline in demand as expenditure switches towards foreign output. Working in the opposite direction is the effect of exchange rates on production costs. If an industry relies heavily on imported intermediate inputs then an exchange rate appreciation will lower costs. This may allow firms in that industry to lower their prices and increase sales. Finally, the degree of competition in the industry, which is likely to be related to average firm mark-ups, may also determine whether firms adjust margins or prices in response to exchange rate movements. In industries that adjust margins, we

would expect exchange rate movements to have a smaller absolute effect on output.

To disentangle these different channels, Table 1 lists descriptive statistics for each industry in the Australian economy.

As expected, highly trade-exposed industries like manufacturing and mining are among the most responsive to exchange rate movements. However, large responses are not limited to the parts of the economy with direct trade exposure. For example, business services industries generally cater to the domestic market, have little imported competition and yet display a large response to exchange rate movements. Many of these industries do, however, have considerable exposure to trade-exposed industries.¹¹ For example, around a quarter of the output of administrative & support services is ultimately consumed by trade-exposed industries. So, while business services firms typically have little direct trade exposure, they have considerable indirect exposure to foreign trade. This may explain their responsiveness to exchange rate movements.

Evidence of a cost channel of exchange rate transmission is limited. Many sectors with a relatively large imported input share, including the manufacturing and personal services industries, experience relatively large decreases in output following an exchange rate appreciation that reduces their cost of imported inputs. Given the trade exposure of these two industries, it is likely that the expenditure-switching effect overwhelms any benefits that these industries receive from lower costs. In contrast, lower imported input costs may explain the initially large positive response of goods distribution output.¹²

The relationship between industry mark-ups and responsiveness to exchange rate movements is difficult to discern in the data. For example, although average

¹¹ For a more detailed discussion of supply chains in Australia, see Kelly and La Cava (2014).

¹² Although the goods distribution sector's imported input share is only around 5 per cent, this figure only accounts for the value of distribution services. That is, it does not include the actual value of the goods sold by wholesalers and retailers. However, demand for distribution services is linked to the final prices of the goods sold, which in turn are linked to the cost of purchasing these goods. We estimate that the imported input share of the goods distribution sector rises to around 19 per cent when the value of the goods sold are included as both an input and an output of the sector.

mark-ups are relatively low in the manufacturing and goods distribution industries, the responses of these two sectors to exchange rate movements differs greatly. It may be that mark-ups affect these two industries differently. Low mark-ups in the manufacturing industry may prevent firms from reducing the Australian dollar prices of their output in response to an exchange rate appreciation. This may contribute to the large decreases in output that this industry experiences following an appreciation. In contrast, if there is a relatively high degree of competition in the goods distribution sector, then firms may be forced to pass on to customers a large portion of any reduction in the costs of goods sold. This may contribute to the initial increase in output that this industry experiences. However, it is not possible to quantify these effects separately using our model.

Table 1: Industry Characteristics

Per cent (*continued next page*)

	Share of output ^(a)	Average mark-up ^(b)	Export propensity ^(c)	Imported input share ^(d)	Import penetration ^(e)	Trade-related exposure ^(f)
Mining	8½	4.3	56½	4	11½	30½
Manufacturing	7	1.4	20	15	34½	29¼
Construction	8¼	1.8	¼	4	0	5¼
Goods distribution	14½	1.3	11½	4¾	3½	20
Wholesale trade	4¼	1.2	9¾	4½	0	22¼
Retail trade	5	1.2	3	2¼	0	8½
Transport, postal & warehousing	5¼	2.4	19¼	6½	8	26¼
Finance & insurance services	8¾	na	1	½	¾	9
Other business services	16	2.3	2¼	3	3	12½
Information media & telecommunications	3	3.0	3	6	7¼	9¾
Rental, hiring & real estate services	2¾	3.5	¾	¾	1¾	6¾
Professional, scientific & technical services	7¼	1.9	3½	3¾	3	16¼
Administrative & support services	3	1.6	2	4	1½	25½

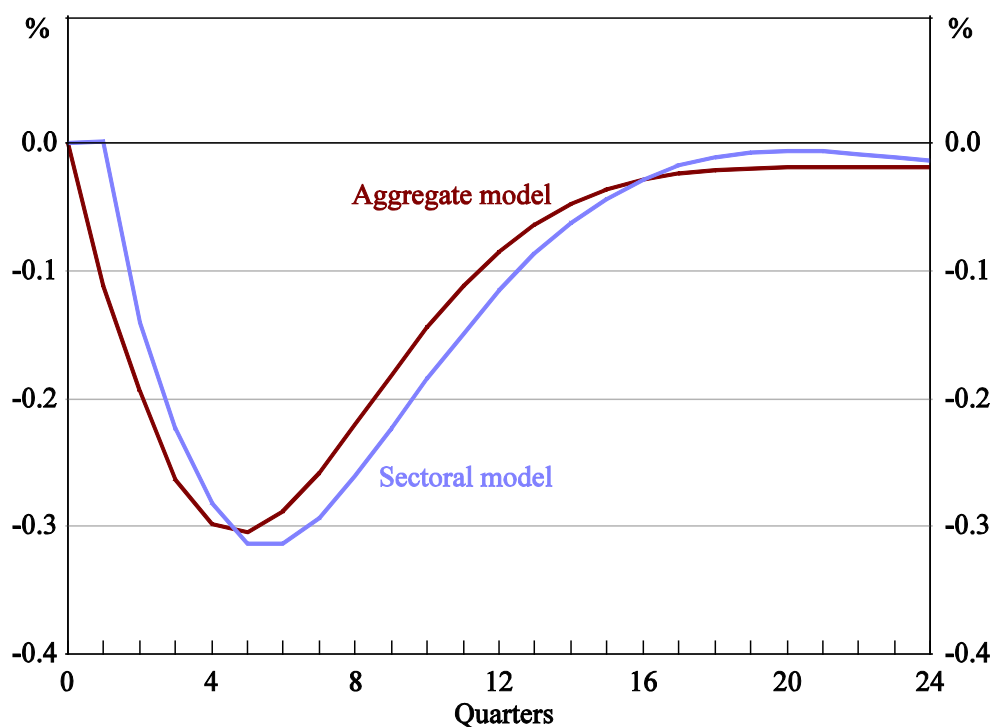
Table 1: Industry Characteristics
Per cent (*continued*)

	Share of output ^(a)	Average mark-up ^(b)	Export propensity ^(c)	Imported input share ^(d)	Import penetration ^(e)	Trade-related exposure ^(f)
Personal services	5¼	1.8	6½	8½	5¼	10¾
Accommodation & food services	2½	1.7	11¾	5¼	9¼	6
Arts & recreation	1	3.5	4	10¼	2¾	2¾
Other services	2	1.6	½	12¼	¾	22
Social services	11¾	1.7	3½	4¼	1½	½
Education & training	5	1.5	7½	3¼	2½	1
Health care & social assistance	7	1.8	½	5	½	0
Agriculture, forestry & fishing	2½	2.2	14	5½	2	61
Electricity, gas, water & waste services	3	2.0	0	3½	0	18¾
Public administration & safety	5½	2.0	¼	3¾	0	3¼

Notes: (a) Industry gross value added (GVA) as a share of aggregate GVA; data for 2012/13
(b) Sum of sales and service income plus funding from government plus change in inventories divided by the sum of labour costs plus purchases; data an average of 2001/02 to 2011/12
(c) Exports as a share of total domestic production in each industry; data for 2009/10
(d) Imported inputs as a share of total domestic production in each industry; data for 2009/10
(e) Competing imports as a share of the total supply of the corresponding industry; data for 2009/10
(f) Percentage of domestic sales to an industry with an export propensity of greater than 10 per cent; data for 2009/10

Sources: ABS; Authors' calculations

One might wonder whether our sectoral responses, which are calculated using a separate VAR for each industry of the economy, are consistent with responses of the aggregate model. To answer this question, Figure 5 compares the response of GDP in our aggregate model with the cumulated responses of the sectoral models, with each industry's output weighted by its average share of output. Reassuringly, the two lines correspond extremely closely and in both the appreciation triggers a 0.3 per cent decrease in the level of GDP after 12–18 months. The response of the sectoral models appears to lag the responses of the aggregate model by a quarter or so. However, given the fairly large confidence bands around the aggregate responses, this difference is not statistically significant.

Figure 5: Gross Domestic Product

3.3 Is the Exchange Rate a Shock Absorber or a Source of Shocks?

The previous section showed that real exchange rate shocks can have a meaningful impact on the Australian economy. This raises the question of whether real exchange rate shocks (that is, those exchange rate movements that are not an endogenous response to changes in other economic variables) are an important cause of Australian macroeconomic volatility.

It turns out that the answer to this question is no. To demonstrate this, Table 2 shows the contribution of real exchange rate shocks to the variance of other domestic variables in the VAR at horizons ranging from six months to ten years.¹³ Regardless of the horizon, exchange rate shocks explain little of the volatility in any of the other domestic aggregate variables.

¹³ The assumption of block exogeneity implies that exchange rate shocks do not contribute to the variance of the foreign variables in the VAR.

Table 2: Variance Decomposition – Aggregate Variables
Per cent of variance explained by exchange rate shocks

Variable	Horizon (quarters)			
	2	10	20	40
GDP	0.2	2.6	2.1	1.5
Inflation	1.0	3.6	3.9	3.3
Cash rate	0.1	1.9	3.8	3.2

At an industry level, the pattern is similar (Table 3). Exchange rate shocks explain a modest proportion of the variance of the manufacturing and other business services sectors at horizons of more than two years. Surprisingly, the VARs also suggest that exchange rate shocks contribute to the variance of the electricity, gas, water & waste industry. Although this industry has little direct exposure to foreign trade, it does have a relatively high indirect exposure through its interactions with trade-exposed industries (Table 1). However, exchange rate shocks explain little of the variance of other industries in the economy.

Table 3: Variance Decomposition – Industry Variables
Per cent of variance explained by exchange rate shocks

Variable	Horizon (quarters)			
	2	10	20	40
Agriculture, forestry & fishing	0.9	1.6	2.0	2.0
Mining	0.6	1.2	1.1	1.0
Manufacturing	0.4	7.2	5.9	4.4
Electricity, gas, water & waste services	0.1	5.2	5.2	4.9
Construction	0.1	0.5	0.5	0.5
Finance & insurance services	0.2	3.6	2.2	1.5
Other business services	0.1	5.8	6.5	5.4
Personal services	0.0	3.4	2.7	1.6
Goods distribution	5.4	4.3	3.2	1.8
Social services	0.0	0.2	0.4	0.3

Variance decompositions can also be used to examine what shocks typically cause real exchange rate movements. Table 4 shows the contribution of foreign and domestic shocks to the variance of the real exchange rate. At short horizons, much of the variance of the real exchange rate is determined by its own shock. This is consistent with the observation that movements in nominal exchange rates (which determine most short-horizon movements in the real exchange rate) cannot be explained by macroeconomic fundamentals (Meese and Rogoff 1983). At horizons beyond two years, foreign variables are the most important determinant of real exchange rate fluctuations. This aligns with previous research that has shown that long-run movements in Australia's real exchange rate can largely be explained by the evolution of the terms of trade as well as interest differentials between Australia and overseas (Gruen and Wilkinson 1994), though it contrasts with more recent findings by Voss and Willard (2009) that attribute only a small share of Australia's exchange rate movements to foreign variable shocks. Other domestic shocks explain only a small proportion of the movements in the real exchange rate, and their influence is greatest over a horizon of around two years.

Table 4: Variance Decomposition – Exchange Rate

Per cent of variance

Shock	Horizon (quarters)			
	1	10	20	40
Foreign	11.3	60.1	82.0	92.0
Domestic non-exchange rate	2.6	11.8	5.4	2.4
Exchange rate	86.1	28.1	12.6	5.6

In sum, our model indicates that over all but the shortest horizons Australia's real exchange rate is largely determined by international factors and that exchange rate shocks contribute little to the volatility of other macroeconomic variables in Australia. These results provide some support to the idea that exchange rate movements have served to mitigate the impact of foreign shocks on the Australian

economy, rather than acting as a source of shocks in their own right.¹⁴ We investigate this issue further in the following section.

4. Scenario Analysis

Having established the aggregate and industry implications of exchange rate shocks, we now use these results to ask how exchange rate movements, which are combinations of shocks and endogenous responses to economic developments, have contributed to Australia's economic performance over the past decade. To do this, we construct two scenarios. In the first, we discuss how the Australian economy might have behaved if it had experienced the same international and domestic shocks but the nominal exchange rate had not appreciated. In the second, we examine how the Australian economy might have evolved without the terms of trade boom and the global financial crisis.

4.1 What if the Nominal Exchange Rate Had Remained Constant?

Starting in the March quarter of 2003, we examine a scenario whereby all of the model's structural shocks, except the one for the exchange rate, remain at their estimated historical values and impose shocks on the real exchange rate in such a way that the nominal exchange rate remains unchanged at its initial level. To do this, we make use of the definition of the real exchange rate, which implies that:

$$\Delta NTWI_t = \Delta RTWI_t - \pi_t + \pi_t^* \quad (2)$$

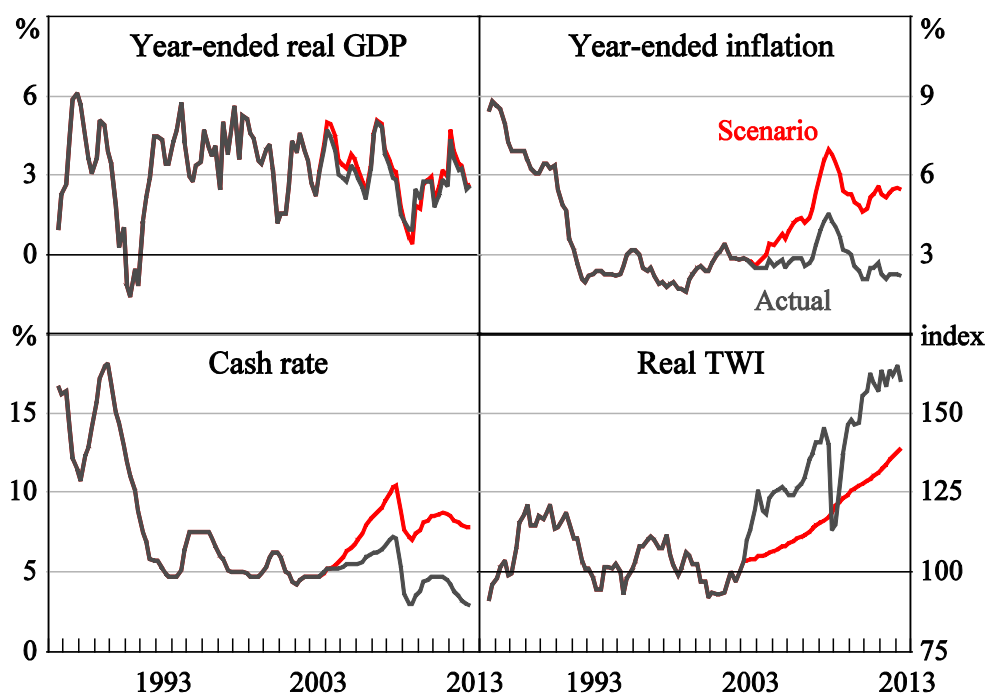
Where $\Delta NTWI_t$ is the percentage change in the nominal exchange rate, $\Delta RTWI_t$ is the percentage change in the real exchange rate, π_t is the domestic inflation rate and π_t^* is the overseas inflation rate. By assumption, the foreign inflation rate is unaffected by domestic economic conditions and the domestic inflation rate is only affected by real exchange rate shocks with a lag. Consequently, by imposing a suitable real exchange rate shock each period, given overseas inflation (which is unaffected by Australian economic developments) and domestic inflation (which

¹⁴ This notion typically emphasises flexibility of the nominal, rather than real, exchange rate. However, price stickiness means that, over short horizons, nominal exchange rate flexibility determines the degree of real exchange rate flexibility.

we allow to evolve endogenously), we are able to simulate a path of the real exchange rate for which the nominal exchange rate remains constant.

Figure 6 shows the counterfactual paths of the real exchange rate, inflation, the cash rate and GDP growth in this scenario.¹⁵

Figure 6: Constant Exchange Rate Scenario – Aggregate Implications



Sources: ABS; Authors' calculations; RBA

The model suggests that, even if the nominal exchange rate had remained constant, the economy would have experienced a large real exchange rate appreciation over the past decade. This reflects the fact that most of the appreciation of the real exchange rate was due to economic fundamentals, in particular the large increase in the terms of trade. A flexible nominal exchange rate ensured that this real exchange rate appreciation occurred in a timely manner, and mitigated much of the effect of the commodities boom on domestic prices. But even without this mechanism, the model suggests that, in a world of rising commodity prices, the real exchange rate would still have appreciated eventually.

¹⁵ Note that our assumption that Australian variables do not affect US GDP or the terms of trade means that these foreign variables are unaffected by this scenario.

However, the model also suggests that, without the appreciation of the nominal exchange rate, the terms of trade boom would have had a destabilising effect on the nominal side of the economy. In the scenario, the inflation rate increases to over 6 per cent in 2008 and remains at an elevated level subsequently. This reflects the fact that, if the nominal exchange rate is fixed, a real appreciation requires an increase in the domestic price level relative to the foreign price level. If foreign inflation is unaffected by Australian economic conditions, this implies higher domestic inflation. The model suggests that Australian nominal interest rates would have been considerably higher if the nominal exchange rate had not appreciated, reflecting higher domestic inflation.¹⁶

Initially, the model suggests a constant nominal exchange rate would have increased the pace of economic growth. This is because, in the scenario, the appreciation of the real exchange rate occurs more slowly than it did in reality, as domestic prices adjust more slowly to economic shocks than nominal exchange rates do. Once the real exchange rate begins to appreciate, however, GDP growth in the scenario is similar to its actual level and, if anything, is slightly lower during the global financial crisis, as higher inflation limits the ability of the RBA to respond to weaker domestic economic conditions.

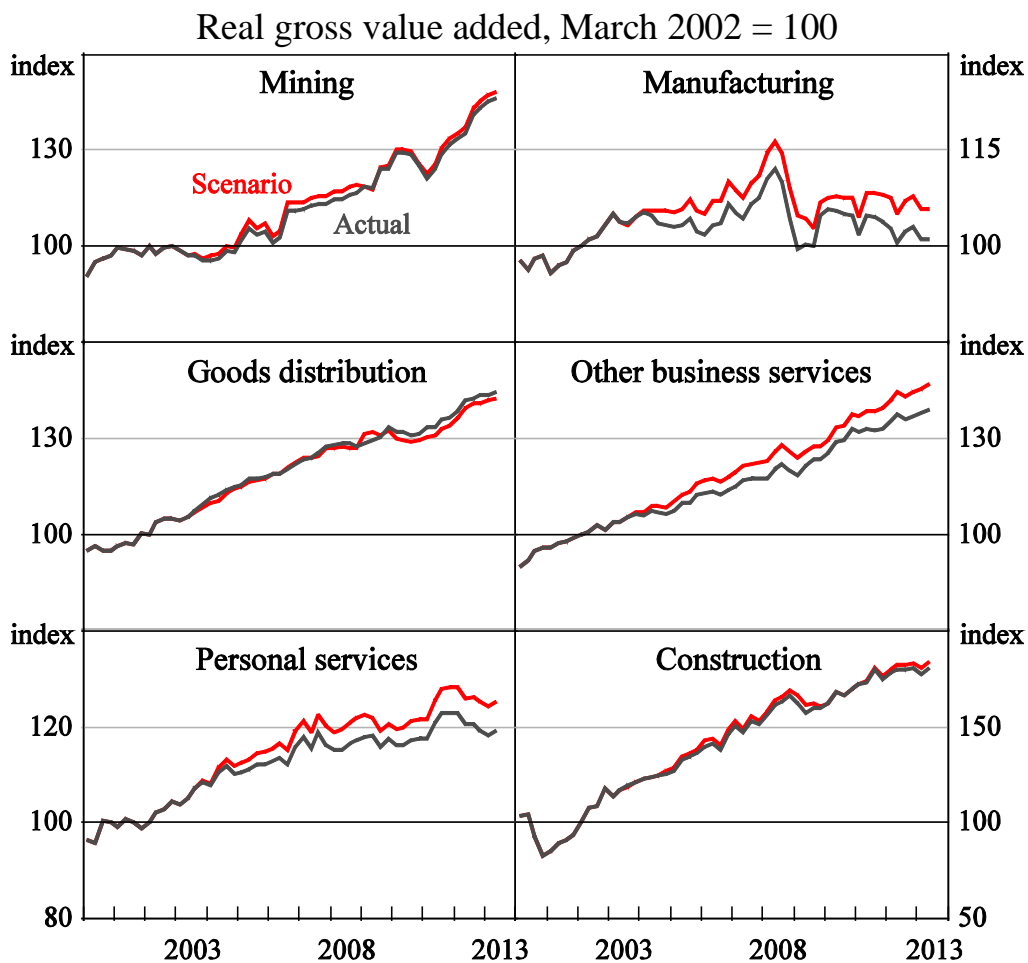
An important caveat to this result is that it reflects the impact of a sequence of unanticipated negative shocks to the nominal exchange rate and hence may overstate the impact of a persistently weaker nominal exchange rate on inflation. If the RBA had anticipated that the terms of trade boom would not have been accompanied by an appreciation of the nominal exchange rate, it may have responded more aggressively to rising inflation than in this scenario. This would have moderated the increase in inflation but also reduced the pace of economic growth.

Figure 7 shows the estimated implications of a constant nominal exchange rate for various sectors of the economy. As suggested by the aggregate responses, several industries would have experienced more rapid growth in the early stages of the

¹⁶ At first glance, this increase in inflation might seem large. However, it is of broadly similar magnitude to that which occurred between 1972 and 1974, which was an episode in which Australia experienced a large increase in its terms of trade in an environment of limited exchange rate flexibility (Atkin *et al* 2014).

mining boom if the nominal – and, by association, real – exchange rate had not appreciated. For the business services and personal services industries, the model suggests that this faster growth in the initial stages of the boom would have left the level of output in these industries noticeably higher today. However, for other industries, such as mining and construction, a constant nominal exchange rate would have had left the level of output little changed, while output in the goods distribution sector would have grown less rapidly.

Figure 7: Constant Exchange Rate Scenario – Industry Implications



Sources: ABS; Authors' calculations

The manufacturing sector would also have benefited from a weaker Australian dollar in the early stages of the terms of trade boom. However, even a constant nominal exchange rate would not have prevented the ongoing decline in the relative size of manufacturing, which is due to broader technological and economic factors. At most, according to this scenario, a weaker exchange rate would have reduced the pace of this decline.

4.2 What if There Were No Foreign Surprises?

As a second exercise, we examine the contribution of foreign developments to the appreciation of the real TWI and other domestic economic outcomes over the past decade. To do so, we run a second simulation in which we set all domestic shocks, including the exchange rate shocks, at their estimated historical values, and impose shocks on the foreign variables such that US output grows at its estimated trend and the terms of trade is constant. In this way, the scenario abstracts from the terms of trade boom and the global financial crisis as well as other, less notable, foreign developments.

Figure 8 suggests that, absent unusual foreign circumstances, the real exchange rate would have remained at around the same level in the 2000s as it did during the previous two decades. That is, the appreciation of the real exchange rate over the past decade has been almost entirely due to global factors. However, despite the weaker exchange rate, output would have grown more slowly and inflation would have been lower in the mid 2000s than was actually the case. Consequently, the cash rate would also have been lower, although the model suggests that this would not have been sufficient to offset fully the absence of the terms of trade boom.¹⁷

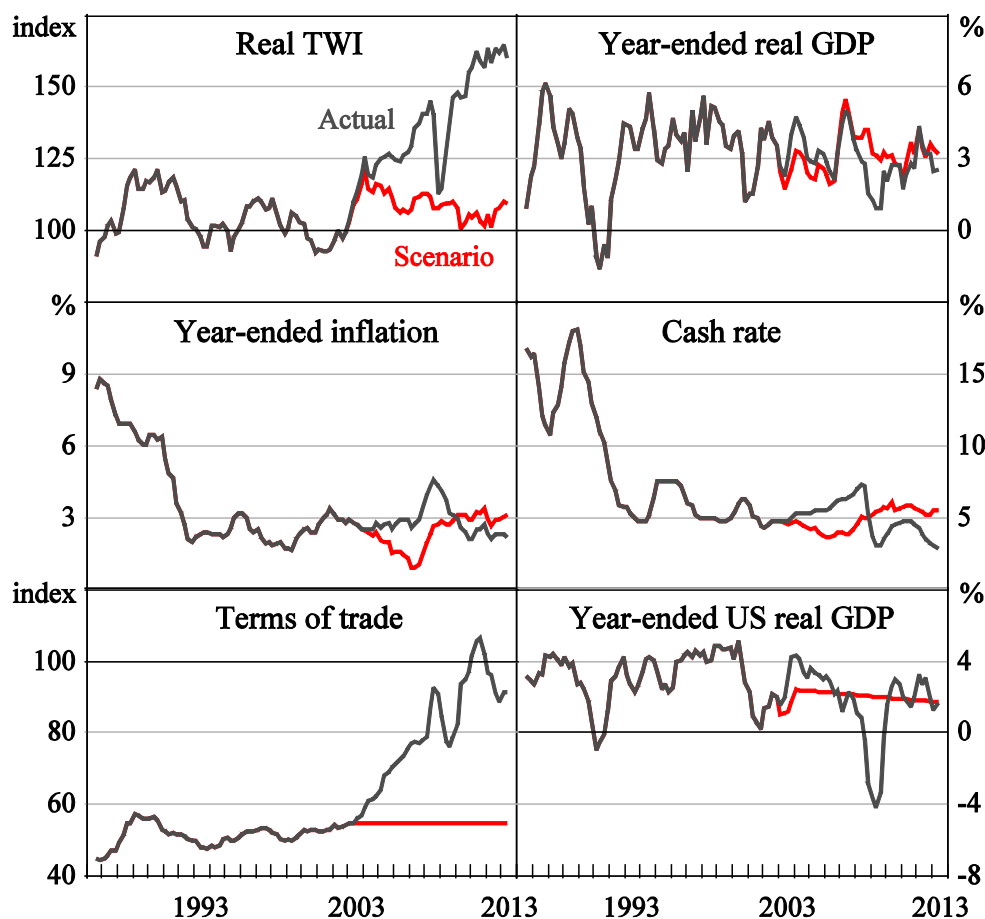
Since the onset of the global financial crisis in mid 2008, the Australian economy has faced a more challenging international environment. Weak economic growth in advanced economies has exerted a contractionary effect on the Australian economy. However, growth in emerging economies, which has been associated with ongoing strength in commodity prices, has supported domestic economic activity. The model confirms that the slowdown in advanced economies lowered Australian economic growth in 2008 and 2009. However, it also suggests that, on balance, international economic developments have had a neutral impact on Australian economic activity since 2010.

In terms of the nominal variables, the model suggests that, absent international developments, inflation would have also been higher in recent years. But, unlike the previous scenario, inflation would have remained broadly in line with the

¹⁷Note that this exercise understates the effects of the terms of trade boom on domestic living standards because, as well as increasing GDP growth, the boom also increased domestic income.

RBA's inflation target. Higher inflation and stronger economic growth would have translated into higher nominal interest rates. However, at 5–6 per cent, the cash rate would have been at around its average level in the inflation-targeting era.

Figure 8: No Foreign Surprises Scenario



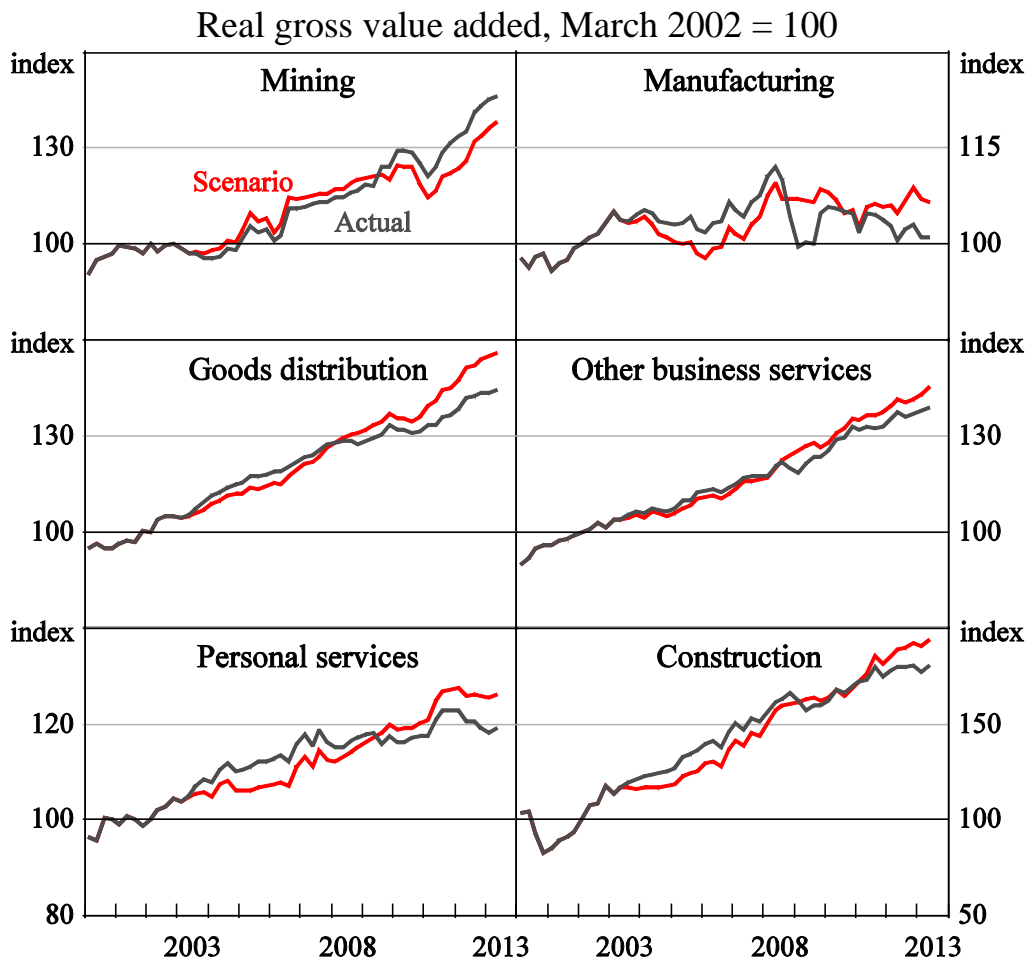
Sources: ABS; Authors' calculations; RBA

Figure 9 shows the sectoral implications of the no foreign surprises scenario. The manufacturing, goods distribution and personal services sectors would all have grown considerably more slowly in the mid 2000s without the income boost from the early stages of the terms of trade boom and the strong economic conditions in other developed economies. This result coincides with the findings of Downes, Hanslow and Tulip (2014) that, in the early stages of the terms of trade boom, the demand-side effects of rising mining investment largely offset the competitiveness effects of a stronger exchange rate for many import-competing domestic industries.

More recently, global economic conditions have had a negative impact on output in these sectors. In the case of manufacturing, this may reflect the impact of subdued

demand from advanced economies, which account for a larger share of Australia's manufacturing exports than they do of resource exports. For the services sectors, the result may reflect the reductions in domestic income and wealth resulting from the global financial crisis as well as the effects of lower levels of business and consumer confidence that these events, and their aftermaths, generated.

Figure 9: No Foreign Surprises Scenario – Industry Implications



Sources: ABS; Authors' calculations

The model suggests that global economic developments had a comparatively small effect on the quantity of mining output, especially in the early years of the scenario. At first glance, this might seem surprising as higher commodity prices would be expected to have triggered an increase in mining production. However, it is consistent with the idea that the early stages of the terms of trade boom led to income gains without large increases in production as firms waited to see how persistent the boom was before committing to large investment projects – and that these investment projects take several years to result in increased capacity (Plumb,

Kent and Bishop 2013).¹⁸ Indeed, the model suggests that, more recently, mining production would have been lower without the cumulative effect of the global economic developments of the past decade.

Putting the constant nominal exchange rate and no foreign shocks scenarios together, the results suggest that foreign economic developments had a substantial positive impact on Australian economic activity in the mid 2000s. Absent these developments, the economy would have experienced a period of below-trend growth, partly mitigated by more accommodative monetary policy and a modest exchange rate depreciation.¹⁹ The appreciation of the nominal exchange rate limited the spillover of increased economic growth and higher domestic incomes resulting from the terms of trade boom onto the nominal side of the economy. Without this appreciation, our model suggests that much tighter monetary policy would have been required to maintain a rate of inflation consistent with the RBA's inflation target.

Since 2008, foreign economic developments have had, overall, a contractionary effect on the Australian economy – particularly during the global financial crisis. Absent these developments, nominal interest rates would have been at more normal levels, although the effect on economic growth in recent times would have been modest.

Although the no foreign surprises scenario featured a weaker real exchange rate than the constant nominal exchange rate scenario, output growth was no faster in the former scenario and inflation was lower. The differing outcomes reinforce a key message of this paper: that the impact of an exchange rate movement on the Australian economy ultimately depends on what factors cause the movement.

¹⁸ In addition, some of the increased demand due to the commodities boom may have been met by other industries, including the construction, business services and manufacturing industries (Rayner and Bishop 2013). To the extent that the contribution of these industries was particularly large during the investment phase of the mining boom it is not surprising to see a delayed response in mining output to higher commodity prices.

¹⁹ This result is consistent with the views of economic policymakers at the time. In 2005, before the full scale of the terms of trade boom was apparent, then RBA Governor Ian Macfarlane suggested that the economy was likely to experience a period of slower growth with, 'GDP growth rates starting with the numbers 2 or 3 rather than 3 or 4 for a time' (Macfarlane 2005, p 8).

5. Robustness Checks

In this section, we discuss the robustness of our results to different model specifications and across the sectoral VARs.

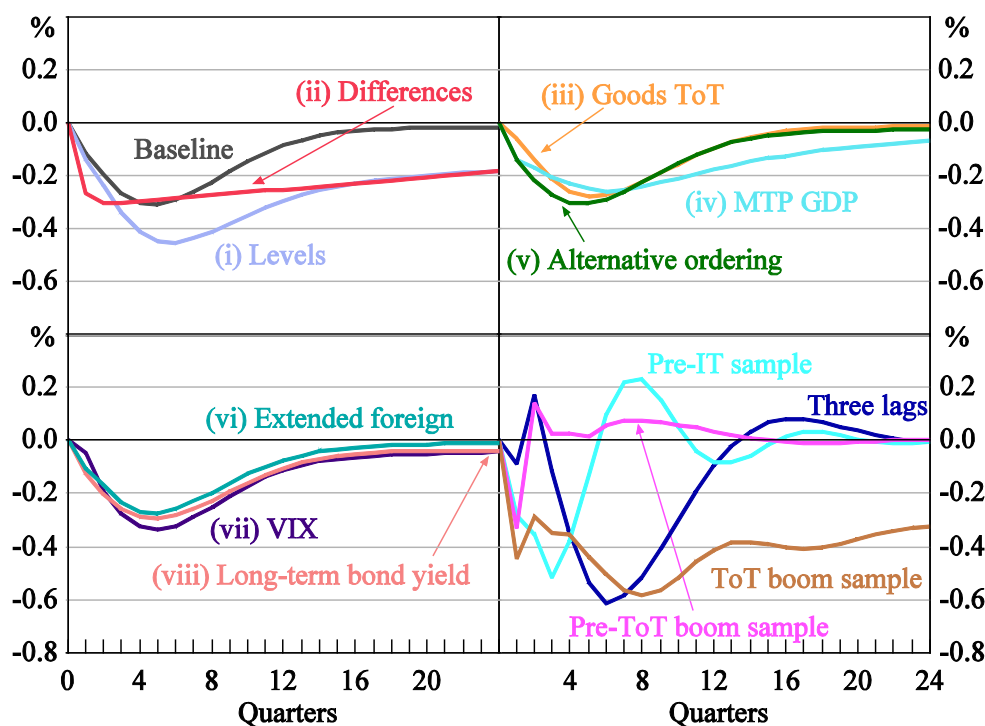
Figure 10 compares the response of aggregate GDP in our baseline model with the responses using alternative model specifications. The top two and bottom left panels contain eight alternative specifications:

- i) GDP and the price level enter the VAR in log levels
- ii) GDP, the exchange rate and terms of trade enter in differences
- iii) The goods terms of trade replaces the goods and services terms of trade
- iv) The growth rate of Australia's major trading partners replaces US GDP growth
- v) The exchange rate is ordered before the cash rate in the identification scheme
- vi) US CPI inflation and the US federal funds rate are included as additional foreign variables
- vii) The VIX index is included as an additional foreign variable
- viii) The Australian 10-year government bond yield is included as an additional domestic variable.

Compared to the baseline model, the levels specification implies a somewhat larger GDP response, while the peak effect in the differences specification is similar to the baseline model but occurs earlier. In both the levels and the differences specifications, the impact of an exchange rate appreciation is considerably more persistent. Although we prefer the specification with detrended GDP as it is more consistent with standard theoretical open economy models, VARs are often estimated with GDP in levels or differences specifications and these models

suggest that our baseline results may understate the effect of exchange rate shocks on output.

Figure 10: Response of GDP to Exchange Rate Shock



In contrast, the model that includes US inflation and interest rates generates a path of GDP that is almost identical to our baseline model. This is reassuring as it suggests that the results in our baseline model adequately account for deviations from uncovered interest rate parity generated by changes in foreign monetary policy. The results are also largely unaffected by changing the measure of the terms of trade or the measure of foreign GDP that we include in the model, though in the latter case, the GDP response is somewhat more persistent. Allowing monetary policy to respond contemporaneously to the exchange rate shock makes little difference to our results, suggesting that we are not misidentifying monetary policy shocks as exchange rate shocks.

The response of GDP to an exchange rate shock in specifications including the VIX index and long-term bond yields are also nearly indistinguishable from our baseline results. The fact that including the VIX does not affect our results suggests that our identification scheme is not mistakenly capturing the effects of changes in investor risk premia rather than the effects of exchange rate movements. The fact that including long-term bond yields does not affect the results suggests

that our identification strategy is not misinterpreting exchange rate movements caused by the expectation of future cash rate movements as exchange rate shocks.

The bottom-right panel of Figure 10 shows the responses of GDP to an exchange rate shock in a model including more lags as well as models estimated over alternative sub-samples. Although lag order selection tests favour two lags rather than three, a larger number of lags may allow the model to capture more completely the interactions between the responses of macroeconomic variables to exchange rate shocks. The response of GDP in the three-lag specification is roughly twice as large as that generated in our baseline results. The response of GDP also occurs later – it takes roughly a year for GDP to respond to the exchange rate shock. Once again, this could indicate that our model provides a lower bound to the effect of exchange rate shocks on output.

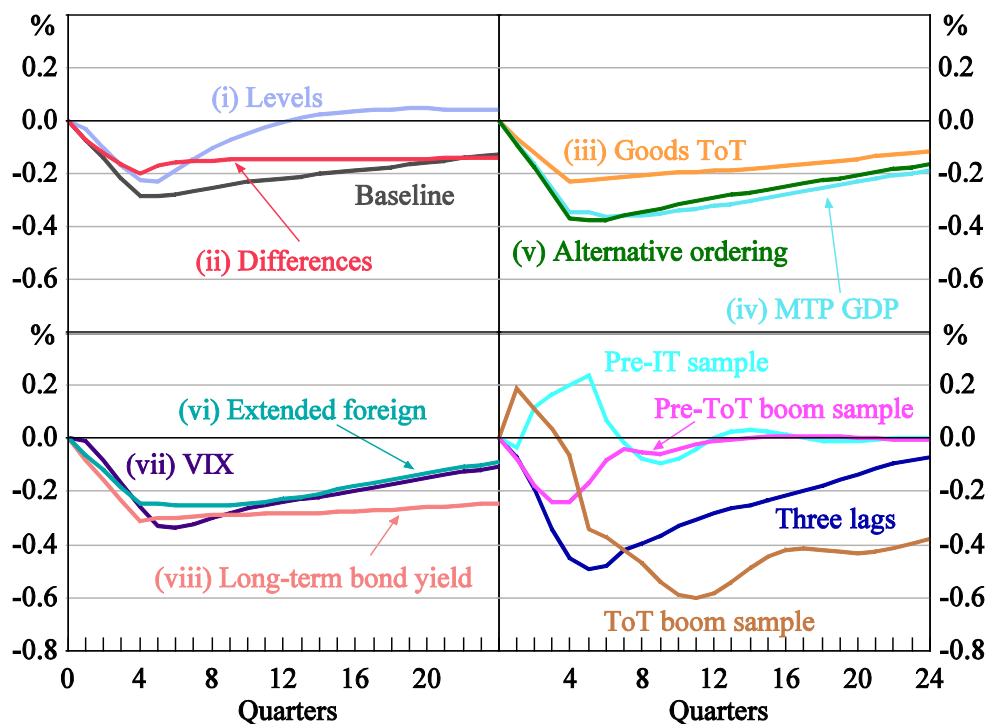
The three sub-samples that we consider are: a pre-inflation targeting sample (1985:Q1 to 1992:Q4); a pre-terms of trade boom sample (1993:Q1 to 2002:Q4) and a terms of trade boom sample (2003:Q1 to 2013:Q2). The point estimates from the pre-inflation targeting and terms of trade boom samples suggest a larger GDP response than our baseline results, while the middle sample points to a response that is similar in magnitude at its peak but shorter in duration. Although there is some evidence of sub-sample instability, this should be viewed in the context of the wide confidence bands around our baseline results.

Figure 11 shows the response of year-ended inflation to an exchange rate shock in each of the model specifications discussed above. In general, the result from the baseline model is robust to changes in included variables and their ordering. In most models, the appreciation triggers a fall in year-ended inflation of between 0.2 and 0.4 percentage points five quarters after the shock, after which inflation gradually returns to trend.

As with the response of GDP to an exchange rate shock, the response of inflation is sensitive to the estimation sample. In the inflation-targeting era, an appreciation has a negative effect on inflation, though the estimated effect is noticeably larger and more persistent in the terms of trade boom sample. In contrast, inflation is estimated to rise following an exchange rate appreciation prior to the inflation-

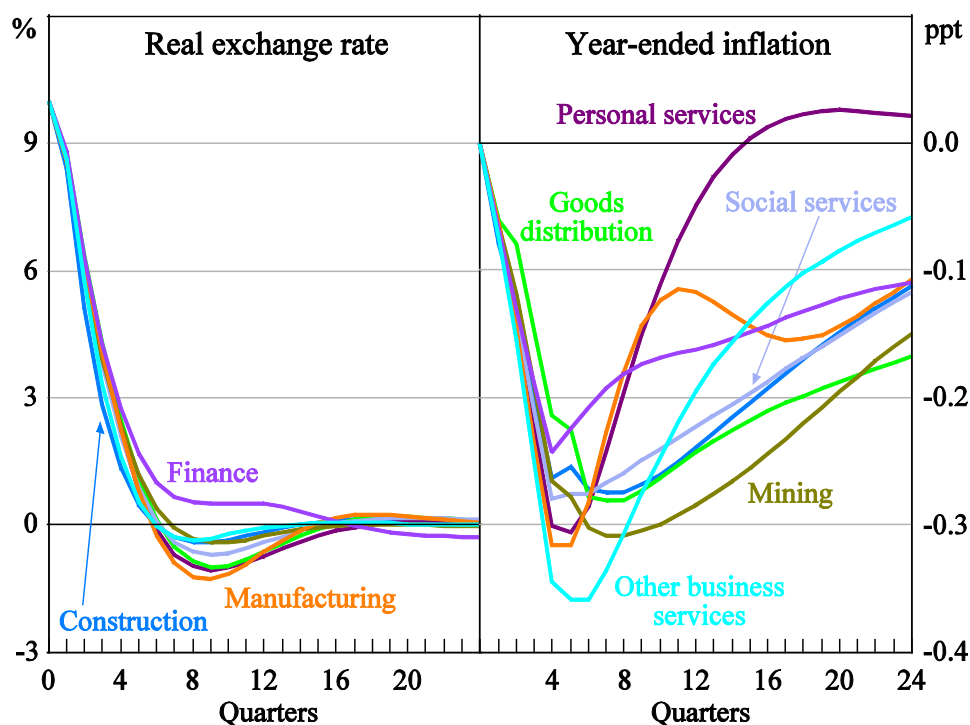
targeting era. Chung, Kohler and Lewis (2011) previously noted that the extent of exchange rate pass-through in Australia has varied over time.

Figure 11: Response of Year-ended Inflation to Exchange Rate Shock



Because we estimate a separate VAR for each industry, one might be concerned that we do not identify the same exchange rate shocks for each industry. To examine whether this is the case, Figure 12 compares the responses of the exchange rate and inflation to an exchange rate shock in the various industry models. Reassuringly, the exchange rate response is almost identical across models. There is slightly more variation in the inflation response. However, in all models, the appreciation triggers a decrease in year-ended inflation of between 0.25 and 0.35 percentage points five quarters following the shock, after which inflation gradually returns to trend. On the basis of these results we are confident that the exchange rate shocks that we identify are similar across our industry models.²⁰

²⁰ We have also visually inspected the historical real exchange rate shocks implied by the industry models. They are virtually identical in all cases.

Figure 12: Responses to an Exchange Rate Shock in Industry Models

6. Conclusion

In this paper, we have analysed the aggregate and sectoral impact of exchange rate shocks in Australia. While the broad direction of the aggregate responses to exchange rate movements are predictable from economic theory, our results quantify these responses. Our results confirm that the mining, manufacturing, personal services and other business services industries are particularly sensitive to exchange rate movements, while social services output is somewhat less affected. Although exchange rate shocks can have a large effect on economic activity, these shocks explain only a small proportion of the volatility of Australian macroeconomic variables. Instead, most exchange rate movements, at least over the medium- and long-run, are a response to more fundamental economic changes, and the resulting movements in the real exchange rate are a stabilising influence on the economy.

We then use our model to examine how the Australian economy might have evolved under alternative exchange rate scenarios and alternative scenarios for international influences on recent exchange rate movements. These results reinforce the need to determine the source of real exchange rate movements, as

well as their size and magnitude, in order to gauge the effect of the exchange rate on the economy. Our results suggest that, even if the nominal exchange rate had remained constant over the past decade, the real exchange rate would still have appreciated. However, this appreciation would have been accompanied by substantially higher inflation without a noticeable increase in the pace of economic growth. In contrast, if the terms of trade boom had not occurred, the real exchange rate would not have appreciated. But, despite a weaker exchange rate, the Australian economy would not have grown more rapidly.

Appendix A: Data

The data series that we use in the model are as follows:

Australian inflation: Quarterly inflation of the trimmed mean consumer price index excluding interest and tax changes (RBA statistical table G1 Consumer Price Inflation).

Australian major trading partner gross domestic product: The natural logarithm of quarterly seasonally adjusted Australian major trading partner real GDP (RBA).

Australian real gross domestic product: The natural logarithm of seasonally adjusted chain volume GDP (ABS Cat No 5206.0).

CBOE Volatility Index (VIX): The level of the VIX index, averaged over the quarter (Chicago Board Options Exchange (www.cboe.com/micro/VIX/vixintro.aspx)).

Industry gross value added: The natural logarithm of quarterly chain volume gross value added (GVA) for each industry (ABS Cat No 5206.0). ‘Other business services’ GVA is the sum of chain volume GVA for the following industries: information media & telecommunications; professional, scientific & technical services; rental, hiring & real estate services and administrative & support services. ‘Personal services’ GVA is the sum of chain volume GVA for the following industries: accommodation & food services; arts & recreation services and other services. ‘Social services’ GVA is the sum of chain volume GVA for the education & training and health care & social assistance services industries.

Overnight cash rate: Overnight cash rate, averaged over the quarter. Nominal official cash rate until June 1998, and then the interbank overnight rate (RBA statistical table F1.1 Interest Rates and Yields – Money Market).

Real trade-weighted index: The natural logarithm of the real trade-weighted exchange rate index (RBA statistical table F15 Real Exchange Rate Measures).

Terms of trade: The natural logarithm of seasonally adjusted terms of trade (ABS Cat No 5302.0).

United States consumer price inflation: Quarterly inflation of the chain price index for personal consumption (Datastream code: USCE...E).

United States federal funds rate: The US federal funds target rate, averaged over the quarter (Datastream code: USFDTRG).

United States real gross domestic product: The natural logarithm of seasonally adjusted quarterly real US GDP (Datastream code: USGDP...D).

Appendix B: Estimation and Identification

To recover the structural shocks in Equation (1), we estimate the reduced form equation:

$$\begin{bmatrix} Y_t^F \\ Y_t^D \end{bmatrix} = \begin{bmatrix} B_{FF}(L) & 0 \\ B_{FD}(L) & B_{DD}(L) \end{bmatrix} Y_{t-1} + u_t \quad (\text{B1})$$

Where Y_t^F is a vector of foreign variables, Y_t^D is a vector of domestic variables and $u_t \equiv \begin{bmatrix} u_t^{F'} & u_t^{D'} \end{bmatrix}'$ is a vector of potentially correlated reduced form shocks with a variance-covariance matrix Σ .

The matrix Σ and the structural variance-covariance matrix, Ω , are related according to:

$$\Sigma = \mathbf{A}^{-1} \Omega \mathbf{A}^{-1'} \quad (\text{B2})$$

To identify the structural shocks, we need to place at least $n(n-1)/2$ restrictions on the form of Ω and \mathbf{A} , where n is the number of variables included in each VAR. We identify one structural shock – an exchange rate shock – and identify this shock using a recursive ordering. Specifically, we assume that the exchange rate responds to all other shocks contemporaneously but that exchange rate shocks affect other variables with a lag. To implement this identification, we assume that \mathbf{A} is lower triangular and take a Choleski decomposition of Σ , ordering the exchange rate shock last.

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