THE IMPACT OF AN EXCHANGE RATE SHOCK ON AUSTRALIAN ECONOMY

LI MA
(40129950)
Department of Economics
Faculty of Business and Economics
Macquarie University, Sydney

Thesis submitted in partial fulfilment of the award of the degree of Master of Research in Economics at Macquarie University

Table of Contents

Acknowledgements

I wish to thank my supervisors, George Milunovich and Natalia Ponomareva for helpful comments and suggestions throughout the year. I would also like to thank Tony Bryant for his encouragement and support throughout my study of economics in the MRes seminars and coursework. I am grateful to Daniel Rees for the explanations and valuable information, and to Dario Dodig for his advice on my research arrangements during my Master of Research study.

Abstract

It has been more than 30 years since 1983 when the floating exchange rate regime was introduced in Australia. The floating exchange rate is widely considered to bring benefits to the Australian economy through its role as a shock absorber. The present project investigates how the movement of the exchange rate affects Australian GDP and employment in the post-float era. The study's results demonstrate that the impact from a one-standard-deviation unanticipated real exchange rate shock tends to cause more sectoral shifts on Australian GDP and employment growth rather than aggregate disturbances in the short run. We find that shock impacts are statistically insignificant on aggregate GDP growth and employment growth. At the industrial level, the extent of such shock impacts is largely based on the trade-exposure characteristics of industries. Finally, the results confirm that the floating exchange rate behaves as a shock absorber in the short run.

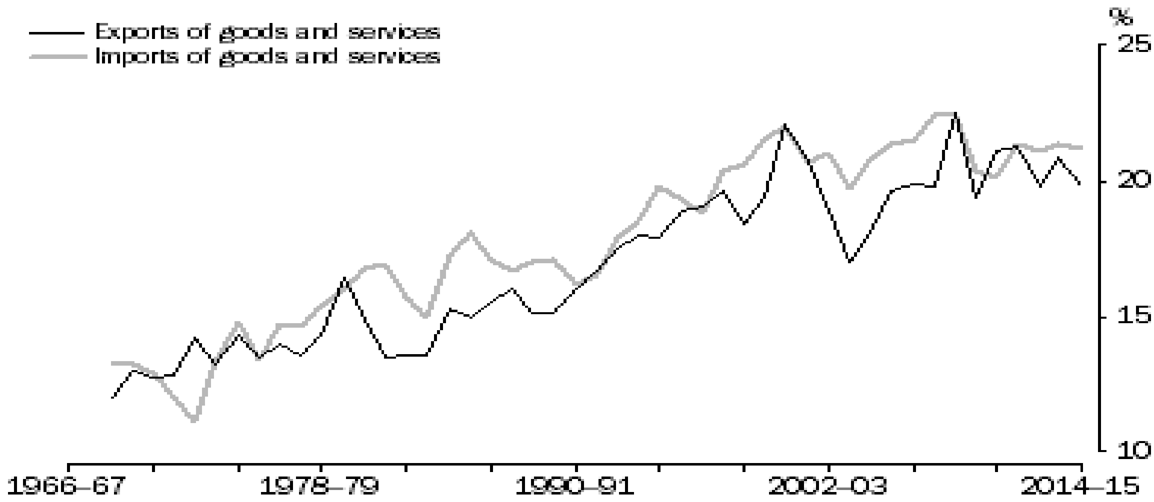
Chapter 1

Introduction

Movements in the exchange rate have broad impacts on the Australian economy. Economic theory suggests that such movements will affect market demand through international trade, and as a result, will alter output levels. These impacts will further cause fluctuations in other macroeconomic fundamentals such as employment and inflation. Under the floating exchange rate regime there have been large swings in the nominal exchange rate, which also resulted in movements in the real exchange rate. Australia is generally considered to be a small open economy. That is to say, the economic outcomes and policies of Australia are assumed to have no significant impact on worldwide output, inflation and interest rates. Therefore, the exchange rate is important as it connects the Australian economy to the rest of world through international trade.

Figure 1.1 shows the ratio of exports and imports to GDP since 1966. An increasing trend can be observed for both exports and imports. According to the Australian Bureau of Statistics (ABS), in 2014-15 exports- and imports-to-GDP ratios were 19.8% and 21.2%, respectively. Over the last decade, the volume of imports increased sharply to 69.7%, while growth of exports volume reached 48.8%. At the same time, net exports contributed 1.4 percentage points to GDP growth in 2015-14.

Figure 1.1 Exports and imports, current prices – relative to GDP



Source: ABS

In 1983 the floating exchange rate regime was introduced in Australia. Throughout more than 30 years of the post-float era, this regime is generally considered to have benefited the Australian economy through its role as shock absorber. However, there is an argument that the fluctuation of the exchange rate will only affect industries, rather than the aggregate economy. In this regard, the present study investigates the possible impacts of an unanticipated exchange rate shock on the Australian economy, for both the aggregate economy and the industrial sectors. As it is a crucial consideration in monetary policy to maintain full employment and have the prosperity to encourage strong and sustainable growth in the economy[1], the research examines the impact of exchange rate shock on both output and employment. Given the recent conditions of the Australian economy, depreciation of the dollar continuously shifts economic activities away from the resources sector towards other sectors. The growth of net service exports is observed to be sensitive to the movements of the exchange rate[2], and employment has been strongly associated with the benefits of depreciation since 2013. Therefore, it

[1] Reserve Bank of Australia, *About Monetary Policy,* http://www.rba.gov.au/monetary-policy/about.html
[2] Reserve Bank of Australia, *RBA Minutes of the Monetary Policy Meeting on 5th April 2016,* http://www.rba.gov.au/monetary-policy/rba-board-minutes/2016/2016-04-05.html

is necessary to develop a firm understanding of the role of the exchange rate, and whether the impacts of movements in the exchange rate would result in aggregate disturbances or sectoral shifts in Australia. At the same time, the short run effect we analyse in this thesis may result the permanent changes on the exchange rate and output level. The study is indirectly relevant to long run shock impacts. In Australian, monetary policy involves managing short run interest rate. When conducting the monetary policy, the policy makers consider short run developments in employment and output growth for the purpose of stabilising short run business cycle fluctuations. This enable monetary policy to realize the long run objective of maintain the growth and the economic prosperity and welfare of the people of Australia[3]. Thus, we will focus on the short run shock impacts in this study.

In the present research, a structural vector autoregression model (SVAR) of the Australian economy is applied to estimate the extent of such impacts[4]. An unanticipated exchange rate shock is identified as a movement of the exchange rate that cannot be explained by other economic factors. To investigate the role of the exchange rate on output levels, the SVAR model is set up based on the strategies described in Manalo, Perera and Rees (2015). The variable, employment, is added in order to investigate the impacts on the labour market. Moreover, by using stationary data, we focus on the growth of GDP and unemployment rather than the levels.

Our results suggest that a one-standard-deviation unanticipated real exchange rate shock will raise the GDP growth by 0.0001 per cent in the short-run and lower employment growth of 5.25 per cent. It followed by a decrease in the inflation of 0.03 per cent and a small impact on cash rate by 0.006 per cent. There is no evidence shows that real exchange rate is a source of shock in Australia. Instead, the

[3] Reserve Bank of Australia, *Monetary Policy,* http://www.rba.gov.au/education/monetary-policy.html

[4] Given the majority of literature which presented in later chapters, SVAR is a more popular method among studies in this area. Comparing to the other methods, such as dynamic simultaneous equation model and the dynamic multipliers effect, SVAR imposes less restrictions on a well-established systemic economic structure for the purpose of solving research questions. As a consequence, the estimates by SVAR models reflects more the real economy shock responses.

results from variance decomposition confirm that the floating exchange rate behaves as a shock absorber during the post-float era.

At an industrial level, we find that the most trade-exposed industries' growth, such as the mining industry, are the most sensitive to an exchange rate shock. Some industries largely consumed by householders, such as retail and wholesale industries, also respond to the exchange rate shock due to the cost effect. Furthermore, industries do not have large direct trade-exposure but closely link with those most trade-exposed industries will also be affected by an exchange rate shock on its growth. These industries include rental and finance industries in Business Service sectors. On the other hand, we find that an unanticipated exchange rate shock will lead to labour shifts across the industries. The most sensitive industries are agriculture, public administration, education, health and mining.

Results from the study contribute to three stands of the existing literature. First, they relate to papers that examine the aggregate and sectoral impacts of an unanticipated exchange rate shock on the Australian economy. Secondly, the SVAR further examines such impacts on the labour market by industries. At the same time, the present research provides some evidence and details on the main objective of monetary policy, namely the maintenance of full employment and economic prosperity.

The rest of the paper is structured as follows: Chapter 2 presents a review of the theory of an unanticipated exchange rate shock, covering the main methods used in the literature to analyse exchange rate shocks. Chapter 3 considers the empirical literature on the impacts of exchange rate shock on output and employment. Chapter 4 presents the empirical results from the investigation of the exchange rate shock on output and employment using SVAR models. Chapter 5 discusses the results and conclusions in detail.

Chapter 2

Literature Review: Theory

2.1 Introduction

Behind the empirical work, the economic theory of exchange rates determines the method used to analyse shock impacts. This chapter contains economic theories related to the relationship between macroeconomic fundamentals and exchange rate shock. Also in this chapter, it presents a review of the literature on structural vector autoregression (SVAR), a common method for analysing an exogenous exchange rate shock.

The next section of this chapter (Section 2.2) discusses two macroeconomic models of exchange rate and shocks. These models help us to understand how an unanticipated exchange rate shock affects the economy and the interrelationships between macroeconomic fundamentals. We begin in Subsection 2.2.1 with the Mundell-Fleming model for a small open economy. In Subsection 2.2.2, we use the AA-DD model to explain the adjustment process to an unanticipated exchange rate shock, and we also present a discussion about the theory of the J-curve effect on the current account deficit when facing a movement of the exchange rate.

In Section 2.3, we review the basic theories of the labour market, starting with the development of the modern labour economics. This is followed by an overview of two-streams of labour economics, and the causes of short-run cyclical unemployment and long-run structural change unemployment.

Section 2.4 provides a review of the literature on the SVAR method. In this section, we present the theory of the SVAR method in three parts: identification (Subsection 2.4.1): impulse response analysis (Subsection 2.4.2); and variance decomposition (Subsection 2.4.3).

Later, in Section 2.5, we present an important concept in shock impact analysis: hysteresis. It is mainly applied in analysis of a short-run shock impacts on unemployment and trade. In Subsection 2.5.1, we discuss the determinants of economic hysteresis. It follows Subsection 2.5.2 with three types of micro-hysteresis: the 'non-ideal relay'; catastrophe theory; and the 'mechanical play'. In the last part of the section, we provide the theoretical base for the aggregate method for macro-hysteresis.

Section 2.6 describes the apparent links of exchange rate and monetary policy. It is important to understand the role of exchange rate in monetary policy. Not only does it provide the theoretical base for the order of the variables in the SVAR model, but it also informs the way monetary policy fulfils its objects in the post-float era and maintains economy stability.

Finally, Section 2.7 concludes this chapter.

2.2 Macroeconomic Models of Exchange Rate and Shocks

2.2.1 *Mundell-Fleming Model*

The Mundell-Fleming model provides the theoretical foundation for analysis of shock impacts. The model was designed by Robert Mundell and Marcus Fleming. The Mundell-Fleming model is an extension of the IS-LM model, and describes the relationship of the interest rate to output and exchange rates in a small open economy.

As explained in Blanchard and Sheen (2013), the model rests on three equations which include: i) the IS curve represents goods market for an open economy; ii) the LM curve represents the money market; and iii) an interest-rate-setting equation represents the central bank's interest rate decision:

$$IS\text{: } \mathrm{Y} = \mathrm{C}(\mathrm{Y} - \mathrm{T}) + \mathrm{I}(\mathrm{Y}, \mathrm{i}) + \mathrm{G} + \mathrm{NX}[\mathrm{Y}, \mathrm{Y}^{*}, \frac{(1+i_t)}{(1+i_t^{*})}\overline{\mathrm{E}^{\mathrm{e}}}] \tag{2.1}$$

$$LM\text{: } \frac{\mathrm{M}}{\mathrm{P}} = \mathrm{YL}(i) \tag{2.2}$$

$$\text{Interest Rate Setting: } i = i_0 \tag{2.3}$$

In Eq. 2.1, aggregate demand, Y, equals to Consumption, C[5], plus Investment, I, plus government spending, G, plus net exports, NX. The level of net exports determined by domestic output, Y, foreign output, Y*, and the interest parity condition, $\frac{(1+i_t)}{(1+i_t^{*})}\overline{\mathrm{E}^{\mathrm{e}}}$. Eq. 2.2 represents the equilibrium on money market, the real money supply, M/P, equals to the real money demand, YL(i). Eq. 2.3 is an interest rate setting rule which explains monetary policy is to set the interest rate at some value, i_0.

[5] In IS relation, consumption, C, is a function of disposal income, Y- T. Investment I, depends on the output, Y, and real interest rate, r. In Eq. 2.1, it assumes that the level of domestic price is given so the real interest rate, r, is the same as the nominal interest rate, i. We simply replace the real interest rate, r, by the nominal interest rate, i.

The interest parity condition enters the IS equation in the relationship of net exports. Eq. 2.4 below shows the interest parity condition states of the relationship between the interest rate and the exchange rate between a foreign country and the home country. In detail, the interest parity condition implies a positive relationship between the home interest rate and the current exchange rate; holding the expected exchange rate and foreign interest rate, i_t^*, unchanged. In this case, an increase in the domestic interest rate, i_t, will lead to an immediate appreciation.

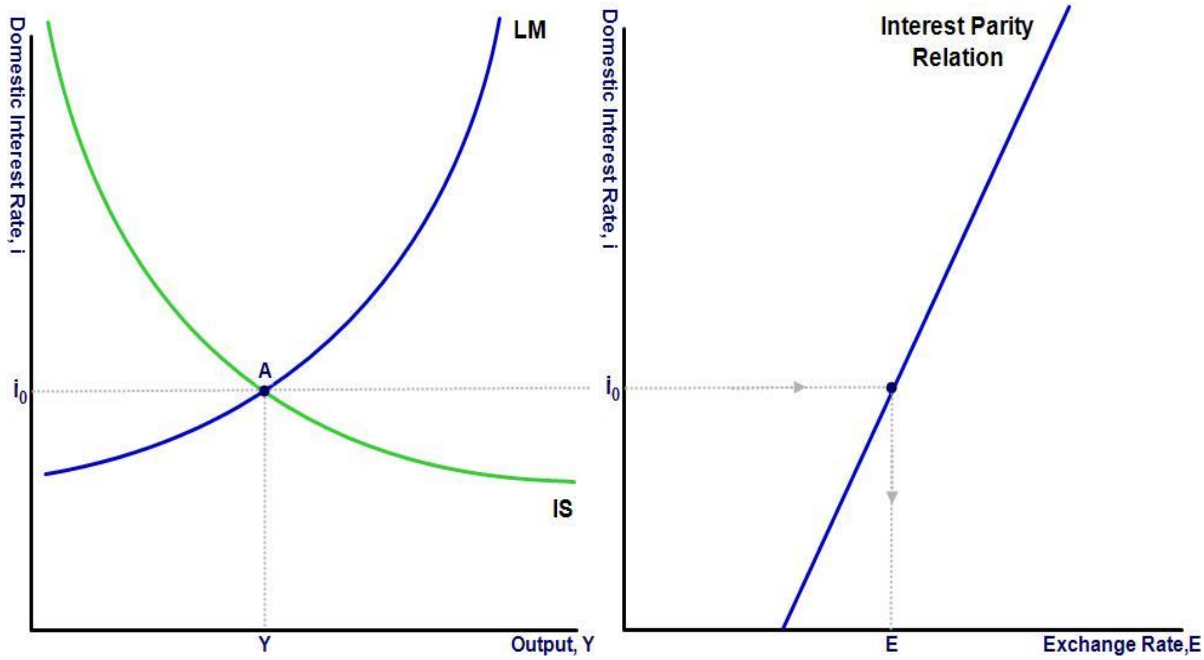
$$E_t = \frac{(1+i_t)}{(1+i_t^*)}\overline{\mathrm{E^e}} \tag{2.4}$$

where $\mathrm{E_t}$ denotes current nominal exchange rate which is the price of Australian currency in terms of foreign currency (the "European terms")[6]. $\overline{\mathrm{E^e}}$ represents the expected future exchange rate. A raise of exchange rate means an appreciation.

Figure 2.1 presents the Mundell-Fleming model. On the IS curve, an increase in the interest rate will lead to a decrease in demand and output directly and indirectly. The direct effect is through decreasing in investment, while the indirect effect is through the appreciation of the exchange rate. For the LM curve, an increase in income will lead to a rise in interest rate along the curve. Altogether, the Mundell-Fleming model shows that the domestic interest rate determines the equilibrium of the exchange rate according to the interest parity condition, given the foreign interest rate and the expected exchange rate.

[6] The nominal exchange rate could be quoted in two methods: *i).* The price of the foreign currency in terms of Australian dollar (i.e. AUS $1.3875 per US dollar); *ii).* The price of Australian dollar in terms of foreign currency (i.e. $0.7207 per Australian dollar). The first quotation is called direct (or American) terms while the second method is called indirect (or European) terms.

Figure 2.1 Mundell-Fleming Model



Source: Blanchard and Sheen (2013)

According to Thomas (1997), the shock impacts explained by the Mundell-Fleming model can be classified into three types: an aggregate supply shock; an aggregate demand shock; and a nominal shock. A positive supply shock will cause excess supply in the domestic goods market and, as a result, leads to a depreciation of the exchange rate. A positive demand shock will cause excess demand and result in an appreciation of the exchange rate. The output level will increase in the short-run. A nominal shock which lowers the interest rate, increases output levels, and leads to a depreciation in the short run.

The above Mundell-Fleming models are set-up on two assumptions: the first is perfect capital substitutability, which assumes that domestic and foreign bonds have the same expected returns, and the second is perfect capital mobility, which means the absence of international capital controls. According to Blanchard and Sheen (2013), perfect capital substitutability tends to exist between countries that have similar risk characteristics, and where the volatility of the exchange rate is modest. When the perfect capital substitutability assumption is relaxed, it requires the addition of a relative risk premium on the interest parity condition, denoted by ρ_t. A positive ρ means that the investment risk on domestic bonds is higher than that of foreign bonds, and vice versa. Perfect capital substitutability implies that ρ equals zero when the investment risks of the two countries are identical. Similarly, the second assumption of perfect capital mobility is more likely to exist for developed countries as developing countries generally have capital controls on the market.

2.2.2 *AA-DD Model*

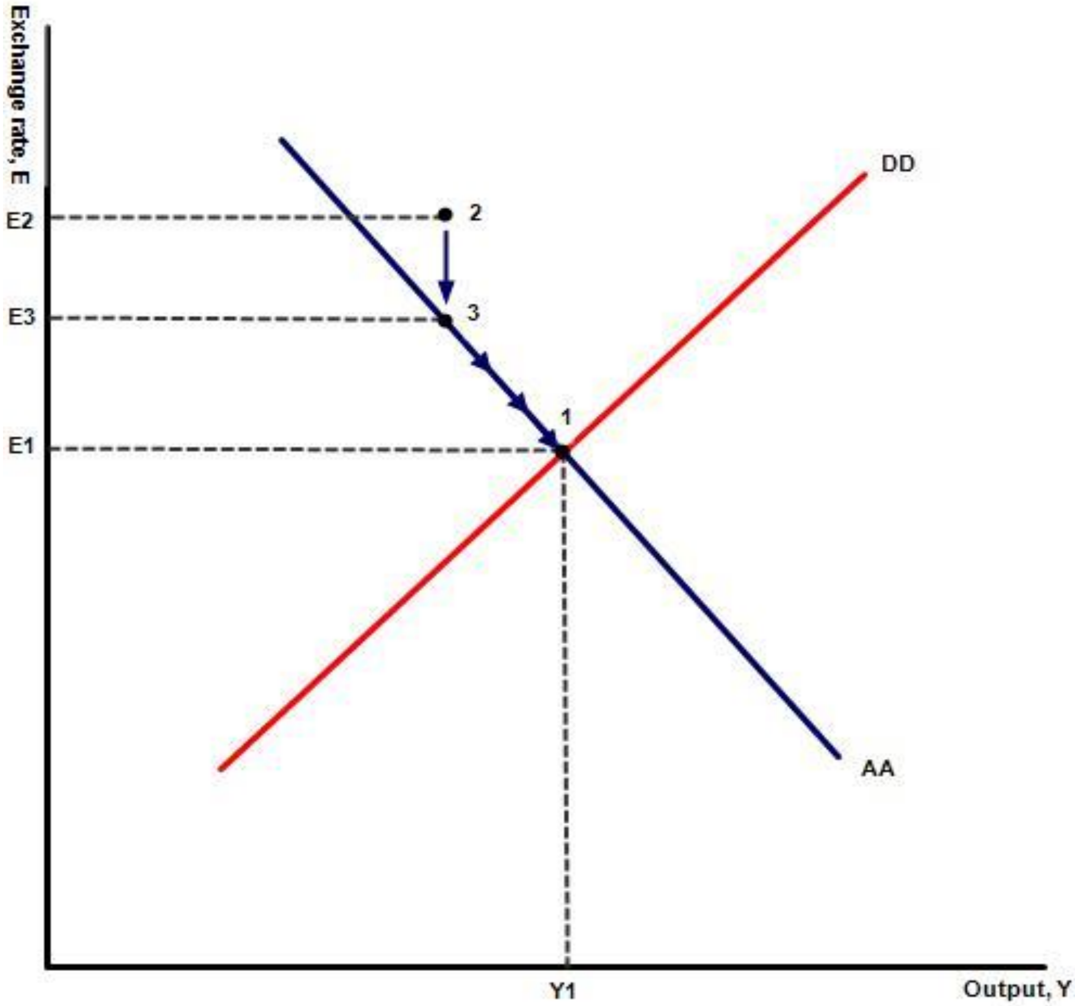
Krugman et al. (2015) implies a standard exchange rate model, AA-DD model, to explain a real exchange rate shock on output. The model involves three markets: the domestic goods market, the money market, and the foreign exchange market[7]. The DD curve captures the relationship of exchange rate and output in the goods market; a real depreciation of domestic currency leads to an increase in output[8]. The AA curve captures the relationship from output to exchange rate. An increase of output level leads to a rise in the domestic interest rate, and a real appreciation of domestic currency.

Figure 2.2 shows the adjustment process of an exchange rate shock. As explained by Blanchard and Sheen (2013), an unanticipated shock will affect people's expectations. Once the future-expected exchange rate changes due to the shock, the equilibrium of the asset market will not hold. Meanwhile, the movements of the exchange rate will change the components of aggregate demand, such as the current account. There is little chance that the positive and negative effects of imports and exports will simply offset each other and the output level remain unchanged. Moreover, as the depreciation

[7] The domestic money market and the foreign exchange market could be combined and would then constitute the asset market.
[8] In AA-DD model, exchange rate is quoted in "American terms". A raise of exchange rate means a depreciation.

is unanticipated, the exchange rate will move to the area above both the AA and DD curves, but will not be located exactly above point 1 in most cases.

Figure 2.2 An Unanticipated Exchange Rate Shock



Source: Krugman et al. (2015)

At point 2, both goods market and asset market are not in equilibrium. The high position of the real exchange rate leads to two issues. First, the future exchange rate is expected to fall as the exchange rate is so high compared to the position of the AA curve. According to the interest rate parity defined in Krugman et al. (2015), the appreciation of the expected future exchange rate implies that the expected domestic currency return on foreign deposits is lower than that on domestic deposits. As a result, it creates excess demand for the domestic currency in the foreign exchange market. Second, the high position of the real exchange rate will make domestic goods much cheaper than foreign goods. In this case, it creates an excess demand for output.

The excess demand for domestic currency causes a fall from point 2 to point 3. As point 3 is located on the AA curve, the asset market is on equilibrium. The second issue of excess demand of output will move point 3 along the AA curve until it reaches point 1 due to the increases in firms' production. At point 1, the aggregate demand and supply are equal, which implies that all three markets are in equilibrium.

A crucial assumption made on DD curve is that the change of exchange rate will affect output (or aggregate demand) contemporaneously. It assumes that, other things being equal, a real depreciation will improve the current account immediately, and vice versa. In reality, this is not always the case. The J-Curve is used to explain the time lags when facing a real depreciation.

In the real world, the current account will decrease sharply right after the real depreciation. This is because most export and import contracts are signed in advance. Assuming the trade volume will not be affected significantly by the real exchange rate, the primary effect will rest on the value of the trade. The export volume will not respond to the real depreciation immediately, but the value of imports will increase due to the movement of the exchange rate. Therefore, the current account will fall initially.

Even after the old contracts end, the market still takes time to adjust fully to exchange rate movements. On the production side, producers need to install more equipment and hire additional labour, and imports need some time to find substitutes. Meanwhile, on the consumption side, there are lags for foreign markets to expend the consumption on domestic goods. According to the J-Curve, the increase of the current account response to the real depreciation will happen in lags. Consequently, it is the same for output due to the increase in the current account.

However, the size of the J-curve effect is subject to the "pricing to market" (PTM) in international trade. The term PTM was first introduced by Krugman (1986) to a phenomenon of third-degree price discrimination[9] imposed by foreign exporters on importers according to the national location. As a result, the import price will become stickiness, and the value increase of imports in the primary effect will be smaller.

2.3 Labour market theory

Labour economics is the study of the demand and supply for the labour market factors of production and human capital. Modern labour economics started with the "Human Capital" revolution by Gary Becker in the 1960s. Since then, the modern labour economy has developed with two significant features, stated by Freeman (2008). The first investigates the behaviour of the individual associated with advanced econometrics. The second is that modern labour economics focuses more on the supply side of the labour market compared to previous labour economics studies.

More recent studies consider the labour market as made up of labour demand, supply and institutions. One stream of study, which is closely linked with human capital, and studies the markets for highly educated workers, who result in a difference of labour force supply and demand in the market. The models used in this area include the cobweb model and the market-clearing model with rational expectations. Another stream of labour economics deals with labour mobility by industries and by geographic, unemployment and related wage patterns[10]. Through observing the patterns of labour

[9] The first degree price discrimination is defined as a monopolistic producer and introduced a heterogeneity among observed consumer types on the market. Under second degree price discrimination, a monopolistic producer could not observe the signals of consumer types on the market. The heterogeneity therefore is put on monopolistic producers' self-selected consumer types. The third degree price discrimination is defined as a monopolist (a foreign exporter), and sets a price discrimination on the domestic importer, according to the national location.

[10] Freeman, R 2008, 'Labour economics', *The New Palgrave Dictionary of Economics*, 2nd Edition, 2008

.

mobility and wage setting across different markets, it is clear that decentralised wage setting will bring benefits to labour mobility.

An important question is whether unemployment is a short-term cyclical phenomenon or long-term structural change. Sorensen and Whitta-Jacobsen (2010) presents types of unemployment through their various causes. They distinguished two types of wage rigidities: short-run cyclical unemployment is caused by short-run wage rigidities, which means the nominal wages rate will adjust to the exogenous shocks with a lag. The long-run wage rigidities occur when the wage-taking labour supply exceeds employment so that the real wage, W/P, has already fully adjusted. In that case, the unemployment caused by the long-run wage rigidity is called long-run structural or natural unemployment. The causes of long-run wage rigidity include abuse, frictional unemployment, search unemployment, efficiency wage and trade unions. In this thesis, the empirical results presented in Chapter 4 only focus on short-run employment growth by industry.

2.4 Structural Vector Autoregression model

The innovation of the VAR model began with Sim's critique in 1980 in his article "Macroeconomics and Reality". He criticised the specification and identification of classical simultaneous equations and advocated SVAR. The VAR method enables the use of the most relevant variables to solve the research questions. By imposing restrictions, the SVAR models reflects the structure of a specific economy. After introduced in Sims (1980), SVAR has been applied in several important research studies in the literature. Sims and Zha (2006a) used SVAR to document the effects of money on output. Blanchard and Quah (1989) use SVAR to analyse the impacts of supply and demand shock on the business cycle.

In Australia, Berkelmans (2005) estimates a SVAR model to examine the response of credit to a monetary policy shock. Lawson and Rees (2008) use a SVAR model to investigate the effect of an unanticipated monetary shock on the expenditure and production components of GDP. Later, Dungey and Pagan (2009) develop a SVAR for the Australian economy.

In theory, SVAR starts from the primitive system as in Eq. 2.5 below, which contains the interrelationship between variables.

$$A_0 Y_t = c + A_1 Y_{t-1} + A_2 Y_{t-2} + \cdots + A_p Y_{t-p} + \varepsilon_t \qquad (2.5)$$

where ε_t is uncorrelated white-noise structural shock. For the purposes of estimation, the reduced-form VAR model is generated by multiplying A_0^{-1} on both sides of Eq. 2.5. Thus, we obtain Eq. 2.6 as follows:

$$Y_t = k + \mathrm{B}_1 Y_{t-1} + \mathrm{B}_2 Y_{t-2} + \cdots + \mathrm{B}_p Y_{t-p} + e_t \qquad (2.6)$$

where $k = A_0^{-1} c$, $\mathrm{B_i} = \mathrm{A}_0^{-1}\mathrm{A_i}$ for $i = 1, \ldots, p$, and $\mathrm{e_t} = \mathrm{A}_0^{-1}\varepsilon_\mathrm{t}$. Thereafter, the estimation of the reduced-form for the structural form parameters of the VAR process could be done by least squares, maximum likelihood, or the Bayesian method.

2.4.1 *Identification*

As pointed out in Zha (2008), one of the major objectives for the VAR process is to obtain the economically meaningful impulse in response to structural shocks as defined in the primitive system.

Enders (2014) explains that the minimum number of restrictions depends on the knowns and unknowns of matrix A. Let *n* represent the number of variables. The known elements are $(n^2 + n)/2$. This is because the total number of knowns equals *n* distinct elements from the principle diagonal plus $(n^2 - n)/2$ elements off the principle diagonal. In return, the results of $(\mathrm{n} + (n^2 - n)/2)$ is $(n^2 + n)/2$. The unknown elements include two parts. First, matrix A has $(n^2 - n)$ unknowns, where minus *n* represents the 1s of principle diagonal elements. Meanwhile, there are *n* unknown variance of μ. In total, the number of unknowns equals to $(n^2 - n + n) = n^2$. The minimum number of restrictions is $n^2 - [(n^2 + n)/2] = (n^2 - n)/2$.

In the literature, there are two additional popular identification strategies: short-run restrictions and long -run restrictions. According to Enders (2014), Sims (1986) provides the first identification strategy regarding a money supply shock in a six-variable SVAR in the short-run. The idea behind it is that there is a lag effect for the impact of shocks on the economy. The long-run restrictions are provided in Blanchard and Quah (1989), which intend to reconsider the Beveridge and Nelson (1981) decomposition of real GNP into its temporary and permanent components. This identification traces the long-run shock effects on the economy.

2.4.2 *Impulse Response Analysis*

Impulse response analysis is used to analyse the dynamic interactions between the endogenous variables of a VAR(p) process. Impulse response functions present the reactions of variables to a specific shock. We start from a stationary reduced-form VAR system of order *p* defined in Eq. 2.6. A stationary VAR(*p*) process has a Wold moving average MA(∞) representation, as in Lutkepohl (2008):

$$Y_t = e_t + \Phi_1 e_{t-1} + \Phi_2 e_{t-2} + \cdots = e_t + \sum_{i=1}^{\infty} \Phi_i e_{t-i} \tag{2.7}$$

The row i, column j element of the matrix Φ_s for $s = 1,2,\ldots$ may be interpreted as

$$\phi_{s,ij} = \frac{\partial y_{i,t+s}}{\partial e_{j,t}} \tag{2.8}$$

Eq. 2.8 represents the impulse response analysis based on the reduced-form which traces the marginal effect of shock e_j on one variable y_i at time t. However, Lutkepohl (2008) claims that this impulse response is based on the counterfactual experiment which may not reflect the actual response. This is because the reduced-form error term, e_t, is instantaneously correlated. We are thus interested in the impulse response function with uncorrelated white-noise structure shocks, ε_t . Therefore, orthogonalised impulse responses are considered under this case. By using the Choleski decomposition, we would be able to recover the structural parameters in the primitive system from the reduced-form VAR model. The details of the Choleski decomposition is discussed in Subsection 4.2.3.

As a result, the impulse response function with respect to the structural shocks is defined as the response of the variable y_i for $i \in \{1, \dots, k\}$ at time $t+s$ to a one standard deviation increase in the shock ε_j for $j \in \{1, \dots k\}$ at the time period t given by

$$\psi_{s,ij} = \frac{\partial y_{i,t+s}}{\partial \varepsilon_{j,t}} \tag{2.9}$$

By applying the Choleski decomposition, the first variable may have an instantaneous effect on all the variables, whereas a shock in the second variable cannot have an instantaneous impact on the first variable but only on the other variables, and so on. Therefore, this is consistent with the recursive assumption discussed in Subsection 4.2.3. Meanwhile, the effects of a shock may depend on the way the variables are ordered in the vector y_t. The estimations of impulse response functions are generally obtained from VAR parameter estimates.

Lutkepohl (2005) lists critiques of impulse response analysis. One of problems is the possibility of an omitted variable in low-dimensional VAR systems. Omitted variables are currently treated in the innovations. However, if an important variable is omitted, the impulse response analysis based on this structural VAR may not reflect the actual responses to the shocks.

2.4.3 *Forecast Error Variance Decomposition*

According to Lutkepohl (2008), an h-steps ahead forecast conditional on original T can be obtained from the reduced-form VAR system (Eq. 2.6) recursively for h=1, 2, …, as follows:

$$y_{T+h|T} = k + \mathrm{B}_1 y_{T+h-1|T} + \cdots + \mathrm{B}_p y_{T+h-p|T} \tag{2.10}$$

Hence, the forecast error is now easily described as follows. Denoting the forecast of $y_{i,T+h}$ made at time T by $y_{T+h|T}$. Variable k's variance of the forecast error

$$y_{T+h} - y_{T+h|T} \tag{2.11}$$

Is given by

$$\mathrm{var}\left(y_{T+h} - y_{T+h|T}\right) = \sigma_k^2(h) = \sum_{j=1}^{k}(\theta_{kj,0}^2 + \cdots + \theta_{kj,h-1}^2) \tag{2.12}$$

The term $(\theta_{kj,0}^2 + \cdots + \theta_{kj,h-1}^2)$ represents the contribution of variance j to the h-step forecast error variance of variable k. Forecast error variance decomposition is now defined as the percentage contribution of variable j to the h-step forecast error variance of variable k, computed as follows:

$$\omega_{kj}(h) = \frac{\theta_{kj,0}^2 + \cdots + \theta_{kj,h-1}^2}{\sigma_k^2(h)} \tag{2.13}$$

Forecast error variance decomposition is proposed by Sims (1980). Once again, to make the interpretation of Eq. 2.13 to be economically meaningful, we could apply a popular method of the Choleski decomposition here. Similar to impulse response analysis, the estimation of the forecast error variance components, $\omega_{kj}(h)$, are generally obtained from VAR parameter estimates.

2.5 Hysteresis

Hysteresis occurs when a temporary exogenous disturbance causes a permanent effect and, as a result, the economic status does not return to its initial position when the exogenous disturbance is removed. Hysteresis applies to several fields in economics such as when a short-run shock effect causes structure changes in the long-run. The term “hysteresis” was first coined by James Alfred Ewing in his paper published in 1881. Alexei Pokrovskii later contributed significant efforts on applying hysteresis to the economics system. As stated in Gocke (2002), hysteresis is now predominantly in two fields: i) labour economics of the time path dependence of the “natural” rate of unemployment; ii) the analysis of the relationship between the exchange rate and foreign trade in relation to persistent effects. In this section, we first discuss the determinants of economic hysteresis in both trade and labour economics. Further, we present three basic types of hysteresis in microeconomics and in macroeconomics through aggregating a multitude of weak-hysteretic behaviour[11].

2.5.1 *Determinants of Economic Hysteresis*

According to Gocke (2002), the hysteresis of trade would be determined by three major factors. The supply side determinants are sunk costs and unit cost. Sunk costs include the entry cost and expansion investment. Every firm has its own sunk cost and variable cost. The change of market price will affect firms’ decisions on supply quantities, shutdown or market access. As for the unit cost, Gocke (2002) states that a decrease of unit cost may be caused by the learning effects from former production activities. On the demand side, opening a new market is another factor that causes hysteresis. Opening

[11] Weak-hysteretic relations exist at the microeconomic level as a trigger value that is necessary to induce a persistence hysteretic effect. On the macroeconomic level, the passing of trigger value is not necessary as the macro-hysteretic aggregates the weak hysteretic behaviours. In this case, the macro-hysteretic is called strong-hysteretic. Trigger value is defined as value that switches to another possible situation.

a new market will result in temporary revenue declines due to capital adjustment and training costs. Later, revenue will rise due to the product becoming well-recognised.

According to Gocke (2002), hysteresis determinants for unemployment is due to following factors. First, in the labour market, the employers must pay the hiring cost for the hiring and training employees. The hiring cost is treated as sunk cost. Secondly, the demand of labour is based on its productivity. Generally, a long employment will raise the productivity and gain more relevant experience according to on-job-learning. The more experienced employees tend to have higher productivity, thus receive higher pay. Finally, inactivity in labour market lowers the quality of unemployed labour due to the lack of on job training. As employers aware of this effect, a long duration of unemployment will lead to a negative impact on the new hires.

2.5.2 *Types of Hysteresis*

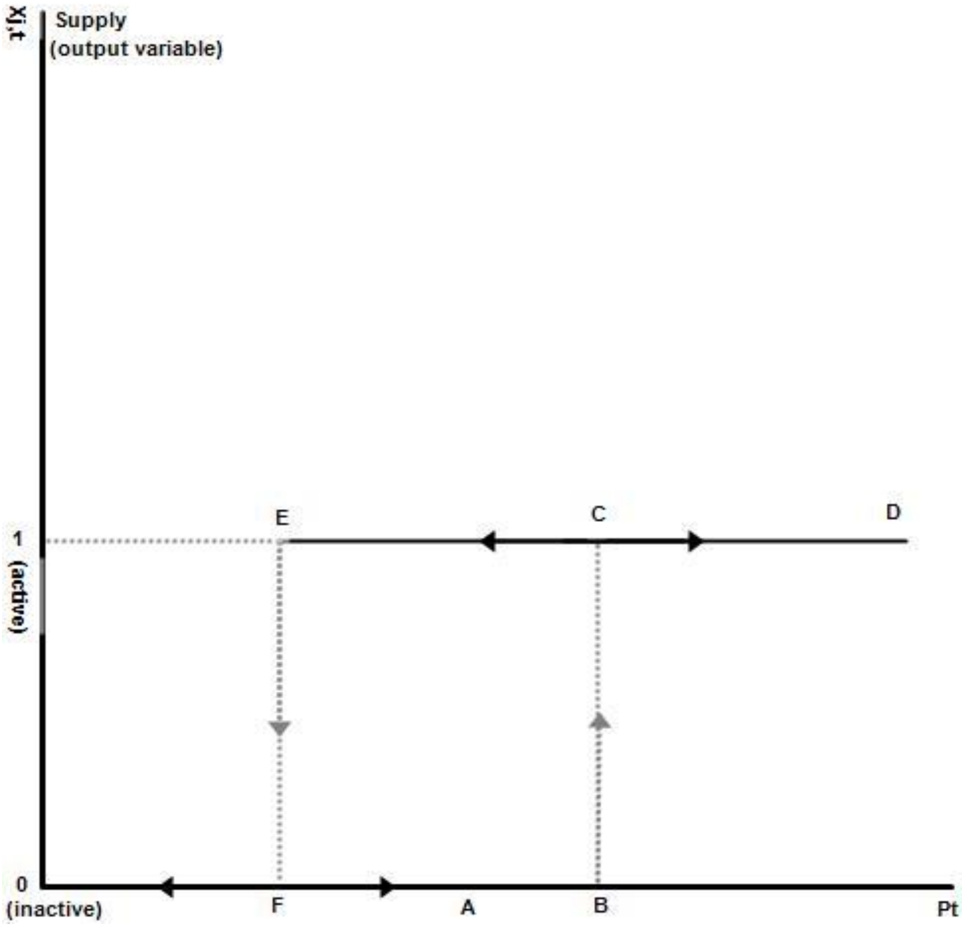
i) The 'Non-Ideal Relay' of Micro-Hysteresis

This micro-hysteresis is named 'non-ideal relay' is because of the switch between two possible situations based on two trigger values, as explained in Krasnosel'skii and Pokrovskii (1989). In the 'non-ideal relay', the trigger value is denoted by the supply of a firm *j* at time t, $x_{j,t}$. Let p_t denote market price, c_j denote variable costs and k_j denote fixed costs. The supply of price-taking firm *j* is summarised below:

$$x_{j,t} = \begin{cases} 1 & if\ (x_{j,t-1} = 0\ and\ p_t > c_j + k_j) \\ 1 & if\ (x_{j,t-1} = 1\ and\ p_t \geq c_j) \\ 0 & if\ (x_{j,t-1} = 0\ and\ p_t \leq c_j + k_j) \\ 0 & if\ (x_{j,t-1} = 1\ and\ p_t < c_j) \end{cases} \tag{2.14}$$

According to Eq. 2.14, if the firm enters a new market at time t, the market price, p_t, must be greater than the sum of variable costs and fixed costs. Then, at time t, the supply of the firm will be 1. Assuming the firm produces 1 unit at time t-1 and the market price could cover the variable costs, at time t, a firm will continue producing 1 unit at time t. Next, if the market price at time t is less than the sum of variable costs and fixed costs, the firm will not enter the market. At last, the firm will exit the market when the market price at time t could not cover variable costs. The trigger value 0 and 1 determines the hysteresis loop in Figure 2.3.

Figure 2.3 Hysteresis Loop of 'Non-Ideal Relay'



Source: Gocke (2002)

At point A, the market price is less than $c_j + k_j$ so the firm will not enter the new market. The supply of the firm would be zero until the price reaches point B. At point B, the firm enters the new market, which implies that a jump from $x_j = 0$ line to the second branch $x_j = 1$ line (point C). At point C, if the market price declines, but is still greater than c_j. The firm will continue supplying one unit as long as the variable costs could be covered. When the price is lower than that of point E ($p_t < c_j$), the firm will exit the market. As a result, the supply of the firm will jump to $x_j = 0$ line.

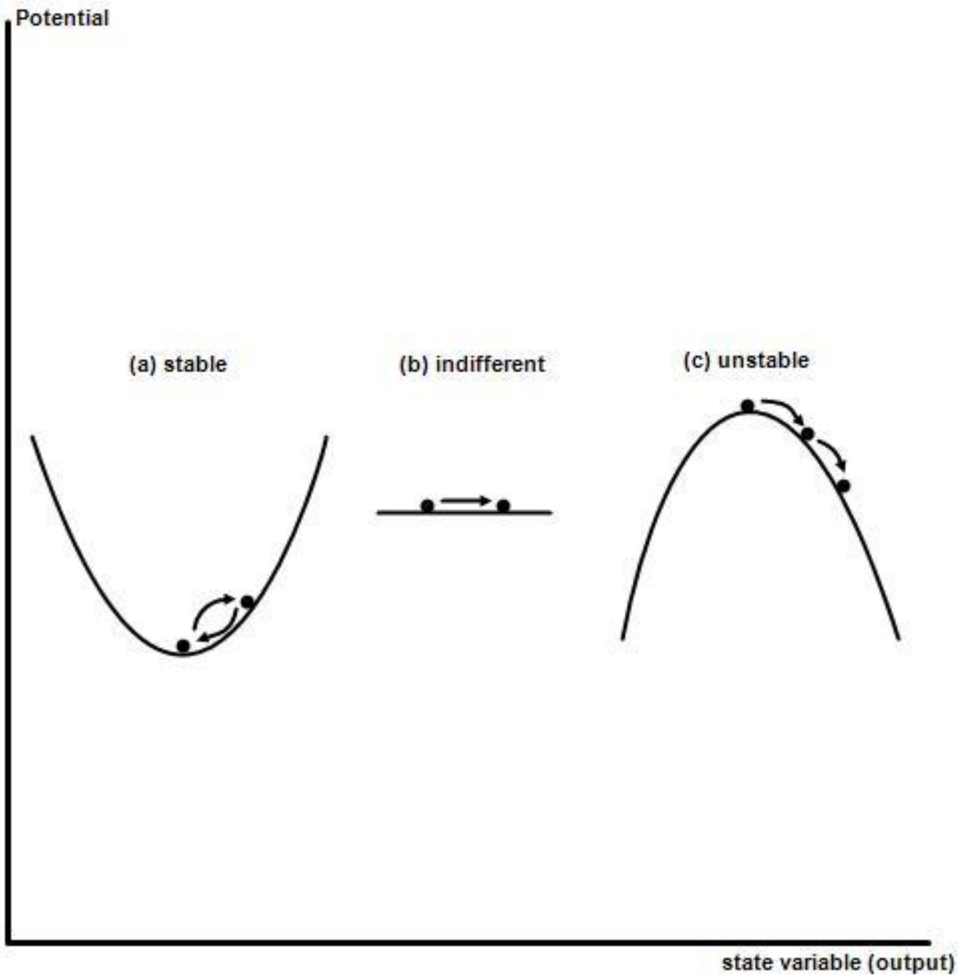
The 'non-ideal relay' is a simple case as transition is only between two possible branches. However, the relation is non-linear as the switch is between different branches. Meanwhile, the branch itself could be non-linear, as pointed out in Gocke (2002). Moreover, this hysteresis is reversible. In application, the trigger values may be due to a large shock which leads to a permanent effect in economics.

ii). Catastrophe Theory of Micro-Hysteresis

The catastrophe theory relates to non-linear models with multiple equilibria where sudden 'jumps' occur between different equilibria. Figure 2.4 illustrates different equilibrium situations. Equilibria are the points which have zero slope on the potential function[12]. The shape of the potential function depends on the parameters. If parameters imply a convex potential curve, the equilibrium would be a stable point located at the minimum of the potential function as in part (a). If the parameters imply a concave potential curve, the equilibrium would be an unstable point as the maximum of the potential function in part (c). If the parameters show that the potential curve is a horizontal line, all points are equilibria and indifferent as in part (b). According to Gocke (2002), in this case, as impulse on the equilibria has a persistent effect, the adjustment process is implied by the non-zero slope points. In a relatively complex case, 'cusp-catastrophe' theory could be implied to show the abrupt changes between different equilibria as in Gocke (2002).

[12] Potential means the optimum in economics according to Gocke (2002). For example, minimize the costs or maximize the profits.

Figure 2.4 Hysteresis Loop of Catastrophe Theory



Source: Gocke (2002)

iii) 'Mechanical Play' of Micro-Hysteresis

The third type of micro-hysteresis is called 'mechanical play' which results from sunk adjustment costs. According to Gocke (2002), in this case, the firm has to pay additional variable costs due to the adjustment of sunk costs. These costs, k_j per unit, associated with the cost increases in the firm's production expansion and distribution capacity. It therefore depends on the different production level of the cost function of the firm. One of the cost functions is under the condition when $x_{j,t} \leq x_{j,t-1}$.

The other function for a firm's costs when $x_{j,t} > x_{j,t-1}$. implies that there are two different optimal quantities as in Eq. 2.15.

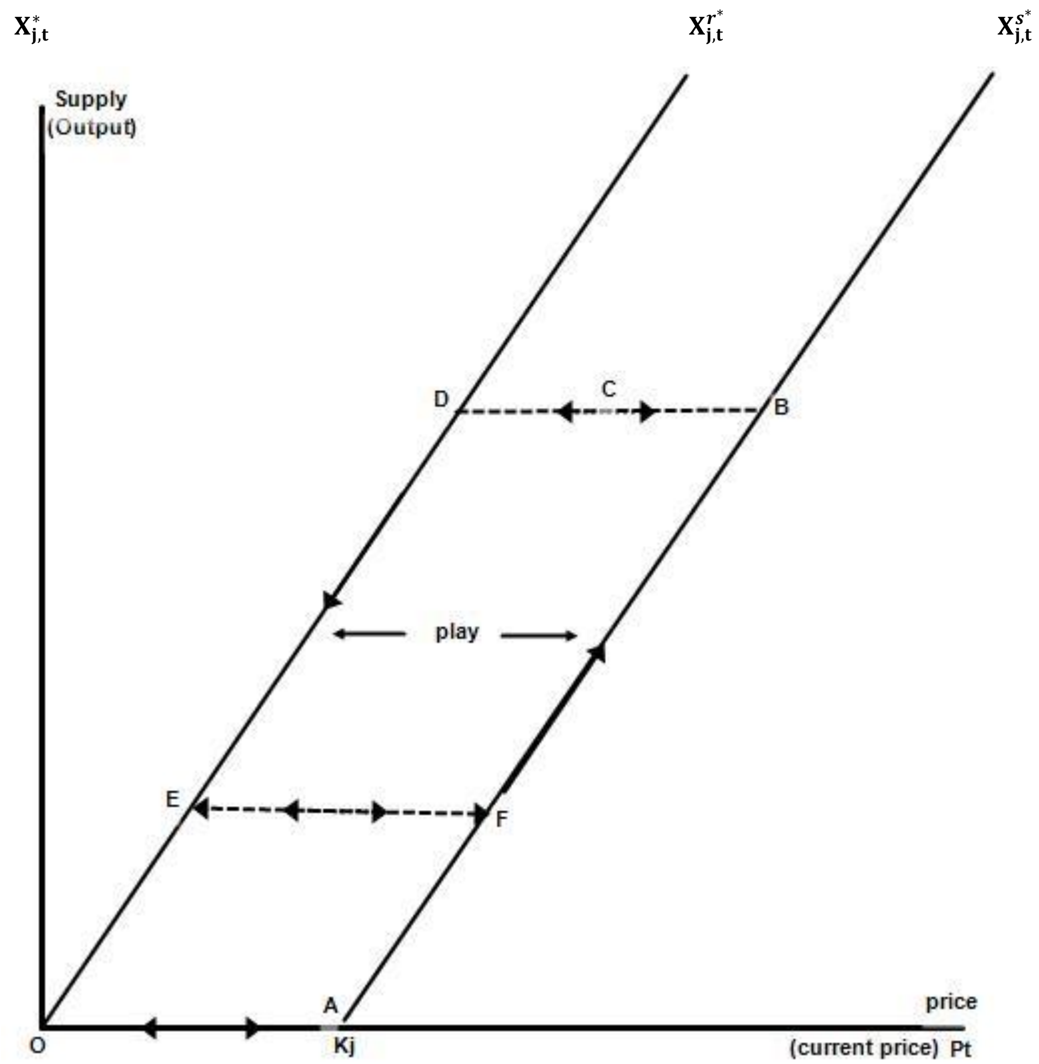
$$x^{s^*}_{j,t} = \frac{p_t - k_j}{2 \cdot c_j} \left(x_{j,t} \leq x_{j,t-1}\right) \quad and \quad x^{r^*}_{j,t} = \frac{p_t}{2 \cdot c_j} \left(x_{j,t} > x_{j,t-1}\right) \quad \text{with:} \quad x^{r^*}_{j,t} \geq x^{s^*}_{j,t} \qquad (2.15)$$

In detail, the optimum supply of the firm, $x^*_{j,t}$, could be classified into three categories via comparing above two conditions' optima, as shown in Eq. 2.16.

$$x^*_{j,t} = \begin{cases} x^{s^*}_{j,t} = \frac{p_t - k_j}{2 \cdot c_j} & if\ (x^{s^*}_{j,t} > x_{j,t-1}) \\ x_{j,t-1} & if\ (x^{s^*}_{j,t} \leq x_{j,t-1} \leq x^{r^*}_{j,t}) \\ x^{r^*}_{j,t} = \frac{p_t}{2 \cdot c_j} & if\ (x^{r^*}_{t,j} < x_{j,t-1}) \end{cases} \qquad (2.16)$$

Figure 2.5 presents the hysteresis loop of 'mechanical play'.

Figure 2.5 Hysteresis Loop of 'Mechanical Play'



Source: Gocke (2002)

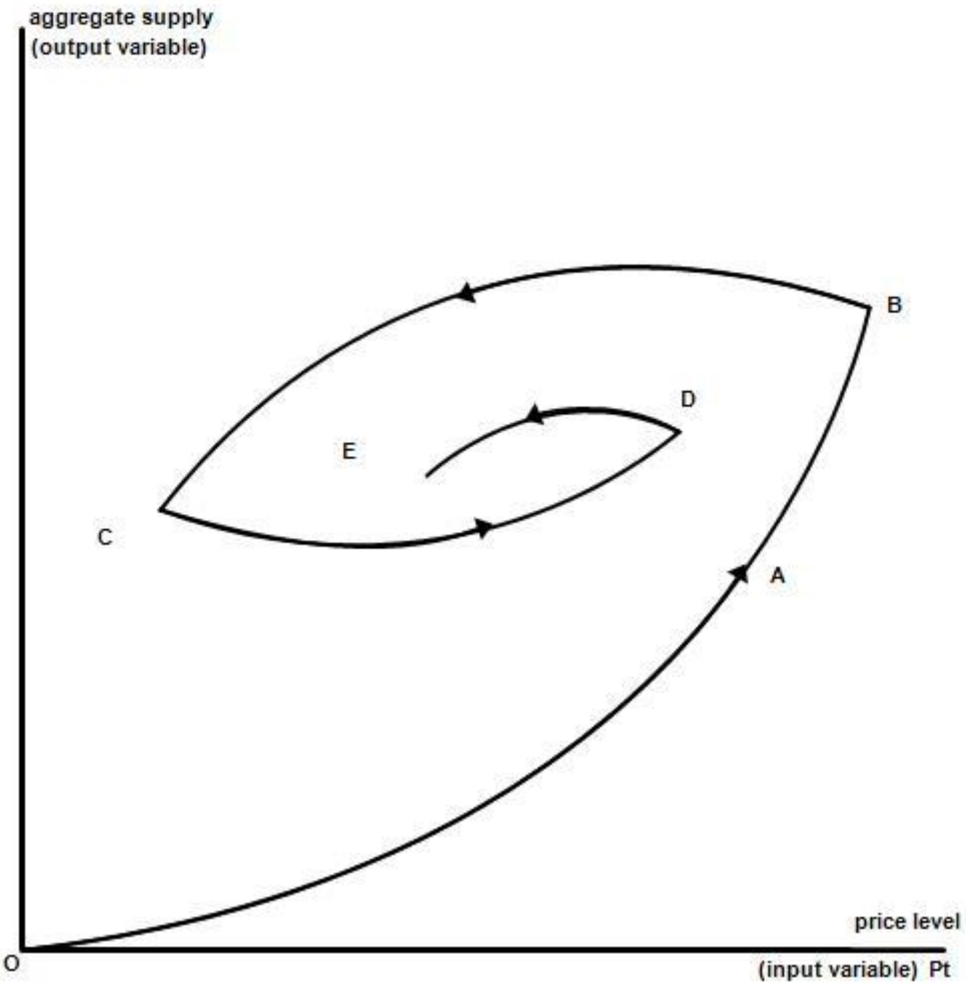
The market price increases from the initial point O. The output will not increase until the market price covers the fixed cost, k_j. After the price reaches point A, the output increases along $x^{s^*}_{j,t}$ line and goes through points A, F, B. This situation implies that $x^{s^*}_{j,t} > x_{j,t-1}$. If at point B, the price starts to reduce, the production will not change immediately. Instead, the production will move along the line BCD. This implies that $x^*_{j,t} = x_{j,t-1}$ with $x^{s^*}_{j,t} \leq x_{j,t-1} \leq x^{r^*}_{j,t}$. Until the market price is less than that at point D, the production starts to decline along $x^{r^*}_{j,t}$ line and goes through points D, E. Once again, if at point

E the market price increases again, the output level will remain the same along the EF line for a while. The output will raise only when the market price exceeds that at point F. From the hysteresis loop of 'mechanical play', the production levels on the OA, EF and BD lines do not respond to the exogenous changes until the size of the price change passes the border. As a result, the change of output induces permanent effects on the change of the economic structure.

iv) Macro-hysteresis

Macro-hysteresis is an aggregation of the micro-hysteresis of individual firms. Amable et al. (1991) and Cross (1993) apply aggregation procedures in Mayergoyz (1986) in economics. The aggregation procedure could be separated into two parts as explained in Gocke (2002). The first part discusses the active firms and inactive firms in the market with two trigger values: the entry trigger price and the exit trigger price. The changes in active firms and inactive firms are caused by the variation of market price. In the second part, the hysteresis loop shows the relationship between the aggregate supply and the price level according to the firms that remain in the market. The macro-hysteresis loop represents the amount of all possible branches as a consequence of the market price. Generally, the more homogeneous the firms are, the more groups of firms there are, thus, there will be more branches. Figure 2.6 shows a simple macro-hysteresis loop demonstrating the relationship between the supply of firms and the price level.

Figure 2.6 Hysteresis Loop of Macro-Hysteresis



Source: Gocke (2002)

2.6 Exchange Rate and Monetary Policy

The Reserve Bank of Australia (RBA) has been operating monetary policy under an inflation target regime since 1993. There are generally three instruments of monetary policy: reserve requirements, lending to banks, and open-market operations. As explained in Blanchard and Sheen (2013), the first instrument, reserve requirements has been abandoned in Australia. On the other hand, open-market operations of government bonds is a commonly used conventional monetary policy. Exchange rate plays an important role in conducting monetary policy as stated by the RBA. Australia adopted a floating exchange rate regime in 1983. During the post-float era, exchange rate behaves as a shock absorb through its contribution to a decline in the output volatility during the shock periods and smoothing the fluctuations.

In this regard, the exchange rate is considered in the transmission mechanism[13] of monetary policy. The change of monetary policy implies a change in operation target for the cash rate. Movement of the cash rate will pass to other interest rates on capital market such as bond yields. The change of interest rate affects both economic activities and inflation. The various mechanisms of economic activities that interest rates may impact comprise the saving and spending behaviours of firms and households, cash flow, the supply of credit, asset prices and the exchange rate. Further, these impacts will bring changes to aggregate demand in the whole economy. In return, the change of aggregate demand, together with the corresponding reaction of aggregate supply, will affect the inflation level. At the same time, inflation will be affected by the exchange rate pass-through and the effect of inflation expectations.

In many theories, the way monetary policy affects the exchange rate is explained by the Mundell-Fleming model and the AA-DD model. Based on Mundell-Fleming model, Blanchard and Sheen (2013) explains the short-run effects of monetary policy on a small open economy. A contraction monetary policy with an increasing interest rate leads to a decrease of output and an appreciation of the domestic currency. Krugman et al. (2015) uses the AA-DD model to show the effect of a contraction monetary policy in the short-run. According to the AA-DD model, the increasing of the domestic interest rate causes interest rate difference between the home country and foreign countries. In order to hold the interest rate at parity condition, the home currency will appreciate. On the other hand, an unanticipated real exchange rate shock will affect the economy to some extent as well, such as in GDP

[13] Reserve Bank of Australia, *About Monetary Policy,* http://www.rba.gov.au/monetary-policy/about.html

growth and the labour market. Detailed analysis of exchange rate shock impacts are presented in Chapter 4.

2.7 Summary

In this chapter we have encountered various theories of how shock impacts the economy from different angles. The purpose of this chapter is to present an overview of theory on shock analysis.

We first provided two macroeconomic models in Section 2.2: the Mundell-Fleming model and the AA-DD model. The models explain the relationship between output and exchange rate in macroeconomic theory. They give the equilibrium level of exchange rate and output. Intuitively, these models constitute part of the motivations. In AA-DD model, a depreciation of exchange rate leads to an increase in demand. As a consequence, the output will raise on aggregate level. However, it is not always the case in our investigations on industries level. Meanwhile, employment growth also varies across the industries. On the other hand, in order to solve the research question, the marcoeconomic models provide the theoretical base for the SVAR models in relates to selecting variables and the recursive order.

Secondly, Section 2.3 provides the basic theories of the modern labour economy. It reviews the studies of labour mobility and the causes of short-run and long-run unemployment. Section 2.4 discusses the theoretical literature reviews of SVAR, a popular method to analyse shocks. The section starts with types of identification in theory, and follows up with the principles of impulse responses analyse and variance decomposition.

In Section 2.5, we briefly described hysteresis in economics. Hysteresis is about the permanent effect caused by a temporary change (or an exogenous shock) and has been applied to both microeconomics and macroeconomics. In this section, we present three basic types of micro-hysteresis and the aggregate method for macro-hysteresis. In application, different econometrics methods would be used for each type of hysteresis in empirical studies. At last, in Section 2.6, the role of the exchange rate in the transmission mechanism of monetary policy is discussed.

In conclusion, from this theoretical review of the literature, we can understand the following important points about shocks from the principles of macroeconomic models for shock analysis, and from the key principles of a common econometric method, SVAR. Also, by understanding the concepts of hysteresis, it can be seen how a temporary shock may have permanent impacts on the economy. Finally, we discussed the close links of exchange rate and monetary policy.

Chapter 3

Literature Review: Empirical

3.1 Introduction

This chapter provides an overview of the empirical work in the literature on exchange rate shocks on output and employment. A summary of the data, methodology and empirical findings in this area is presented. This chapter will first discuss studies in this area done on the Australian economy, and then extend to the international economy.

Section 3.2 reviews papers analysing a temporary unanticipated exchange rate shock and its impacts on the economy. It will first go through Australian research on exchange rate shocks. An overview of foreign researches on this topic will be presented later. This section focuses on empirical results in Subsection 3.2.1, methodology in Subsection 3.2.2, variables and data in Subsection 3.2.3. In addition, according to the advantages of the VAR model which relates to number of variables and restrictions as in Dungey and Pagan (2009), the methodology section will only discuss the VAR models in various research studies. Subsection 3.2.2, also provides some comparisons of the VAR model as it is applied in empirical research.

Section 3.3 presents a summary of empirical work on labour market impacts from real exchange rate shock. Subsection 3.3.1 reviews the research papers on labour market turnover and job tenure, and Subsection 3.3.2, presents the factors that drive job turnover. Subsection 3.3.3 discusses labour mobility and adjustment mechanism in Australian by industries. The final Section 3.4 summarises this chapter.

3.2 The Exchange Rate and Output

3.2.1 *Empirical Findings*

i) The Exchange Rate and Aggregate Output

In order to assess the impacts from movement of the real trade-weighted exchange rate on Australian aggregate output, the model implied in the research is important. Kohler et al. (2014) compares the results of two different models: SVAR and DSGE. Table 3.1 shows that the estimated impacts of an unanticipated exchange rate shock depend to some extent on the model chosen. Furthermore, SVAR is commonly used in analysing the effects when a shock hits the economy. In light of this, Table 3.2 presents results from three research papers that use SVAR to analyse the impacts of exchange rate shock on the euro area, New Zealand and Australia, respectively.

Table 3.1: Effect of the Exchange Rate on Output – Estimated response to a 10 per cent real TWI depreciation

	Temporary Change in the Exchange Rate	
	Peak Effect on Level of GDP	**Peak Timing**
Model	Per cent	Quarters after Depreciation
SVAR	0.3~0.6	4-6
DSGE	0.4	2

Source: Kohler et al. (2014).

Table 3.2: Effect of the Exchange Rate on Euro Area, New Zealand and Australian Output

	Temporary Change in the Exchange Rate	
	Peak effect on level of GDP	**Peak Timing**
Model	Per cent	Quarters after Appreciation
Euro area[(a)]	-0.14	4-5
New Zealand[(b)]	-0.1~-0.11	5
Australia[(c)]	-0.3~-0.6	4-6

Notes: [a] Hahn (2007) estimates the impacts of a one percent appreciation of the nominal effective exchange rate.
[b] Karagedikli et al. (2013) estimates the impact of a one per cent shock to the nominal exchange rate.
[c] Estimated response to a 10 per cent real TWI appreciation in Manalo et al. (2015).

Table 3.1 summarises the estimated results of the SVAR and DSGE models, and shows that a temporary 10 per cent depreciation will lead to an increase in GDP level by one-third to three-fifths per cent within two years. According to Kohler, Manalo and Perera (2014), a 90 per cent confidence interval is implied in the SVAR method. After about one year, there is a 90 per cent probability that the shock impact on GDP will be between 0 and three-quarters per cent. However, this result is insignificant. The results summarised in Table 3.2 demonstrate that a short-run exchange rate shock (an appreciation) will reduce GDP by 0.1 to 0.14 using nominal the exchange rate, and by 0.3 to 0.6 using the real exchange rate in four to six quarters.

ii) The Exchange Rate and Industry Activity

At the industrial level, responses to exchange rate shock can be different. Kohler et al. (2014) points out that there are two main effects determining the shock impacts across industries. The first effect of Australian dollar depreciation is through “expenditure switching”, which allows the most trade-exposed industries to benefit from the depreciation. Industries with a high degree of import competition will also benefited. In Australia, mining, manufacturing and transport are the largest industries exposed to international trade. Industries such as construction, business services, health and education have relatively low trade exposure. Manufacturing also faces a significant degree of import competition. On the other hand, construction, business services, health and education have much lower degrees of import competition. The first effect of exchange rate depreciation is: raising the output level through an increase in the export competitiveness of Australian goods. The second effect on output by depreciation is the increasing import costs, which may partly offset the expansion of GDP. However, the extent to which imports may be substituted by domestic goods is subject to many factors, and there are many issues firms need to consider before replacing foreign supply with domestic supply, which could reduce the size of the second effect.

Lawson and Rees (2008) shows that in most industries, output levels are raised when the currency depreciates. This is because depreciation increases export competitiveness and reduces import competition for trade-exposed industries. In addition, it may lead to higher aggregate demand associated with higher income and employment. Therefore, the two most trade-exposed industries, manufacturing and mining, are also the most sensitive to an exchange rate shock. A 10 per cent exchange rate depreciation will cause output in these two industries to increase by one per cent after two to six quarters. Industries which have close links to the above two industries, such as business services, also respond to the exchange rate shock. Industries with little trade exposure, such as construction, will have the lowest response to the shock given that these industries have little external demand or import competition in international markets. These results are consistent with findings in Manalo et al. (2015).

Kohler et al. (2014) further states that the shock impacts of some industries to a depreciation is negative at the first few quarters and increases later. This is because industries that are closely related to household spending will have an initial negative effect due to the higher cost of imported goods. In addition, depreciation will increase the cost of raw materials and intermediate inputs and will shrink the profits of firms. The manufacturing and transport industries will be generally affected by this profit outcome because of the increase in input costs.

Hahn (2007) demonstrates that production in different industries has various sensitivities to impacts by one per cent appreciation of the nominal effective exchange rate in the euro area. Industrial production is divided into four categories: capital goods, intermediate goods, consumer goods and energy goods production. The estimated findings demonstrate that capital goods show the largest response to exchange rate shock in the EU. This is because of the high degree of trade exposure and import competition in this sector. The response of intermediate goods production to exchange rate shock is smaller than that for capital goods but is still substantial. However, the response from consumer goods production is much smaller. The output response for energy production is insignificant but slightly positive. The relatively high response from intermediate goods output is due to the low degree of product differentiation and the high degree of import competition. The lower response for consumer goods output is due to the large product differentiation as well as the low price elasticity of demand for non-durable consumer goods. Hahn E (2007) explains that there are several factors affecting the responses for energy goods production. First, energy production in the euro area is largely focused on the domestic market. Meanwhile, the higher degree of international market segmentation and oligopolistic market structures in some euro areas lowers the degree of sensitivity to exchange rate movements in this sector. Moreover, in energy production, most inputs in the euro area are imported. An unanticipated appreciation in the euro will benefit imports, therefore production in this sector will increase.

It is also noticed in Hahn (2007) that the adjustment speed of exchange rate shocks is different across the sectors. Impacts on energy production is estimated to be the fastest, and happens immediately in the first quarter. This is because the impacts are affected by energy inputs such as oil, which is priced daily on the international market, and largely exposed to exchange rate movements. The response from intermediate goods production is much faster than that of consumer goods and capital goods output. Due to the characteristics in intermediate goods of low differentiation and high import competition, the contracts of these goods may adjust to the exchange rate movement contemporaneously. Capital goods, on the other hand, are highly differentiated and specific in their usage. Contracts on these goods may be signed in advanced, and therefore, there exists a time effect to some extent to allow the price to adjust according to exchange rate movements. For consumer goods, the time effect of an exchange rate shock is subject to the features of the individual consumer good sub-class.

Karagedikli et al. (2013) highlights the impact on seven industries from a one per cent shock to the nominal exchange rate in New Zealand. The study investigates the size and time effects of an unanticipated exchange rate shock on individual sub-sectors. The manufacturing industry is the most sensitive to exchange rate shocks, with all sub-sectors experiencing negative impacts and the peak impacts occurring between quarters 5 to 7. In the manufacturing industries, sub-sectors such as non-metallic mineral products, and printing and textiles suffer significantly as these products have less differentiation and face a higher degree of import competition. The impact on the agriculture and mining sectors are negative and more persistent in New Zealand. The mining sector shows a slow decrease, while the agriculture sector shows a slight increase. The peak impact appears on 3-4 quarters for both sub-sectors. Local governments' responses to an exchange rate shock are insignificant according to the estimation. The wholesale and retail sub-sectors experience smaller negative impacts compared to the manufacturing sector. However, as both sectors have a significant degree of trade exposure, the decline of output reflects the fact of expenditure switching when the exchange rate appreciates. The estimated results further show a decrease of output in the utilities and transport industries. Karagedikli et al. (2013) explains the transmission mechanism behind the decline of construction output is due to the fall in the population in New Zealand. As a consequence, there has been falls in house prices and market confidence, which affects output levels in the construction sector. Finally, the decline in the service sector is due to several factors. First, appreciation of the NZ dollar will lead to lower numbers of foreign tourists. For domestic citizens, many may choose an overseas holiday when the exchange rate appreciates. Thus, it will affect a large part of services activities. In addition, the change in population dynamics will also put downward pressure on the service sector.

3.2.2 *Methodology*

First, in Manalo et al. (2015) output depends on a vector of foreign variables (F_t) and domestic variables (D_t). The structural VAR model could be expressed as Eq. 2.5 in Section 2.4. In the research there is a SVAR model for the aggregate economy, and for each industrial sector there is a separate VAR model. There are two foreign variables: US Real GDP and Australian Terms of Trade. The domestic variables include Australian Real GDP, Sectional Production (Gross Value Added), Trimmed Mean Inflation, Overnight Cash Rate and the Real Trade-Weighted Index. However, sectoral production is included only in the sectoral model. The choice of the number of variables are under the principle of the parsimonious SVAR model. The minimal restriction implied is n(n-1)/2 where n is the number of variables. Choleski decomposition is applied to the identification for recursive ordering. In their research, Manalo et al. (2015) further assumes that the real exchange rate responds to all other shocks contemporaneously, while the other variables will be affected by the real exchange rate in a lag. In this regard, the real exchange rate, represented by the real trade-weighted index, is ordered last. There are two reasons behind this assumption. First, as the Australian exchange rate operates under a floating exchange rate regime, the nominal exchange rate floats freely and its value adjusts quickly according to the fluctuations of macroeconomic fundamentals. Second, due to the nominal rigidities in the short run, especially regarding price stickiness, it takes time for firms or the economy to respond to the movements of the exchange rate by altering price levels and making production decisions.

The estimation of real exchange rate shock rests on the reduced form of the SVAR model, with foreign and domestic variables, as below:

$$\begin{bmatrix} Y_t^F \\ Y_t^D \end{bmatrix} = \begin{bmatrix} B_{FF}(L) & 0 \\ B_{FD}(L) & B_{DD}(L) \end{bmatrix} Y_{t-1} + u_t \tag{3.1}$$

where Y_t^F denotes a vector of foreign variable, Y_t^D is a vector of domestic variable, and $u_t \equiv \begin{bmatrix} u_t^{F'} \\ u_t^{D'} \end{bmatrix}$ is a vector of forecast error. The reduced-form, after imposing the block restrictions of small open economy, expressed in Eq. 3.1 is estimated with ordinary least squares (OLS). Based on the lag selection criterion, two lags are chosen for the SVAR model. Further, impulse response functions and variance decomposition are applied to analyse the shock impacts on both the aggregate economy and each industry.

In robustness, Manalo et al. (2015) tests eight alternative specifications in regard to various economic conditions:

i) GDP and the price level enter the VAR in log levels;
ii) GDP, the exchange rate and terms of trade enter in 1st difference;
iii) Goods terms of trade enters the model and replaces the goods and services terms of trade;
iv) Australia's major trading partners' growth rate replaces US GDP growth;
v) The exchange rate order before the overnight cash rate;
vi) US CPI inflation and the US federal funds rate are added as additional foreign variables;
vii) The VIX index is included as a foreign variable; and
viii) The Australian 10-year government bond yield is included in the domestic variables.

The robustness check further shows that the results are not sensitive to the change of variables, lag length or alternative economic conditions.

Karagedikli et al. (2013) estimates a Factor Augmented Vector Autoregression (FAVAR) to examine the sectoral impacts of an unanticipated exchange rate shock for the New Zealand economy. The FAVAR enables the use of more than 300 variables in the model. The data period is from 1994:Q3 to 2011:Q2. The findings in this research show that unanticipated appreciation has a significant negative impact on New Zealand tradable sectors. The second finding shows that such exchange rate shock also has a significant impact on non-tradable sectors in New Zealand due to the cyclical nature of the population dynamics of permanent and long-term migration.

Hahn (2007) uses a VAR model to investigate the magnitude and speed of the impact of exchange rate shocks on sectoral activity and producer prices in industries sub-sectors (excluding the construction industry) in the euro area. There are five variables in his model: exchange rate, GDP, the harmonised index of consumer price (HICP), a sector variable and short-term interest rate. The data range from 1985:Q1 to 2004:Q1. The results show that an exchange rate shock would have the strongest impact on value added in industry. The trade and transport industries show the greatest response to shock impacts. Within industry, capital and intermediate goods production are significantly affected by exchange rate shock. Regarding the impact on producer prices, electricity, gas and water supply shows the largest response to exchange rate shock. Among the main industrial groupings (MIGs), the energy sector is most sensitive to the exchange rate shock.

When comparing the SVAR model used in Manalo et al. (2015) and the VAR model used in Hahn (2007), Karagedikli et al. (2013) state that the biggest advantage in using the FAVAR model is that more variables can be used in the model. The reason for including so many variables is because, in reality, there is much more information that the central bank needs to consider, but the SVAR models can only include a small number of variables. Karagedikli et al. (2013) states that, in the FAVAR model, the large number of variables is summarised by a small number of factors. Meanwhile, the FAVAR model enables researchers and policy makers to see the shock impacts with a number of different variables. In order to be consistent with previous research conducted in New Zealand, Karagedikli et al. (2013) uses a 90-day interest rate in his study. In Hahn (2007), the research demonstrates not only the magnitude of the shock impacts on output and price, but also the speed with which the impacts effect economic activities. The method used in Hahn (2007) is similar to that in Manalo et al. (2015) with five variables. The biggest difference between Hahn’s SVAR model and the one in Manalo et al. (2015) is that the model does not involve any foreign variables – all of the five variables are domestic.

In the literature, the business-cycle theory assumes that aggregate disturbances are the primary cause of cyclical fluctuation in economic conditions. However, the aggregate model fails to account for the details and the possibility of sector shifts in economic conditions and its macro consequences across sectors. The above SVAR approaches provide insights to each of the sectors impacted by the exchange rate shock.

3.2.3 *Data*

After the discussions above regarding empirical findings and methodology of a number of research studies, in this section we turn to a summary of some insights relating to issues with the data. These data issues are associated with estimating shock impacts in Australia.

As stated in Dungey and Pangan (2009), the choice of variables in an Australian VAR model is associated with several concerns. Huh (1999) constructs a model to investigate the fitness of the Mundell-Fleming model in Australia after the Bretton Woods System. The variables included in this model includes interest rates, real GDP, the nominal exchange rate, prices and money supply, which links the openness of the Australian economy under the assumption of uncovered interest parity. Huh concludes that world shocks are not important in explaining Australian real output. Moreno (1992) constructs a four-variable VAR model to investigate the impacts of demand and supply shocks on macroeconomic conditions in Australia. These variables include oil prices, labour supply, real GDP and prices. The choice of these variables enables the VAR model to explain the behaviour of demand and supply shocks in Australia, but there is no foreign variable in the model. Given the openness of Australian economy, such a model does not reflect Australian economy structure in reality. In Brischetto and Voss (1990), the VAR model constructed to examine the effects of monetary policy on Australia includes two foreign variables: current US spot price for oil, and the US Federal Funds rate. The five domestic variables in this model are: real GDP, consumer price index, monetary aggregate (M1), cash rate and the bilateral exchange rate between the US and the Australian dollar. Brischetto and Voss (1990) states that their VAR model is based on the Kim and Roubini model. They applied this SVAR model to Australia in a similar style. The research focuses on the effect of monetary policy on the Australian economy, but the first two foreign variables included in this SVAR reflect the interaction of Australia with the international economy, more specifically, the US economy.

In Dungey and Pagan (2009), one of the issues of variables in the SVAR is in deciding on the minimal set of variables to be involved in the model for the Australian economy. They highlight 11 variables which capture important links between and within the commodity and financial markets, and the monetary policy effects. These are: a measure of foreign output (US GDP); foreign real interest rate (real US interest rate); the terms of trade (Australian terms of trade); exports (real exports); real foreign asset prices (the ratio of the Dow Jones index); real domestic asset prices (the ratio of the All Ordinaries Index to the Australian Implicit Price Deflator for Plant and Equipment); domestic aggregate demand (real Australian gross national expenditure); domestic output (real Australian GDP); inflation (inflation rate); a monetary policy instrument (the cash rate); and a real exchange rate (real trade-weighted exchange rate index). According to Dungey and Pagan (2009), each of these variables could represent an individual demand shock in the SVAR model the form of a regression equation. However, they claim that the list of variables may not be sufficient for all the shocks in the economy, for example, fiscal policy shock, but this will not affect the model capturing most of the key characteristics of the Australian economy. Furthermore, to realise the real economy structure as a small open economy, it is necessary to add a further block restriction between foreign variables and domestic variables. According to Dungey and Pagan (2009), the principles of variable choice could be summarised as:

i) The variables should capture the interactions between the Australian economy and foreign economies;
ii) The variables should be able to represent macroeconomic elements for Australia and foreign countries;

iii) The variable selected should link with the research questions when constructing the VAR model.

More recently, Lawson and Rees (2008) constructed a VAR model for Australian sectoral effects on monetary policy. It includes six variables: US GDP, commodity price, Australian GDP, inflation, the cash rate and real trade-weighted exchange rate index. Manalo et al. (2015) constructed a SVAR with six variables including US real GDP, Australian terms of trade, Australian real GDP, trimmed mean inflation, the cash rate and the real trade-weighted exchange rate. The model is able to expand the investigation of unanticipated exchange rate shock impacts from the aggregate economy to sectors. The model captures the small open economy feature of Australia by imposing block restrictions between foreign and domestic variables.

3.3 Labour Market Turnover and Mobility

According to D'Arcy et al. (2012), labour mobility is generally considered an indicator of the flexibility of labour market adjustments to economic shocks and structural change. Labour market turnover, which is calculated by the ratio of employees that leave their jobs during a period divided by the number of employees in the same period, is driven by several reasons in Australia. In the following subsections, the key concepts and findings from research in Australian labour mobility is presented. However, as geographic mobility is beyond the scope of this thesis, the geographic aspects of labour mobility in the empirical studies will not be described.

3.3.1. *Australian Labour Market Turnover and Job Tenure*

Intuitively, labour turnover and job tenure creates a trade-off between job mobility and job stability according to the benefits and costs of both. According to D'Arcy et al. (2012), about 80 per cent of workers did not change their jobs in the previous 12 months for the year up to February 2012. For the other 20 per cent, half of these employees move to new jobs and the other half is made up of those who were newly employed in 2012. Comparing the most recent labour mobility information released by the Australian Bureau of Statistics (ABS), around 43 per cent of people changed to a new job in less than one year in 2015.

On the other hand, D'Arcy et al. (2012) shows that the average job tenure for all employees is about seven years in Australia. Over 40 per cent of people remain in their job for more than five years, and around 25 per cent have the same job for more than ten years. Only one in five employees change jobs within one year. This is because job stability provides benefits to both firms and employees. Firms benefit from the experience gained by stable employees, while the employees themselves are provided benefits from economic security. ABS statistics show that about 18 per cent of employees remained in the same job throughout 2015. This is consistent with the findings in D'Arcy et al. (2012), that job stability on average has increased on a modest rate recently. D'Arcy et al. (2012) further states that this is because there has been no severe cyclical downturn in the past two decades in Australia.

Meanwhile, it is noticed that the distribution of job tenure is uneven across employees. The difference of labour turnover is due to individuals' experience, age, gender and the industries which they work. Farber (1999) points out that there is a negative relationship between job tenure and job separation. This negative relationship is due to individual effects and the nature of job matching. The next section discusses the factors affecting labour market turnover in Australia.

3.3.2 *Drivers of Labour Market Turnover*

The reasons for job separations can be divided into two parts: involuntary and voluntary job separations. According to D'Arcy et al. (2012), the former reason accounts for about one-third of total job separations, while the latter accounts for around two-thirds in Australia. Involuntary separations could be further classified into retrenchments and temporary jobs ending, which are 15 per cent and 17 per cent, respectively. From a macroeconomic point of view, retrenchments are more important as this reflects firms' decisions during an economic recession to downsize their job supply. Separations from temporary jobs ending, on the other hand, is an indication of how firms respond to uncertainty when facing an economic downturn. Involuntary separations are generally negatively correlated with employment growth so that it is countercyclical. D'Arcy et al. (2012) further shows that during the recessions in the early 1980s, early 1990s and during the global financial crisis in the 2000s, involuntary separations reached a pick due to the rise in retrenchments. Younger employees are more likely to experience an involuntary separation as firms are more likely to reduce inexperienced staff when hit by a negative economic shock.

Reasons for voluntary separations include job-sorting, life-cycle and personal reasons; each of these accounts for around one-third of job separations. As they tend to be driven by such considerations, the costs associated with voluntary separations are largely borne by the employees. This leads to voluntary separations being considered as pro-cyclical because employees are more willing to bear the costs and risks of changing jobs when the labour market is strong. At the same time, employees' expectations on the returns from a new job are high during economic booms. The causes of job-sorting are dominated by young employees compared to prime-age workers. Life-cycle and personal motivations for job separation are largely due to women leaving their jobs for family reasons. Blau and Kahn (1981) find that women on average have higher quit rates than men. Generally, employees who leave their jobs voluntarily will have relatively higher employment rates in subsequent periods than those leave their jobs involuntarily.

Carroll and Poehl (2007) investigates the characteristics of employees in Australia who are more likely to separate from their job. They find that employees with longer tenure are less likely to quit or be laid off. Job satisfaction has a significant effect on the probability of job separation, and is an important determinant of voluntary separation. It is also noted that job-to-job flows are large, that is to say, there is a high degree of employees switching between jobs smoothly in the Australian labour market.

3.3.3 *Turnover by Industry and Structural Adjustment*

Labour mobility plays an important role in employees' changing their jobs within and between industries according to the labour market conditions. According to ABS data in 2015[14], 57 per cent of labour mobility involves changing to another industry. D'Arcy et al. (2012) finds that movements between industries involves more changing occupations than those who change to a new job within the same industry. However, the extent of labour mobility is different across industries. Research shows that the difference that extends across industries is determined by several factors, comprising the differences in the characteristics of the individuals, the characteristics of firms, the competitiveness and environment of industries, industrial relations, and the nature of shocks on industries.

Through analysing the correlations between movement across industries and measures of industry average wage and average employee age, D'Arcy et al. (2012) further discovered that industries that have higher average earnings and older employees will generally have a low degree of mobility. This is because experienced employees have less incentive to change jobs when their accumulated experience is rewarded in their current job. On the other hand, young employees with less experience and earning lower wages will have more incentive to change jobs.

Another important factor is job-specific experience, which explains the variance of labour mobility between industries. Job turnover in the hospitality and retail industries is high among all industries as the employees are relatively younger and less experienced. Employees in the health care and social assistance, and education and training industries are usually older. Therefore, employees in these industries are relatively stable in their current jobs and receive benefits such as long service leave and other rewards for job-specific experience. At the same time, results show that the higher degree of

[14] Australian Bureau of Statistics 2015, *Participation, Job Search and Mobility, Australia, February 2015*, Cats No.6226.0, ABS, Canberra.

job turnover in the mining industry is much lower compared to the research findings in earlier decades. It has been observed that more intra-industry job movements and new labour force entry occurred in the mining industry in 2012. The results in D'Arcy et al. (2012) are largely consistent with ABS statistics in 2015 which show professional, health care and social industries have a relatively larger degree of job stability.

Labour mobility between industries is an important indicator of labour supply changes due to changes in the industrial structure of the economy, and will further alter the labour demand on the market. By using the HILDA data and the ABS labour force data, D'Arcy et al. (2012) estimates the size of direct labour flows between industries and their contribution to the adjustment in the labour market from 2001 to 2010. A comparison of estimated net employment flows between 19 industries shows that the retail and hospitality industries account for the largest labour outflow between industries. At the same time, these two industries absorb a large part of new labour inflow to the labour market. This is because young employees constitute a large share of the total labour force in these industries. D'Arcy et al. (2012) further provides the estimated work flows of selected industries from three sources between 2001 and 2010. These three sources are from outside of employment, from retail trade, accommodation and food services, and from all other industries. The results first demonstrate that direct transitions between different industries and the flow of new labour are important to the adjustment process in the industry composition of the labour force. Secondly, apart from the retail and hospitality industries, manufacturing is the only industry that has a large net outflow to other industries. This reflects the down-sizing of manufacturing employment over time. Finally, industries such as construction and mining with their strong labour force growth attracted large inflows from other industries. The trend shows that these flows became larger due to the expansion of the mining industry up to 2010.

3.4 Summary

This chapter has summarised the empirical research on the shock impacts on Australian output and employment. The purpose of this chapter is to provide some insights into previous studies relating to the effects of shocks on GDP and labour mobility. At the same time, it has provided some extent of support for our later empirical model and analysis in Chapter 4.

First, we discussed the shock impacts on output as examined in previous empirical research in three aspects: the empirical findings, methodology and data in Section 3.2. In detail, Subsection 3.2.1 presented the findings of aggregate output and sectoral output; Subsection 3.2.2 analysed the principles of the VAR model as applied in shock impacts investigations; and Subsection 3.2.3 highlighted the insights of data issues in previous studies using the VAR model.

Secondly, in Section 3.3, we focused on research in mobility for the Australian labour market's reaction to shock. Subsection 3.3.1 presented the analysis of labour market turnover and stability, as well as the relationship between these two elements. Subsection 3.3.2 discussed the causes of job separation through involuntary job separations and voluntary separations. At last, in Subsection 3.3.3 we further discussed the labour mobility between industries.

As a result of reviewing the empirical research in each of corresponding areas, we can conclude:

i) In the literature, exchange rate shock impacts on output are more likely to be seen as sectoral shifts rather than as aggregate impact from both the SVAR and the DSGE models. The aggregate impacts on output are relatively smaller. However, the output level fluctuates across the sectors due to various industrial characteristics. ii) These shock impacts are seen as a key drivers of labour mobility. In the literature, it is found that labour mobility between jobs is quite large, such as in Carroll and Poehl (2007). Furthermore, regarding job separation, involuntary job separations tend to closely link with shocks' effects on the economy.

Chapter 4

Empirical Work

4.1 Introduction

The purpose of this chapter is to investigate the effects of an unanticipated real exchange rate shock on the Australian economy using a SVAR model. The model captures the dynamic relationship among the variables and, in particular, allows an analysis of the impacts of a real exchange rate shock on the growth of output and employment both on aggregate and industrial levels.

Before describing the model setup and the results, we first discuss the industry structure of the Australian economy. Table 4.1 presents the share of industry output in Australian GDP and the share of industry employment in total employment. To a large extent Australian output is driven by the mining industry, specifically the mining boom in recent decades. However, due to the capital intensive characteristic of the mining sector, its share of GDP grows much more than its share of employment. In Table 4.1, the mining sector’s share of GDP increased by three per cent, while its share of employment increased by one per cent. Business sectors such as professional and finance also show an increase in share of their output in total GDP. Employment is driven by the service industries. Social services (education and health) and business services (professional) have experienced an increase in employment share. The construction industry demonstrates increases in both GDP share and employment share. This may be due to the fact that construction is associated with mining boom. Manufacturing is the only industry that has been declined over time. However, this trend is not new and the decline in manufacturing has been observed since the early 1960s in Australia. Furthermore, the recent decline of the employment share of this industry is largely due to the combined effects of the exchange rate appreciation during the mining boom and the global financial crisis, as pointed out by the Australian Productivity Commission[15]. Table 4.1 shows a similar trend of industries' share of GDP and employment in Australia, compared to the analysis in the Australian Industry Report 2015[16]. As claimed by the Australian Productivity Commission, apart from a boom in the mining industry, the Australian industry structure shares a pattern similar to that of other advanced economies: a growth in the service sector, and a decline in both manufacturing and agriculture. Details of the growth of Australian output and employment will be discussed in Section 4.3 Empirical Results.

The structure of this chapter is as follows. Section 4.2 outlines the research methodology, describes the data transformation, and discusses model identification and estimations on the reduced-form. Section 4.3 presents impulse responses of output and employment to a real exchange rate shock and variance decomposition. Section 4.4 demonstrates a robustness check of the main results, which includes alternative variables, alternative identification scheme and different lag length.

[15] Australian Government, The Productivity Commission, *Annual Report 2011-2012,* http://www.pc.gov.au/about/governance/annual-reports/2011-12/annual-report-2011-12.pdf
[16] Department of Industry, Innovation and Science, Office of Chief Economist, *Australian Industry Report 2015*, http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/AIR2015.pdf

Table 4.1 Industrial Proportion of GDP and Employment

Industry	1985 Q1 Share of GDP	1985 Q1 Share of Employment	2015 Q2 Share of GDP	2015 Q2 Share of Employment
	(%)	(%)	(%)	(%)
Agriculture	4	6	3	3
Mining	7	1	10	2
Manufacturing	15	17	7	8
Service Sectors				
Electricity	5	2	3	1
Construction	8	7	9	9
i) Social Services				
Pub admin	8	6	6	6
Education	7	7	6	8
Health	6	8	8	13
ii) Distribution Services				
Retail	6	10	5	10
Wholesale	5	5	5	3
Transport	5	6	5	5
Communication	2	2	3	2
iii) Business Services				
Finance	5	4	10	3
Rental	3	1	3	2
Professional	5	4	7	9
Administration	3	2	3	3
iv) Personal Services				
Accommodation	3	5	3	7
Arts	1	1	1	2
Other services	3	4	2	4
Total	**100**	**100**	**100**	**100**

Notes: The service sector is defined as industries excluding agriculture, mining and manufacturing. Classification of the services sector is based on the Australian Productivity Commission Annual Report 2011-2012. Share of GDP is calculated as industry production divided by the sum of GDP (Industry Gross Value Added, seasonally adjusted), excludes ownership of dwellings, taxes less subsidies on products and the statistical discrepancy, data for 1985 Q1 and 2015 Q2. Share of Employment is calculated as a share of total employment in each industry, data for 1985 Q1 and 2015 Q2.

Source: ABS

4.2 Methodology and Data

The empirical model is designed based on the SVAR model in Manalo et al. (2015), which is a small-scale model on aggregate level. In order to investigate the effect of an unanticipated exchange rate shock on the labour market, we add employment to a set of endogenous variables in the VAR model. The classifications of industries in the sectoral VAR models are based on the Australia and New Zealand Standard Industrial Classification 2006 (ANZSIC 2006), which is described in Appendix 1. Details of the empirical models are presented in the following subsections.

4.2.1 *Unit Root Test*

In the empirical model, we use stationary time series data to investigate shock impacts. All series are tested for deterministic and stochastic non-stationarity using the Augmented Dickey Fuller test (ADF) and the Kwiatkowski–Phillips–Schmidt–Shin test (KPSS). The description of the principles of the ADF test is presented in Appendix 2, and the results of the ADF are shown in Table 4.2. The results of the KPSS test confirm those obtained from the ADF test and are presented in Appendix 2.

The results of the ADF and KPSS tests show that the first difference (the log difference) of the series are all stationary[17]. Thus, all time series are transformed into first difference. Furthermore, according the Johansen test, there is no evidence of cointegration relationship between I(1) variables.

[17] Further, as a form of robustness check, unit root tests with structural breaks are applied to the log differences of the series discussed here. The results confirm our finding that these variables are stationary. Although one may also consider re-examining the issue with SVAR models which allow for such structural breaks, this would represent an extension of this thesis for future research.

Table 4.2 Time Series Unit Root Tests on Variables

(Augmented Dickey Fuller Test)

Variables (Level)	Intercept	Intercept & Trend	Variables (1st difference)	Intercept	Intercept & Trend
usgdp	-1.6354	-1.9342	usgdp(-1)	-7.9568***	-7.9189***
TOT	-0.8203	-2.0421	TOT(-1)	-5.8786***	-5.8554***
rgdp	2.3130	-2.1468	rgdp(-1)	-6.5144***	-6.5138***
employment	0.2308	-1.3620	employment(-1)	-4.8126***	-4.8117***
tmi	-2.3275	-2.2373	tmi(-1)	-10.5510***	-10.5728***
cash	-2.4994	-2.7040	cash(-1)	-5.7403***	-5.6953***
rtwi	-1.4150	-2.3722	rtwi(-1)	-8.4891***	-8.4407***
accommodation	-0.4607	-1.9808	accommodation(-1)	-7.1211***	-7.2000***
accommodation_E	-0.8839	-4.0860***	accommodation_E(-1)	-8.0758***	-8.0580***
administration	-1.4514	-1.2973	administration(-1)	-6.8047***	-7.3985***
administration_E	-1.1069	-1.7089	administration_E(-1)	-7.9127***	-7.9246***
agriculture	-1.0826	-4.6941***	agriculture(-1)	-9.0796***	-9.0433***
agriculture_E	-0.7563	-2.9712	agriculture_E(-1)	-8.1675***	-8.2239***
arts	0.1268	-2.8907	arts(-1)	-11.5039***	-11.4546***
arts_E	-0.5104	-5.2144***	arts_E(-1)	-9.6505***	-9.6252***
communication	0.5408	-2.5807	communication(-1)	-8.0175***	-9.0306***
communication_E	-1.8648	-2.0624	communication_E(-1)	-7.1850***	-7.2080***
construction	0.8940	-1.7777	construction(-1)	-7.0309***	-7.0109***
construction_E	0.1070	-1.7107	construction_E(-1)	-7.5592***	-7.5609***
education	-0.3522	-4.9779***	education(-1)	-13.9476***	-14.3986***
education_E	0.1421	-2.7967	education_E(-1)	-9.6835***	-9.6853***
electricity	-1.7381	-2.9272	electricity(-1)	-10.7713***	-11.3223***
electricity_E	-1.2525	-1.4143	electricity_E(-1)	-8.2397***	-8.5298***
finance	1.1761	-1.2410	finance(-1)	-4.6690***	-4.7744***
finance_E	-1.7657	-2.2337	finance_E(-1)	-8.4135***	-8.4167***
health	4.7272***	-0.0230	health(-1)	-11.6015***	-11.5588***
health_E	1.7085	-0.6643	health_E(-1)	-9.3813***	-9.8496***
manufacturing	-1.7054	-1.2042	manufacturing(-1)	-7.4991***	-7.6751***
manufacturing_E	-1.0108	-3.1517*	manufacturing_E(-1)	-7.1198***	-7.1474***
mining	2.3389	0.0950	mining(-1)	-8.0433***	-8.0081***
mining_E	0.0066	-1.3631	mining_E(-1)	-6.0847***	-6.1967***
otherservices	-0.8364	-2.9765	otherservices(-1)	-9.9647***	-10.1892***
otherservices_E	-1.8734	-3.9749***	otherservices_E(-1)	-9.1567***	-9.1650***
professional	-0.0353	-2.1068	professional(-1)	-6.5305***	-6.7402***
professional_E	0.9196	-2.2718	professional_E(-1)	-8.0629***	-8.1627***
pubadmin	0.4833	-2.9766	pubadmin(-1)	-10.7681***	-10.7222***
pubadmin_E	-0.0042	-2.2476	pubadmin_E(-1)	-7.7090***	-7.7036***
rental	0.3570	-1.6948	rental(-1)	-9.0165***	-9.0571***
rental_E	-1.0253	-3.6818**	rental_E(-1)	-10.2073***	-10.1630***
retail	2.2193	-3.1230	retail(-1)	-6.4324***	-6.4638***
retail_E	-1.5189	-1.9136	retail_E(-1)	-7.2945***	-7.3800***
transport	0.1835	-2.3406	transport(-1)	-8.5756***	-8.6083***
transport_E	0.0938	-2.1217	transport_E(-1)	-8.5564***	-8.6378***
wholesale	0.4065	-2.6631	wholesale(-1)	-6.1129***	-6.0890***
wholesale_E	-3.1999**	-3.1656*	wholesale_E(-1)	-10.2627***	-10.2868***
commodity	-1.8601	-3.3028*	commodity(-1)	-8.2026***	-8.1698***

Table 4.2 Time Series Unit Root Tests on Variables

(Augmented Dickey Fuller Test) (Con't)

Variables (Level)	**Intercept**	**Intercept & Trend**	**Variables (1st difference)**	**Intercept**	**Intercept & Trend**
ntwi	-2.0961	-3.0350	ntwi(-1)	-8.8389***	-8.8093***
mtp gdp	0.9381	-1.2360	mtp gdp(-1)	-9.6404***	-10.0813***

Notes: Critical values for ADF test includes intercept only: 1%: -3.43; 5%: -2.86; 10%: -2.57. Critical value for ADF test includes intercept and trend: 1%: -3.96, 5%: -3.41, 10%: -3.13. ***, **, * denote significance at the 1%, 5% and 10% level, respectively. All results computed by JMulti.

4.2.2 *Data*

In the SVAR model, we use seasonally adjusted quarterly data in the estimation. Data series are ranged from 1985:Q1 to 2015:Q2. All the data are transformed into log difference in the model. There are two exogenous variables in the aggregate SVAR:

1. The US Real GDP growth ($\Delta \mathrm{usgdp}$);
2. The log change of Australian Terms of Trade ($\Delta \mathrm{tot}$)

Meanwhile, there are five endogenous variables that are used for the domestic economy:

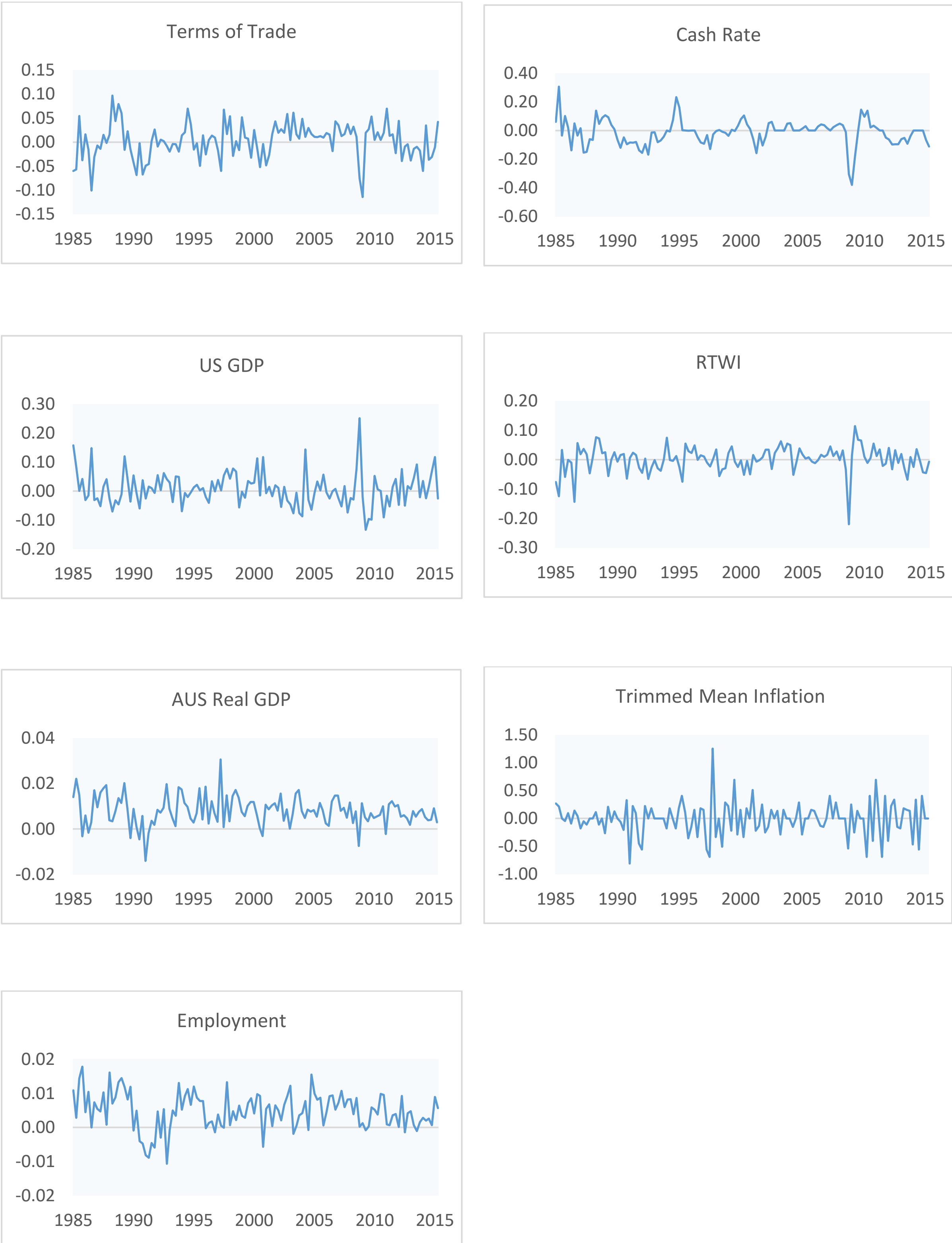
3. The Australian Real GDP growth ($\Delta \mathrm{rgdp}$);
4. The Australian Employment growth ($\Delta \mathrm{employment}$);
5. The log change of Trimmed Mean Inflation ($\Delta \mathrm{tmi}$);
6. The log change of overnight Cash Rate ($\Delta \mathrm{cash}$);
7. The log change of real trade-weight exchange rate index ($\Delta \mathrm{twi}$).

At the industry level, we include two sectoral variables in each industrial VAR model as below:

8. The Australian sector production growth
9. Sector employment growth replaces the Australian Employment growth

In the following, each data series will be discussed in detail. Variables' definitions and data sources are provided in Appendix 1. Figure 4.1 shows the time series plots of the data in the empirical model.

Figure 4.1 Time Series Plot of the Data



- **US Real GDP**

US real GDP is included because the Australian business cycle has a close relationship with the US business cycle, which is widely considered as a stylised fact of the Australian economy. As a large open economy, the US business cycle has a significant influence on Australian domestic economy activities through links to the financial market and exchange rate (or international trade). In Berkelmans (2005), US GDP is used in the SVAR model to investigate the relationship between credit and monetary policy. Beechey et al. (2000) built a small model of the Australian economy based on the underlying strong relationship between the Australian and US business cycles for non-farm output. An alternative way to US GDP could be weighted Major Trading Partners' GDP of Australia. The weights reflect the trade shares of these major trading partners. This possibility is also considered in the robustness check. As presented in Figure 4.1, the log difference of US GDP measures the growth of the real GDP in the United States.

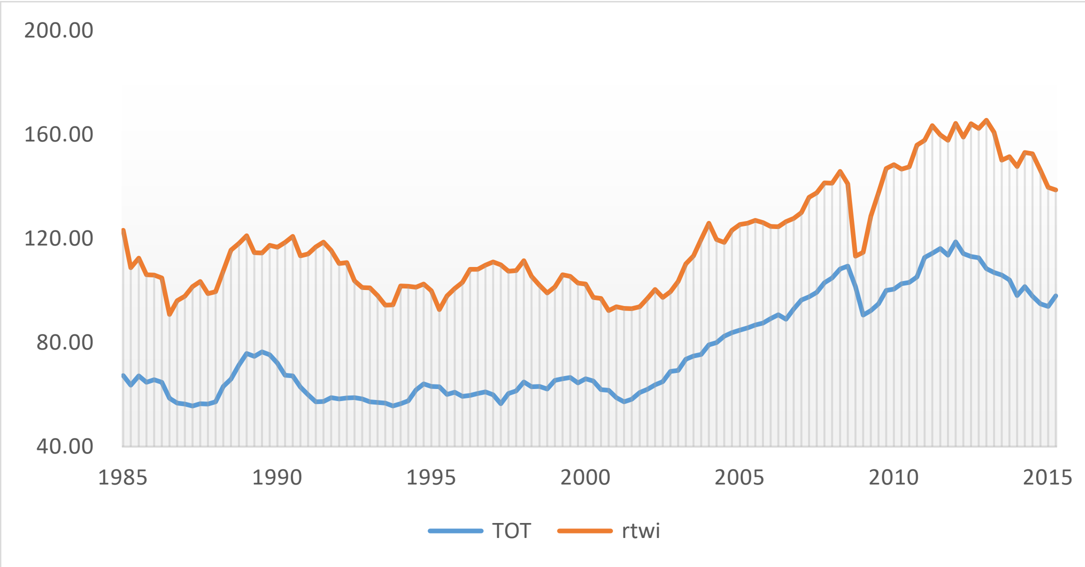
- **Australian Terms of Trade**

Australian terms of trade, which is defined as the dollar amount of exports divided by the dollar amount of imports, is included in the model to reflect the impact of commodities and other export goods. The Australian dollar is generally considered as commodity currency due to the large part of commodity exports. Atkin et al. (2014) shows that resources account for more than one-third of Australian goods exports in 2012. The large share of commodities in the terms of trade reflects the strong resource-intensive growth in demand from China such as for iron ore and coal due to the mining boom. Berkelmans (2005) uses commodity prices in SVAR model in order to resolve the "price puzzle"[18] in VAR. Manalo et al. (2015) uses Australian terms of trade to capture the impact of commodity prices as well as the influence from emerging economies that create demand for

[18] Price puzzle is defined as an increased in price level after a contractionary monetary policy put on force. It was first described in Sims (1991) as an observed effect of contractionary monetary policy according to the pressure of inflation.

Australian goods. The close relationship between the terms of trade and the traded-weighted real exchange rate (RTWI) in Australia was found in many studies such as Blundell-Wignall et al. (1993), Chen and Rogoff (2003), Kent and Bishop (2013). Figure 4.2 shows the co-movement of the terms of trade and the real exchange rate since the floating exchange rate regime began in 1983. Beechey et al. (2000) suggests that a possible reason for this is that the terms of trade is endogenous to the real exchange rate because it changes in the same direction as exchange rate movements.

Figure 4.2: Terms of Trade and Real Exchange Rate



- **Australian Real GDP**

Australian real GDP is used to measure domestic aggregate economic activity. Australian sectoral production measures economic activities at the industry level by gross valued added (GVA). These two measurements are standard methods for GDP. We briefly describe some further principles of GDP measurements. GVA describes the gross product net of intermediate goods by industry and by sector. Each industrial production is estimated using the chain Laspeyres measure in dollar terms. The reference year is chosen on the principle of reducing the impact of non-additivity[19]. GDP is calculated based on the production approach, which is one of three approaches used to measure Australian GDP: the sum of the basic price[20] of gross value added of each industry plus tax and less subsidies on products.

- **Employment**

The growth of Australian real GDP has a direct influence on labour market indicators such as unemployment, employment and the participation rate. Okun's law explains how a change in output affects the unemployment level in the economy. However, according to Plumb et al. (2013), the extent of the Australian labour market response to an unanticipated terms-of-trade shock will partially depend on labour mobility between industrial sectors. Before investigating the shock impacts on the labour market, they make several assumptions about the labour market's response to the terms-of-trade shock. First, they assume that the nominal wage is sticky downwards in the short run and, as a result, the degree of substitutability of labour across sectors is not perfect. Further, the goods and services in tradable and non-tradable sectors are assumed to be substitutable. Their last assumption is that the nominal exchange rate is more flexible than prices.

---

[19] ABS Information Paper No.5248.0. "Introduction of Chain Volume Measures in the Australian National Accounts" available at: http://www.ausstats.abs.gov.au/ausstats/free.nsf/0/A7333B2A7327A9D8CA256ADB001C0CE0/$File/52480.pdf

[20] According to ABS Cat No 5216.0, Basic Price is defined as the amount receivable by the producer from the purchaser for a unit of a good or service produced as output minus any tax payable, and plus any subsidy receivable, on that unit as a consequence of its production or sale. It excludes any transport charges invoiced separately by the producer. Output sold at prices that are not economically significant is not valued at these prices. Rather, such output is valued at its cost of production. (Australian System of National Accounts: Concepts, Sources and Methods, 2015 http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/5216.0Glossary12015?OpenDocument)

- **Inflation**

Australia operates under an inflation-targeting monetary policy regime. One of the main objectives of the Reserve Bank of Australia (RBA) is to maintain consumer price inflation at two-to-three per cent in annual terms over the medium run. According to Beechey et al. (2000), in Australia, inflation is determined by three factors: output gap, exchange pass-through effect and oil price. Beechey et al. (2000) states that the output gap will have a direct impact on unit labour cost and inflation. There would be upward pressure on consumer price inflation when real output grows faster than potential output, and downward pressure when it grows slower than potential output. Chung et al. (2011) argues that the exchange rate pass-through has two stages in Australia. In the first stage there is an effect from the nominal exchange rate to import prices, which is large and fast. In the second stage there is an effect from import prices to consumer price inflation which is slower and small. Chung et al. (2011) shows that overall impacts on price by exchange rate movements is less than one-to-one effect. With a ten per cent appreciation in the exchange rate, the overall consumer price is reduced by one per cent over three years. The oil price will affect the inflation rate through the impact on the input costs of the industry. The increasing of oil prices in the 1970s led to a significant increase in inflation in most industrial countries including Australia. The choice of inflation rather than the price level is consistent with Dungey and Pagan (2000), who states that, as all the variables in the model are in real terms (except the cash rate), the change of prices is more logical to use for the purpose of interacting with the real variables and a nominal interest rate.

The reason for using trimmed mean inflation in the model is that it is a seasonally adjusted variable and so removes the volatility of quarterly inflation[21]. The calculation of trimmed mean inflation is based on a distribution of expenditure classes[22]. Thus, trimmed mean inflation is calculated using a

[21] ABS calculation: "Trimmed mean and weighted median measures of inflation" http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/6401.0.55.003Main+Features62011

[22] Expenditure class: According to ABS, the CPI expenditure classes are ranked from lowest to highest based on the seasonally adjusted percentage quarterly change, comparing to the previous quarter. Further, the seasonally

seasonally adjusted weighted average of the percentage change from the previous quarter from the middle 70 per cent of the distribution of expenditure classes.

- **Overnight Cash Rate**

The overnight cash rate has been the main instrument of Australian monetary policy since the floating exchange rate regime began in 1983. Cash rate could affect the economy in two channels. The first channel is on investment. Another channel of causing the movement of exchange rate. Both of them will impact Australian GDP. Short-run interest rate are often used in VAR studies, for instance, Berkelmans (2005) and Manalo et al. (2015) uses this variable in their models. Karagedikli et al. (2013) uses a 90-day interest rate in their research investigating an exchange rate shock impact in the economy.

- **Real Trade-Weighted Exchange Rate**

The real trade-weighted exchange rate index is a daily exchange rate calculated as the weighted average of the Australian dollar and the currencies of Australia's major trading partners[23]. In other words, the real trade-weighted exchange rate index is the weighted average price of the Australia dollar in terms of basket currencies. The base year is March 1995, which is set to 100 according to RBA statistics. Compared to the generally adopted individual bilateral exchange rate[24], the real trade-weighted exchange rate index is preferred because it allows a better assessment of Australia's competitiveness in the international market. In theory, the movements of real exchange rate are determined by the difference between domestic and foreign interest rates, according to interest rate

---

adjusted relative weight of each expenditure class is calculated according to its previous quarter contribution to the All groups CPI. Refer to RBA, All groups CPI is the measurement of headline CPI.

[23] The real trade-weighted exchange rate index is calculated by the RBA based on the methodology in Ellis (2001).

[24] Bilateral exchange rate: Australia dollar exchange rate against a single currency such as the US dollar.

parity. Furthermore, it is significantly influenced by the terms of trade because of the close relationship between terms of trade and the real exchange rate, as shown in Figure 4.2.

4.2.3 *Empirical Model Set-up*

(i) The VAR model

The empirical model set-up is built on the structural vector autoregression (SVAR) framework, which is similar to the sectoral model of the Australian economy in Lawson and Rees (2008). Earlier in Section 3.2.1, we described the details of previous empirical studies that use similar methods to model the Australian economy, such as Manalo et al. (2015). The structure of the VAR model used in this thesis reflects that Australia is a small open economy. For the purpose of solving the research questions, we form a small-scale model comprising two foreign variables and five domestic variables for the aggregate economy as discussed in the data section 4.2.2 above. In order to investigate the real exchange rate shock impacts on 19 industries, we design a separate VAR for each correspondence industry with two additional variables.

Therefore, the variables included in the aggregate VAR model are: $\Delta\mathrm{usgdp}$, $\Delta\mathrm{tot}$, $\Delta\mathrm{rgdp}$, $\Delta\mathrm{employment}$, $\Delta\mathrm{tmi}$, $\Delta\mathrm{cash}$ and $\Delta\mathrm{twi}$. The sector VAR includes the variables: $\Delta\mathrm{usgdp}$, $\Delta\mathrm{tot}$, $\Delta\mathrm{rgdp}$, Australian sector production growth, Australian sector employment growth, $\Delta\mathrm{tmi}$, $\Delta\mathrm{cash}$ and $\Delta\mathrm{twi}$.

ii) The SVAR Specification

The Australian economy is assumed to be represented by the following structural form:

$$\mathrm{AY_t} = \widetilde{\mathrm{A}}(\mathrm{L})\mathrm{Y_{t-1}} + \varepsilon_\mathrm{t} \tag{4.1}$$

where Matrix A is a $(7\mathrm{x}7)$ coefficient matrix. $\widetilde{\mathrm{A}}(\mathrm{L})$ is a $(7\mathrm{x}7)$ matrix of polynomials in the lag operator L. ε_t is a $(7\mathrm{x}1)$ vector of uncorrelated white-noise structure shocks. The matrix A summarises the contemporaneous relationships between the variables. At the same time, matrix A is non-singular so it could be normalised to have 1s on its diagonal. The variance matrix of the structure shocks ε_t is given by:

$$\mathrm{var}(\varepsilon_t) = \Sigma_\varepsilon = \mathrm{E}(\varepsilon_t \varepsilon_t') = \mathrm{diag}(\sigma_1^2, \sigma_2^2, \dots, \sigma_7^2). \tag{4.2}$$

where the variance matrix is a diagonal matrix and ε_t are serially uncorrelated. The diagonal elements are the variance of the structural shocks and the off-diagonal elements are zeros.

For the purpose of estimation, the reduced form SVAR could be obtained by multiply A^{-1} at both sides of Eq. 4.1.

$$\mathrm{Y_t} = \widetilde{\mathrm{B}}(\mathrm{L})\mathrm{Y_{t-1}} + \mathrm{e_t} \tag{4.3}$$

where $\widetilde{\mathrm{B}}(\mathrm{L}) = \mathrm{A}^{-1}\widetilde{\mathrm{A}}(\mathrm{L})$, $\mathrm{e_t} = \mathrm{A}^{-1}\varepsilon_t$, $\mathrm{E}(\mathrm{e_t}\mathrm{e_t}') = \Omega$. The coefficients of reduced-form would be estimated by ordinary least squares (OLS) method. In order to recover the structural parameters given in the primitive system (Eq. 4.1) from the reduced-form model (Eq. 4.2), a specific restriction needs to be imposed on the structural model. We discuss these issues next.

iii) Identification

In addition to making the assumption of uncorrelated residuals in Eq. 4.2, the main identification strategy implied here as matrix A is a lower triangular matrix. Here we identify an unanticipated exchange rate shock by taking a Choleski decomposition. This strategy is used in a number of recent papers investigating similar issues in the Australian and New Zealand contexts, including Manalo et al. (2015), and Karagedikli et al. (2013).

The lower triangularity of matrix A, also known as the recursive restriction in the SVAR literature, implies that each of the seven regression equations contained in the primitive system (Eq. 4.1) includes contemporaneous terms of the variables ordered above it, but not those below it. Thus, the first equation ($\Delta \mathrm{usgdp}$) contains no contemporaneous terms of any variables. The second equation ($\Delta \mathrm{tot}$) contains variables in the first equation and recorded at the same time period, and so on. In Table 4.3, we present the ordering of the variables and the structure of matrix A used to identify the system.

Table 4.3: Identification Restrictions Given by the Recursive Structure

	Right Hand Variables						
Equation for:	**US real GDP**	**Terms of Trade**	**AUS real GDP**	**Employment**	**Inflation**	**Cash Rate**	**Real Exchange Rate**
US real GDP	1	-	-	-	-	-	-
Terms of Trade	a_{21}	1	-	-	-	-	-
AUS real GDP	a_{31}	a_{32}	1	-	-	-	-
Employment	a_{41}	a_{42}	a_{43}	1	-	-	-
Inflation	a_{51}	a_{52}	a_{53}	a_{54}	1	-	-
Cash Rate	a_{61}	a_{62}	a_{63}	a_{64}	a_{65}	1	-
Real Exchange Rate	a_{71}	a_{72}	a_{73}	a_{74}	a_{75}	a_{76}	1

Note: The parameters a_{ij} represent free parameters, while "-" is used to indicate the variables which are not included in the equations presented across the rows.

Let the variance of the error terms of the reduced form, var($\mathrm{e_t}$) $= \Sigma_{\mathrm{e}} = \mathrm{KK}'$, we could have:

$$\mathrm{KK}' = \Sigma_{\mathrm{e}} = \mathrm{Ee_t e_t'} = \mathrm{EA^{-1}\varepsilon_t\varepsilon_t'(A^{-1})'} = \mathrm{A^{-1}E(\varepsilon_t\varepsilon_t')(A^{-1})'} = \mathrm{A^{-1}}\Sigma_{\varepsilon}\mathrm{(A^{-1})'} \tag{4.4}$$

where $\mathrm{E(\varepsilon_t\varepsilon_t')}$ is the variance of the structural innovations, Σ_{ε}. Thus, $\mathrm{K} = \mathrm{A^{-1}}(\Sigma_{\varepsilon})^{1/2}$. $(\Sigma_{\varepsilon})^{1/2}$ is the (nxn) diagonal matrix as Σ_{ε} is defined as a diagonal matrix. The elements of the principle diagonal be the square root of the variance of the structural innovations. Matrix A is a lower triangular matrix with 1's on diagonal and so does inverse Matrix $\mathrm{A^{-1}}$. Let $\mathrm{A_{ij}}$ denote the elements of Matrix $\mathrm{A^{-1}}$. In detail, K could be expressed as below:

$$
\mathrm{K} = \mathrm{A}^{-1}(\Sigma_\varepsilon)^{1/2} = \frac{1}{|\mathrm{A}|}\,\mathrm{Adj}\mathbf{A}\cdot(\Sigma_\varepsilon)^{1/2} = \begin{bmatrix} 1 & 0 & 0 & \cdots & 0 \\ A_{21} & 1 & 0 & \cdots & 0 \\ A_{31} & A_{32} & 1 & \cdots & 0 \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ A_{71} & A_{72} & A_{73} & \cdots & 1 \end{bmatrix} \begin{bmatrix} \sqrt{\sigma_1^2} & 0 & 0 & \cdots & 0 \\ 0 & \sqrt{\sigma_2^2} & 0 & \cdots & 0 \\ 0 & 0 & \sqrt{\sigma_3^2} & \cdots & 0 \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ 0 & 0 & 0 & \cdots & \sqrt{\sigma_7^2} \end{bmatrix}
$$

$$
= \begin{bmatrix} \sqrt{\sigma_1^2} & 0 & 0 & \cdots & 0 \\ A_{21}\sqrt{\sigma_1^2} & \sqrt{\sigma_2^2} & 0 & \cdots & 0 \\ A_{31}\sqrt{\sigma_1^2} & A_{32}\sqrt{\sigma_2^2} & \sqrt{\sigma_3^2} & \cdots & 0 \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ A_{71}\sqrt{\sigma_1^2} & A_{72}\sqrt{\sigma_2^2} & A_{73}\sqrt{\sigma_3^2} & \cdots & \sqrt{\sigma_7^2} \end{bmatrix} \tag{4.5}
$$

Therefore, by using the Choleski decomposition, we are able to recover the structural parameters given in the primitive system (Eq. 4.1) from the reduced-form model (Eq. 4.2). It is noted that under this method, the order of the variables entering the model is crucial. For this reason, it is also called the recursive ordering approach. The order of the variables in the empirical model is based on the observed interrelation channels of macroeconomic variables and theories. As seen in Table 4.1, in the empirical SVAR, US real GDP is ordered first without depending on any other variables contemporaneously. Australian terms of trade is modelled after the US real GDP and before all the domestic variables. It can be observed that the movement of terms of trade, the dollar amount of exports on imports, tends to result from global demand. The United States, as a large open economy, has a significant impact on the world's economy and demand fluctuations. Apart from the impacts of foreign variables, the growth of Australian real GDP will affect the labour market and inflation. If actual GDP grows faster than potential GDP (a positive GDP gap), there will be upward pressure on unit labour costs and consumer prices, according to Beechey et al. (2000). The change of inflation will have direct impacts on the nominal interest rate under the inflation target regime in Australia. The real exchange rate will be affected according to the interest rate differential between domestic and foreign countries in the exchange rate model as explained in Krugman et al. (2015). Meanwhile, the change in interest rate will affect Australian real GDP with a lag as well as the other macroeconomic variables, which follows the second identification assumption discussed next.

Similar to Manalo et al. (2015), the identification of the real exchange rate rests on two assumptions. First, the macroeconomic shocks will affect the real exchange rate contemporaneously. Second, the real exchange rate shocks will affect the macroeconomic variables in lags. Using a recursive approach, the real exchange rate is therefore ordered as the last variable. In the short run, the movements of the real exchange rate will largely depend on the change in the normal exchange rate. Meanwhile, due to Australia's floating exchange rate regime, the normal exchange rate quickly reflects the changes in macroeconomic fundamentals. The second assumption is based on the price rigidity in the market. Firms will alter the price in lags due to the price rigidity in the short run. Domestic inflation will change as a result of the movements in the real exchange rate. At the same time, the size of changing in inflation will be subject to the exchange rate pass-through effects. According to Chung et al. (2011), the pass-through of exchange rate movements to overall consumer prices occurs with a lag in Australia.

iv) Further Restrictions

Block restriction is commonly used for small open economies. Cushman and Zha (1997) implies block restriction to investigate monetary policy shock on a small open economy, Canada. Voss and Willard (2009) implies block restriction in their two-country structural VAR of monetary policy and exchange rate. Dungey and Pagan (2009) highlights the importance of setting block restrictions while designing an Australian SVAR model. Manalo et al. (2015) includes block restriction to reflect the real relationship between foreign and domestic variables in the VAR model. Following the existing literature, we also impose block restrictions on the AR parameter matrices in the reduced-form (Eq. 4.3), which reflects the small open economy assumption for Australia. In essence, this restriction differentiates between foreign and domestic variables, and posits that foreign variables affect domestic variables contemporaneously, while domestic variables have no impact on foreign variables.

Table 4.4 below summarises these block restrictions imposed on the matrix B given in (Eq 4.3), where the rows of the table represent the equations of the model, while the columns denote lagged right-hand variables.

Table 4.4: Block Restrictions

Equations	US Real GDP	Terms of Trade	Employment	AUS Real GDP	Inflation	Cash Rate	Real Exchange Rate
US Real GDP	b_{11}	b_{12}	-	-	-	-	-
Terms of Trade	b_{21}	b_{22}	-	-	-	-	-
Employment	b_{31}	b_{32}	b_{33}	b_{34}	b_{35}	b_{36}	b_{37}
AUS Real GDP	b_{41}	b_{42}	b_{43}	b_{44}	b_{45}	b_{46}	b_{47}
Inflation	b_{51}	b_{52}	b_{53}	b_{54}	b_{55}	b_{56}	b_{57}
Cash Rate	b_{61}	b_{62}	b_{63}	b_{64}	b_{65}	b_{66}	b_{67}
Real Exchange Rate	b_{71}	b_{72}	b_{73}	b_{74}	b_{75}	b_{76}	b_{77}

Note: The parameters b_{ij} represent free parameters given in (Eq. 4.3), while "-" is used to indicate the variables that are not included in the equations presented across the rows.

The first two equations are of foreign variables which will not be affected by domestic variables. The next four equations represent the Australian domestic economy with two foreign variables. The third equation is for Australian GDP. As described in the literature, Australian GDP closely relates to US GDP and reflects the global economy conditions as a small open economy. The fourth equation is about trimmed mean inflation. The fifth equation is monetary policy, and the last equation is the one modelling the real exchange rate.

4.2.4 *Estimation and Lag Selection*

Coefficients in the SVAR model are estimated under OLS method. The number of lags to be included is determined with reference to information criteria. For the baseline model of output, the Akaike information criteria suggests 10 lags. Hannan-Quinn information criteria suggests a single lag. Schwartz information criterion suggests zero lag. In industrial sectoral models, Hannan-Quinn information criterion always suggests a single lag. Therefore, 1 lag was decided upon for the SVAR model, which is more reasonable when compared to the rest. Tests for lag select are provided in Appendix 2. In section 4.4, we will discuss robustness of the results with alternative lag length.

Several dummy variables are included in the SVAR model with respect to the structure breaks during the sample period. First, Dummy 1 (D1) denotes the period after the inflation-targeting monetary policy regime: since 1993:Q1. Dummy 2 (D2) to Dummy 5 (D5) are dummies for each of the four quarters for the global financial crisis from 2008:Q4. To account for the introduction of the Goods and Services Tax (GST) on the 1st of July 2000, Dummy 6 (D6) and Dummy 7 (D7) are used for the VAR model for the construction industry only.

In Appendix 2, we present details of three tests on the baseline model: i) ARCH effect test with null of no ARCH effect; ii) Residual Normality Test with null of residual are normally distributed; and iii) Breusch-Godfrey LM test for autocorrelation with null of no autocorrelation. The p-values are reported in these tests. It is noted that according to the ARCH effect test, these is no ARCH effect at the 5 per cent significance level as the p-value equals 0.0877. The results of the Doornik test shows the p-value as 0.0000. Thus, we reject the null hypothesis of normality. However, we use a bootstrap method to construct the confidence interval for the point estimation in the impulse response function. The bootstrap method does not robust to the non-normality. The p-value for the Breusch-Godfrey LM test is 0.0000. Therefore, we reject the null hypothesis of no autocorrelation. However, in the robustness (section 4.4), we test the models with 2 lags and 3 lags. We do not find significant differences in the results comparison, so we are confident with the results from the baseline model.

The estimation of the baseline model coefficients are presented in Appendix 3 with standard deviation and p-values.

4.3 Empirical Results

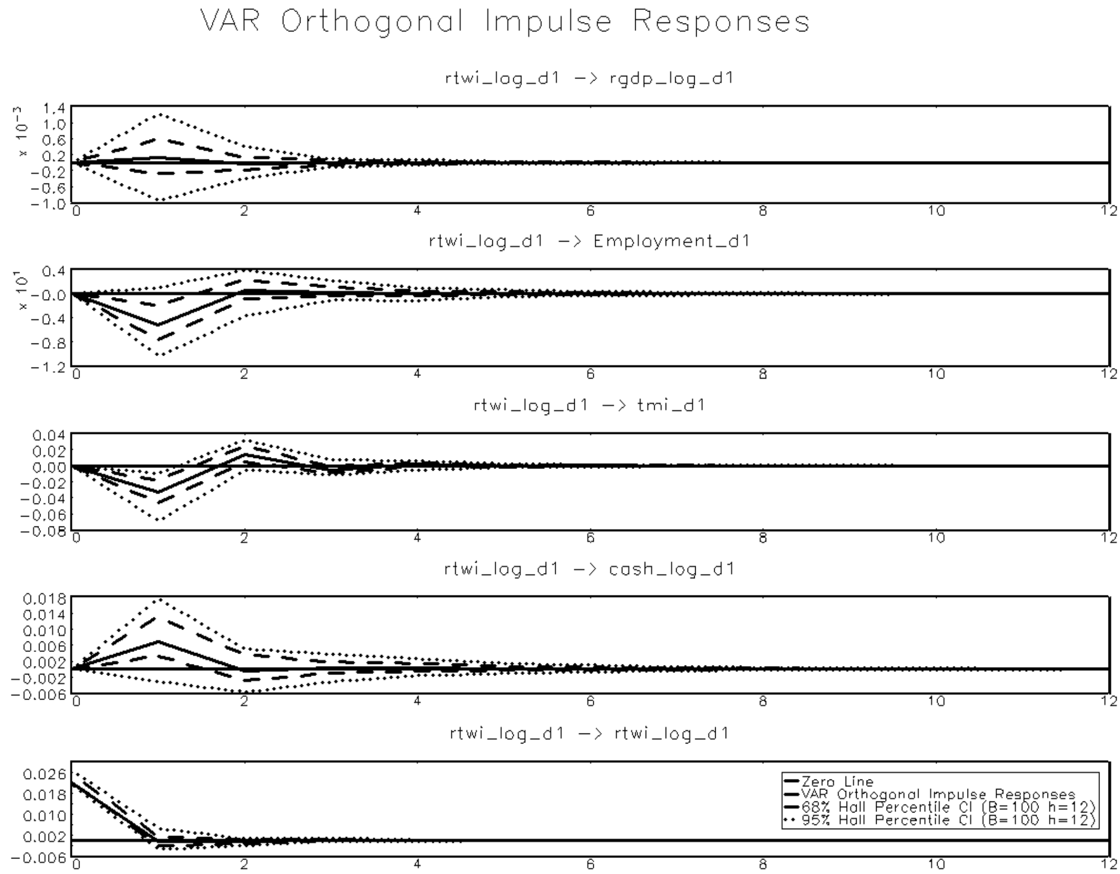
Section 4.3.1 and Section 4.3.2 present the empirical results for aggregate economy and industries, respectively. According to the empirical model principles described in Section 4.2.3 and the data Section 4.2.2, our aggregate model results show the impacts of an exchange rate shock on the whole society. At the same time, by using sectorial data, sectoral models enable to estimate the shock impacts on each industry, separately. Thus industrial impulse response function and variance decomposition are computed from the disaggregate data which are not inferred from aggregate SVAR.

4.3.1 *Aggregate Output and Employment*

Figure 4.3 shows the aggregate variable responses to a one-standard-deviation unanticipated real exchange rate shock. For aggregate output growth, the appreciation of the exchange rate contributes a slight increase in the growth of Australian real GDP. The point estimation shows that an unanticipated shock causes a 0.0001 per cent increase. The output returns to the trend in two quarters after the initial appreciation. However, the shock impact on GDP growth is insignificant at 95 per cent confidence interval. Employment growth is around 5.25 per cent lower at the first quarter after the initial appreciation and dies down afterwards. From Figure 4.3, employment growth is significant only at the 68 per cent confidence interval. Inflation is 0.03 per cent below its trend level and returns to its trend level in subsequent quarters. This shock effect lasts for 2 years before its dies out and is significant at the 68 per cent confidence interval. The responses of the cash rate to an exchange rate shock is relatively smaller at 0.006 per cent, but it is significant at the 68 per cent confidence interval.

Such an effect lasts for about four quarters before it dies out. The real exchange rate is affected by itself endogenously. The shock effects last for about 2 quarters and returns to its initial level after one year.

Figure 4.3 Impulse Response Functions – Exchange Rate Shock

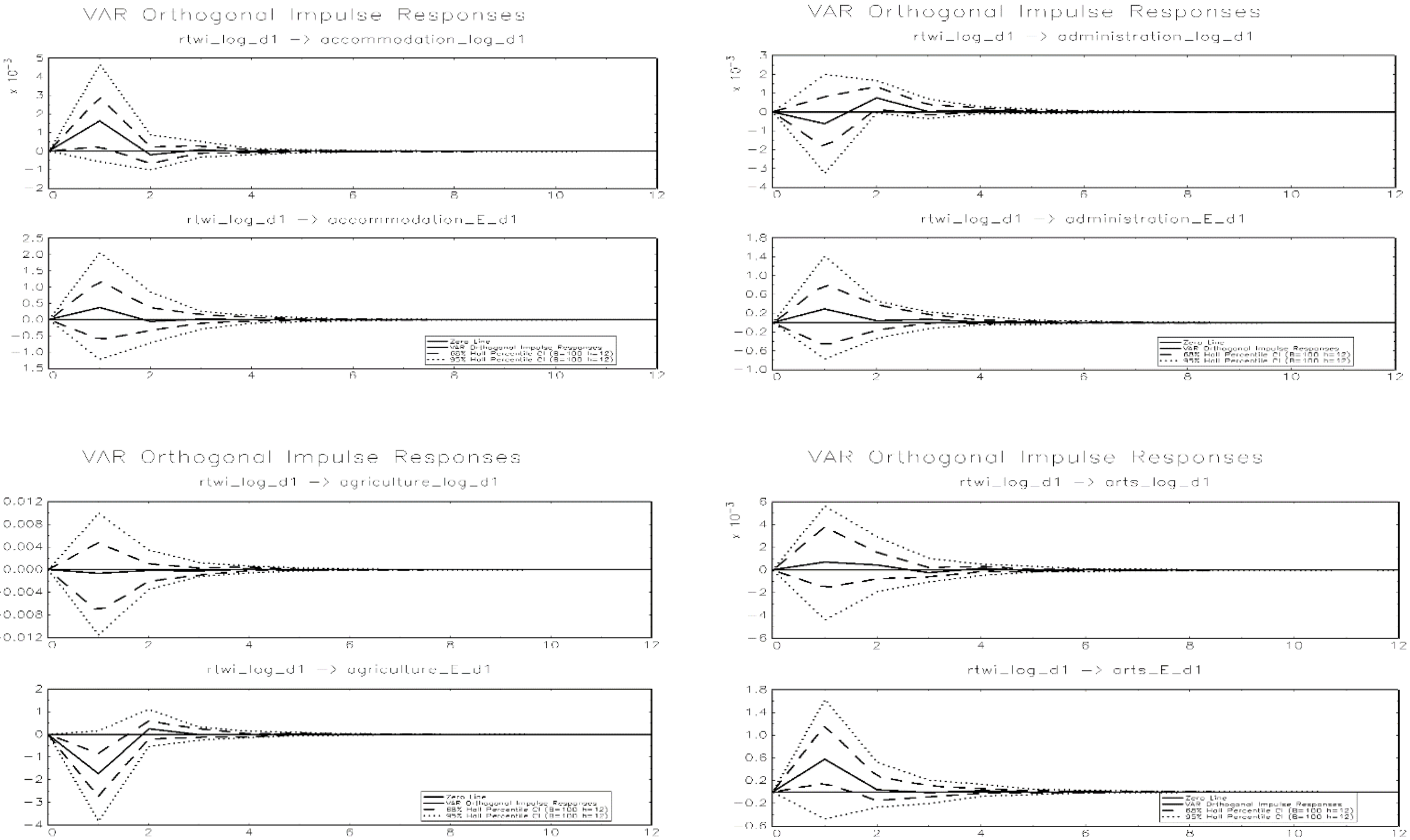


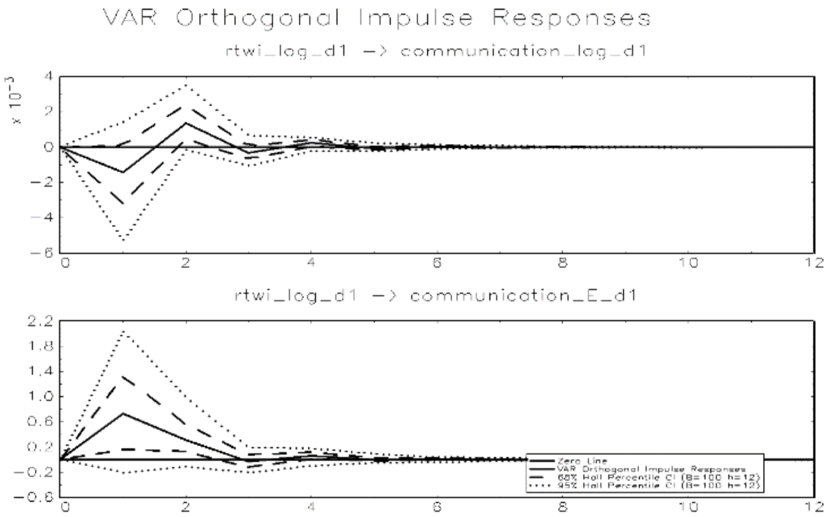
4.3.2 *Industrial Output and Employment*

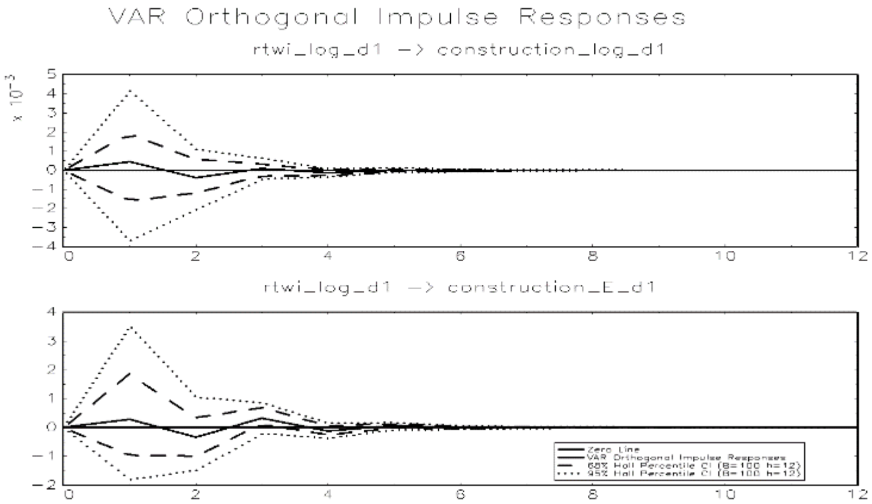
Figure 4.4 shows how the growth in output and employment of different industries responds to a one-standard-deviation transitory exchange rate shock. Consistent with the slight increase of aggregate output growth, 12 industries of a total 19 industries experienced an increase of output growth in the first few quarters. According to IRFs, the top five industries which show the greatest responses to the exchange rate shock are pubadmin, rental, mining, retail and wholesale. The correspondence peak impacts on these five industries are 0.0037 per cent, 0.0027 per cent, 0.0025 per cent, 0.0023 per cent and 0.0022 per cent. Appreciation appears to have negative impacts on the growth of pubadmin and rental and positive impacts on the other three. In these five industries, the peak impact of exchange rate shock occurs at the first quarter and dies out in the following quarters. The responses of pubadmin and the retail industries are significant at 95 per cent confidence interval, while the rental and wholesale industries are significant at 68 per cent confidence interval.

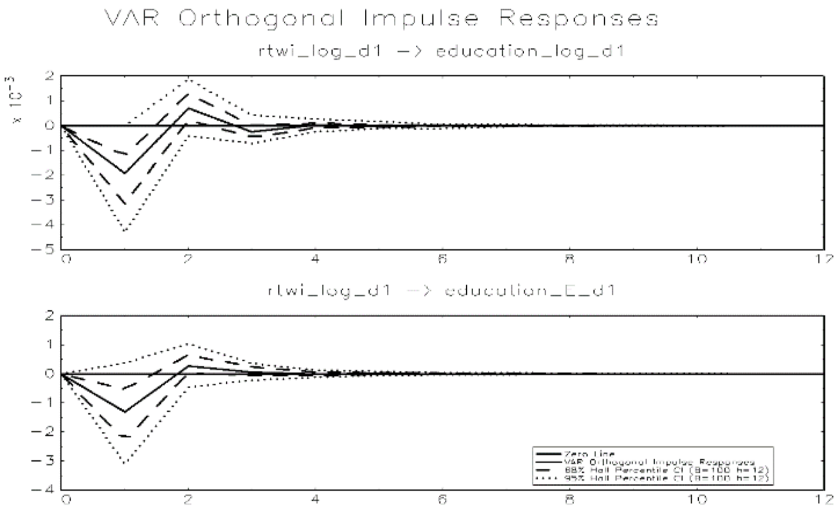
As for employment growth, most industries' employment growth tends to be lower than the trend. Among all 19 industries, agriculture, pubadmin, education, health and mining are the industries most sensitive to an unanticipated exchange rate shock. The peak impacts for each of these industries are 1.7355 per cent, 1.4438 per cent, 1.3184 per cent, 1.2674 per cent and 1.0498 per cent, respectively. All of these industries experience negative impacts on employment growth from an exchange rate shock. At the same time, the responses occur at the first quarter following the shock. Moreover, according to IRFs in Figure 4.4, the response of the mining industry is significant at 95 per cent confidence interval, while the rest of the industries' responses are significant at 68 per cent confidence interval.

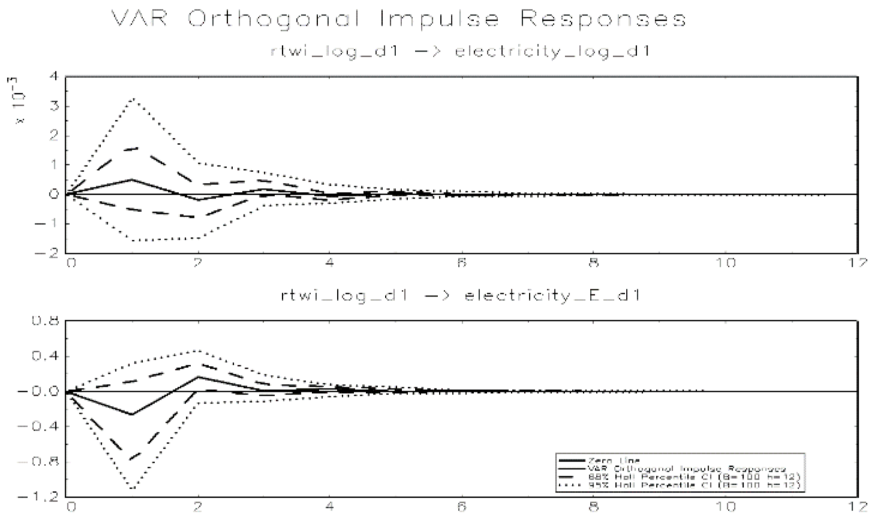
Figure 4.4 Impulse Response Functions – Industry Gross Value Added

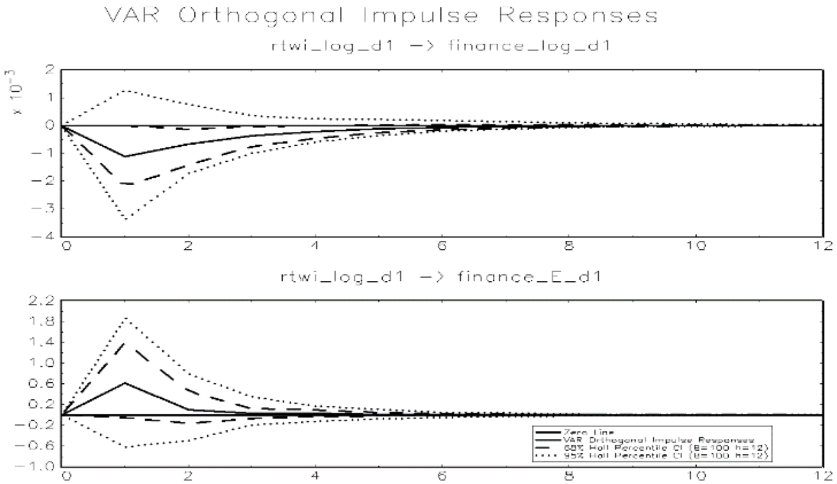


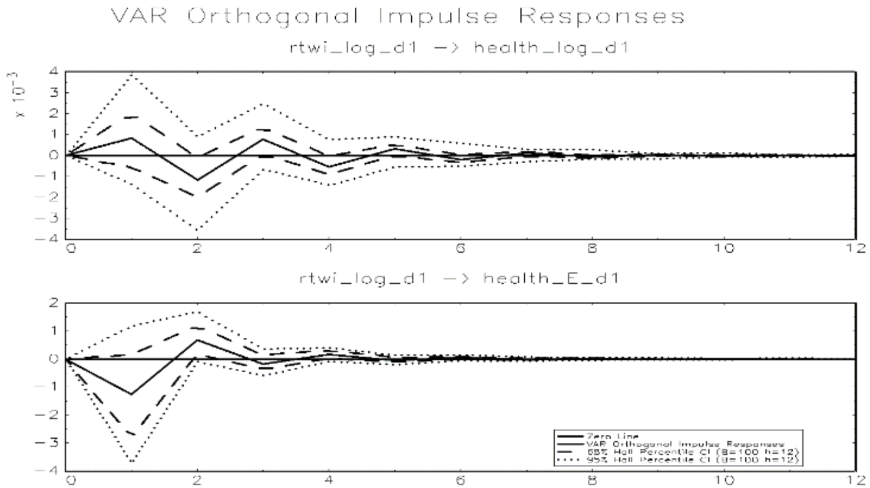

VAR Orthogonal Impulse Responses
rtwi_log_d1 -> communication_log_d1
x 10^-3
rtwi_log_d1 -> communication_E_d1
Zero Line
VAR Orthogonal Impulse Responses
68% Hall Percentile CI (B=100 h=12)
95% Hall Percentile CI (B=100 h=12)

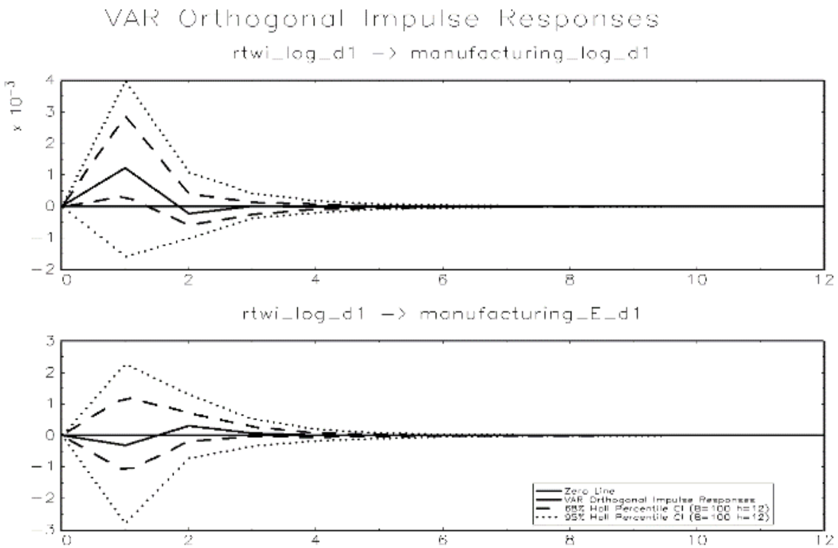

VAR Orthogonal Impulse Responses
rtwi_log_d1 -> construction_log_d1
x 10^-3
rtwi_log_d1 -> construction_E_d1
Zero Line
VAR Orthogonal Impulse Responses
68% Hall Percentile CI (B=100 h=12)
95% Hall Percentile CI (B=100 h=12)

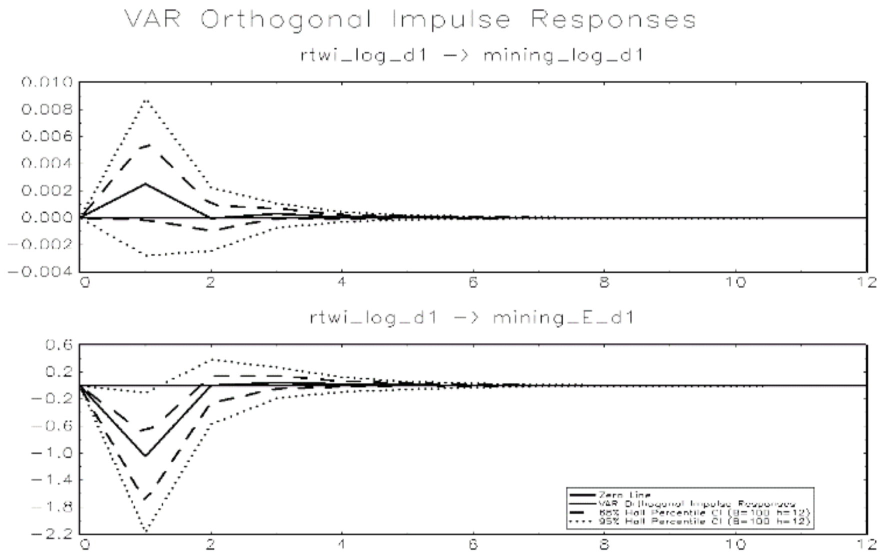

VAR Orthogonal Impulse Responses
rtwi_log_d1 -> education_log_d1
x 10^-3
rtwi_log_d1 -> education_E_d1
Zero Line
VAR Orthogonal Impulse Responses
68% Hall Percentile CI (B=100 h=12)
95% Hall Percentile CI (B=100 h=12)

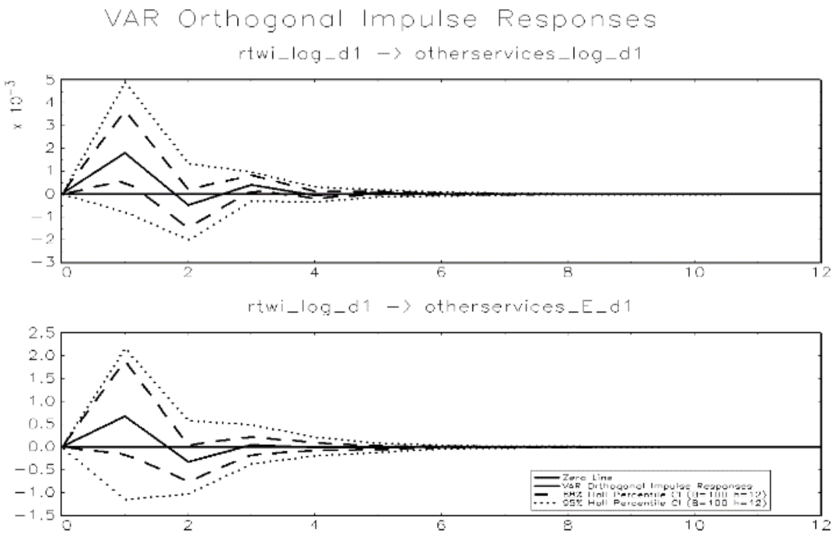

VAR Orthogonal Impulse Responses
rtwi_log_d1 -> electricity_log_d1
x 10^-3
rtwi_log_d1 -> electricity_E_d1
Zero Line
VAR Orthogonal Impulse Responses
68% Hall Percentile CI (B=100 h=12)
95% Hall Percentile CI (B=100 h=12)

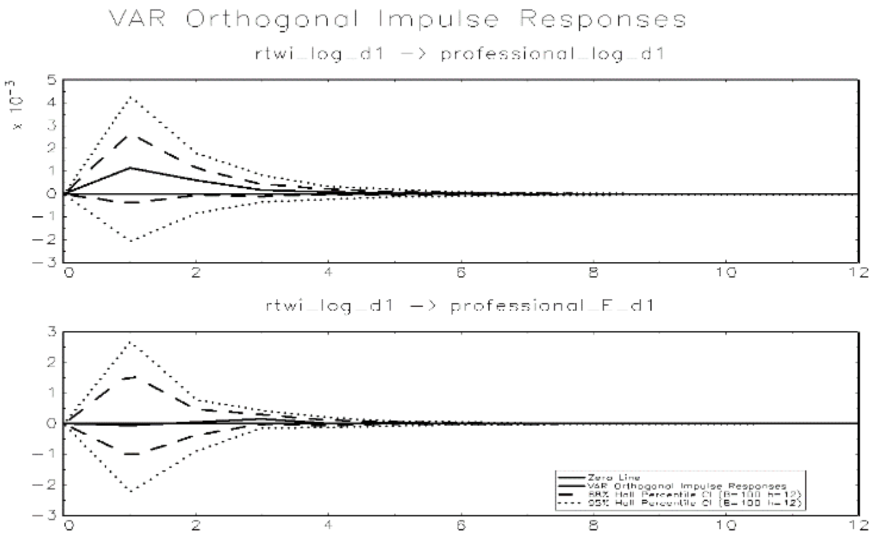

VAR Orthogonal Impulse Responses
rtwi_log_d1 -> finance_log_d1
rtwi_log_d1 -> finance_E_d1
Zero Line
VAR Orthogonal Impulse Responses
68% Hall Percentile CI (B=100 h=12)
95% Hall Percentile CI (B=100 h=12)

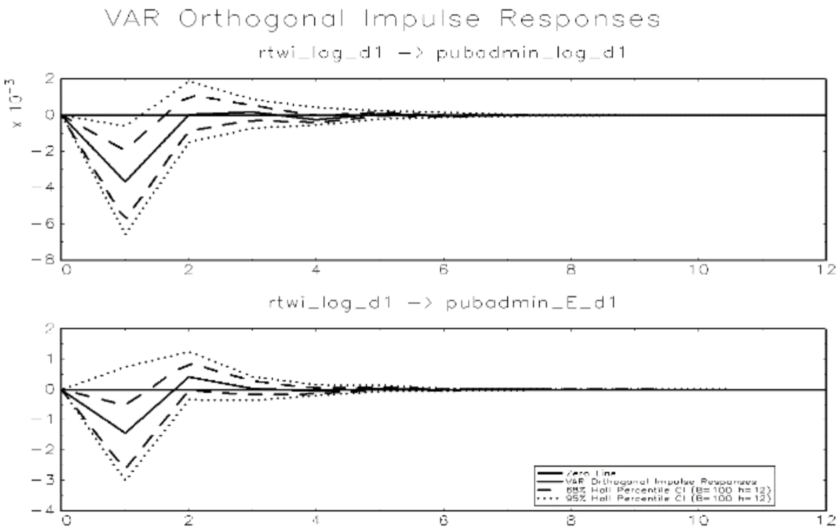

VAR Orthogonal Impulse Responses
rtwi_log_d1 -> health_log_d1
rtwi_log_d1 -> health_E_d1
Zero Line
VAR Orthogonal Impulse Responses
68% Hall Percentile CI (B=100 h=12)
95% Hall Percentile CI (B=100 h=12)

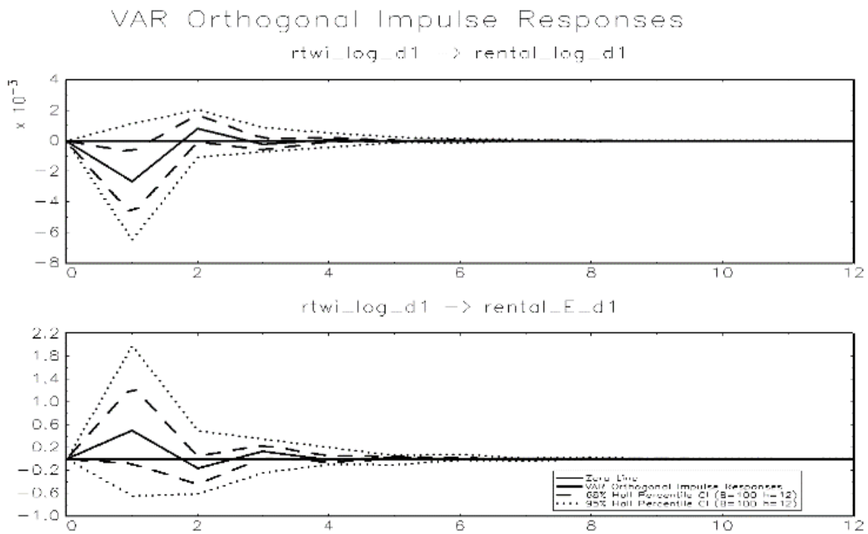

VAR Orthogonal Impulse Responses
rtwi_log_d1 -> manufacturing_log_d1
rtwi_log_d1 -> manufacturing_E_d1
Zero Line
VAR Orthogonal Impulse Responses
68% Hall Percentile CI (B=100 h=12)
95% Hall Percentile CI (B=100 h=12)

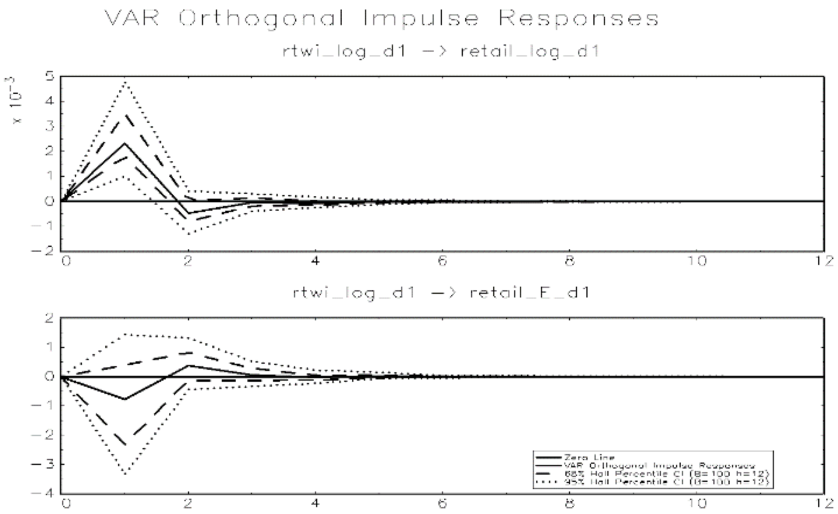

VAR Orthogonal Impulse Responses
rtwi_log_d1 -> mining_log_d1
rtwi_log_d1 -> mining_E_d1
Zero Line
VAR Orthogonal Impulse Responses
68% Hall Percentile CI (B=100 h=12)
95% Hall Percentile CI (B=100 h=12)

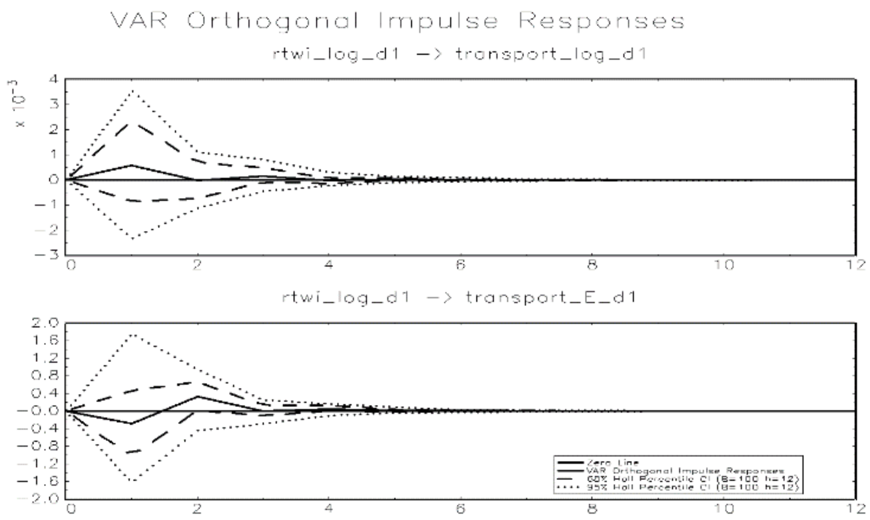

VAR Orthogonal Impulse Responses
rtwi_log_d1 -> otherservices_log_d1
rtwi_log_d1 -> otherservices_E_d1
Zero Line
VAR Orthogonal Impulse Responses
68% Hall Percentile CI (B=100 h=12)
95% Hall Percentile CI (B=100 h=12)

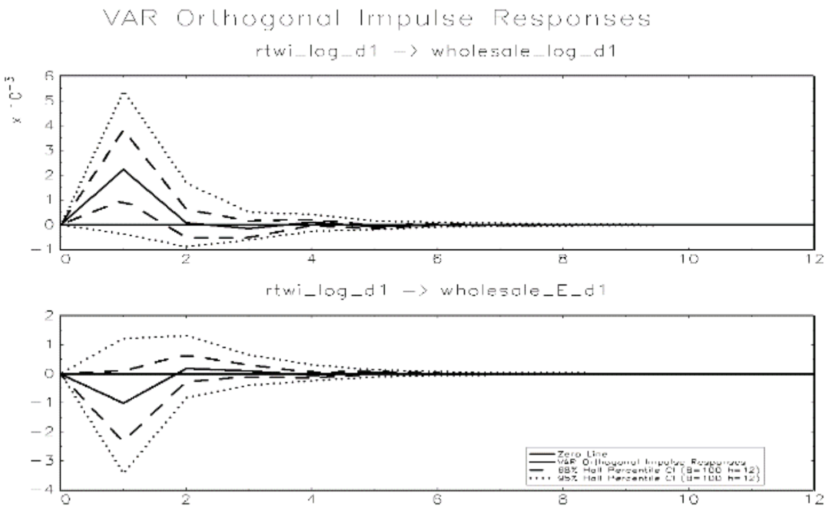

VAR Orthogonal Impulse Responses
rtwi_log_d1 -> professional_log_d1
rtwi_log_d1 -> professional_E_d1
Zero Line
VAR Orthogonal Impulse Responses
68% Hall Percentile CI (B=100 h=12)
95% Hall Percentile CI (B=100 h=12)


VAR Orthogonal Impulse Responses
rtwi_log_d1 -> pubadmin_log_d1
rtwi_log_d1 -> pubadmin_E_d1
Zero Line
VAR Orthogonal Impulse Responses
68% Hall Percentile CI (B=100 h=12)
95% Hall Percentile CI (B=100 h=12)


VAR Orthogonal Impulse Responses
rtwi_log_d1 -> rental_log_d1
rtwi_log_d1 -> rental_E_d1
Zero Line
VAR Orthogonal Impulse Responses
68% Hall Percentile CI (B=100 h=12)
95% Hall Percentile CI (B=100 h=12)


VAR Orthogonal Impulse Responses
rtwi_log_d1 -> retail_log_d1
x 10^-3
rtwi_log_d1 -> retail_E_d1
Zero Line
VAR Orthogonal Impulse Responses
68% Hall Percentile CI (B=100 h=12)
95% Hall Percentile CI (B=100 h=12)


VAR Orthogonal Impulse Responses
rtwi_log_d1 -> transport_log_d1
x 10^-3
rtwi_log_d1 -> transport_E_d1
Zero Line
VAR Orthogonal Impulse Responses
68% Hall Percentile CI (B=100 h=12)
95% Hall Percentile CI (B=100 h=12)


VAR Orthogonal Impulse Responses
rtwi_log_d1 -> wholesale_log_d1
rtwi_log_d1 -> wholesale_E_d1
Zero Line
VAR Orthogonal Impulse Responses
68% Hall Percentile CI (B=100 h=12)
95% Hall Percentile CI (B=100 h=12)

According to Figure 4.4, industrial responses to an exchange rate shock varies across the horizon. This is largely due to the characteristics of each industry. Table 4.5 provides a summary of the industry characteristics for its trade exposure and final consumption group.

Table 4.5: Industry Characteristics (per cent)

Industry	Share of GDP[1]	Export Propensity[2]	Imported input share[3]	Import penetration[4]	Trade-related exposure[5]	Household Consumption[6]	Government Consumption[7]
	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Agriculture	3	20	5	4	42	25	1
Mining	10	63	8	8	16	2	0
Manufacturing	7	23	16	32	107	42	3
Service Sectors							
Electricity	3	0	3	2	23	78	3
Construction	9	0	10	4	31	0	0
i) Social Services							
Pubadmin	6	0	6	2	5	2	96
Education	6	8	6	2	1	43	47
Health	8	0	8	3	0	37	62
ii) Distribution Services							
Retail	5	3	5	1	12	89	2
Wholesale	5	13	6	3	31	53	1
Transport	5	14	8	7	55	50	16
Communication	3	3	5	7	13	72	6
iii) Business Services							
Finance	10	2	1	1	37	92	0
Rental	4	1	2	1	42	95	0
Professional	7	4	2	4	43	10	10
Administration	3	2	1	4	30	28	54
iv) Personal Services							
Accommodation	3	11	8	9	7	87	0
Arts	1	3	15	8	1	77	19
Otherservices	2	1	8	7	14	97	2

Notes:

1. Share of GDP is measured by Industry gross value added (GVA) on aggregate GVA with data for 2015 Q2.
2. Export propensity is measured by industry exports on total Australian production of each industry, data for 2013/14.
3. Imported input share is measured by imported inputs as a share of total Australian production of each industry, data for 2013/14.
4. Import penetration is measured by competing imports on total supply of each industry, data ranged for 2013/14.
5. Trade-related exposure is measured by percentage of domestic sales to industries with export propensity greater than 10 per cent, data for 2013/14.
6. Household consumption is measured by household final consumption expenditure on each industry final uses, data for 2013/14.
7. Government consumption is measured by the share of government final consumption expenditure on each industry final uses, data for 2013/14.

Source: ABS, RBA

The movement in the exchange rate has various impacts on industries. As in the literature, these impacts can be classified into to four channels as in Kohler et al. (2014).

i) The expenditure-switch effect: The effect of an appreciation is through the price effect of exports and imports; An appreciation will generally benefit imports.
ii) Cost effects: The cost of imports for final consumers will decrease associates with an appreciation which, in return, will benefit the profitability.
iii) Debt burden: The extent of unhedged debt in foreign currency will alter the macroeconomic elements such as output and employment.
iv) Capital flow: The relative amount of foreign and domestic investment.

In this thesis, the analysis focuses on the expenditure-switching effect and cost effect. The expenditure-switching effect is recorded as the first-round effect. The cost effect is recognised as the second-round effect.

As expected, the growth of the mining industry is higher than the trend. The mining industry has large export propensity (63 per cent) and moderate import exposure (8 per cent). We assume that the volume effect will dominate the value effect. Most resource contracts are pre-signed so the volume is determined before the movement of the exchange rate. An appreciation will have an initial benefit on the mining industry in the short run.

Manufacturing also experiences positive output growth, but the extent of its growth is much smaller. This is mainly due to two factors. First, the imported input share (16 per cent, as shown in Table 4.5) is the largest among all industries, which brings benefits to the manufacturing industry. An appreciation lower the cost of imported inputs. However, the exports propensity (23 per cent) and import competition (32 per cent) are high, which partly offset the benefits brought by high imported input share. One possible reason for the results in the manufacturing industry's GDP growth that increases at the beginning and then declines. is due to the J-curve effect. During an appreciation, the J-curve effect will cause an initial increase of current account followed by a decrease. The primary effect of the appreciation is to decline the value of the pre-contracted level of imports. However, according to Krugman (1987), the third degree price discrimination introduced by foreign exporters on domestic importers will cause stickiness in the import price. Therefore, the size of the J-curve effect would be smaller.

Among the rest of the industries, which have moderate export exposure, relatively low import competition or moderate import input shares, will be affected by the second-round effect, the cost effect. Compared to the mining and manufacturing industries, the retail and wholesale industries have relatively lower import input shares, at 5 per cent and 6 per cent, respectively. However, these two industries are directly linked with household spending, and this will result in higher spending due to the lower cost of imports. Therefore, the growth of the retail and wholesale industries is driven by the lower cost of sold on imports. Meanwhile, the wholesale industry is the largest export-exposure industry apart from mining, manufacturing and agriculture, and its export propensity is 13 per cent. This partly offsets the benefits brought by the cost advantages, so the response of the wholesale industry is a little smaller than that of the retail industry.

On the other hand, Pubadmin mainly includes services in regulation, defence and public ordering. As shown in Table 4.5, the output growth is largely consumed by government (96 per cent) rather than by household (2 per cent). Therefore, this industry does not depend largely on market demand. This finding is consistent with Kohler et al. (2014), which states that the public administration and safety sector is significantly influenced by supply-side developments.

In addition, the shock response from the business service sector is smaller but substantial. All of the four industries in the business sectors have relatively higher trade-related exposure ratios, ranging from 30 per cent to 43 per cent. Among these industries, the shock responses of the finance and rental industries' output growth are significant at 68 per cent confidence interval. This is largely due to their close links with the exports-exposed industries that have export propensity great than ten per cent, though these links are indirect. In detail, a significant part of the rental industry's domestic sales goes to wholesale and accommodation. According to Table 4.5, the export propensity of the wholesale and accommodation industries is 13 per cent and 11 per cent, respectively. As for the finance industry, it has links with many large export-exposed industries. At the same time, the extent of the links with the finance industry to those industries are relatively even and substantial, compared to other industries in the business service sector. However, the impulse responses show that shock impacts on the finance and rental industries lower their output growth compared to the trend. The shock impacts on industrial level are largely consistent with the theories. The extent of shock impacts depends on the openness of the industry, the size of imports and exports.

Comparing the results with those in Manalo et al. (2015), which investigates an unanticipated exchange rate shock on the level of output, empirical results of output growth shows some different impacts on the aggregate economy and at the industrial level. The Australian real GDP has a negative and significant response to a ten per cent appreciation of the real exchange rate, which lowers the level of real GDP by 0.3 per cent in one-to-two years in Manalo et al. (2015). According to the shock responses shown in Figure 4.3, an unanticipated one-standard-deviation unanticipated exchange rate shock slightly increases the growth of real GDP by 0.0001 per cent. However, the shock impacts on real GDP growth is insignificant, and the impact period on GDP growth is much shorter, as discussed in section 4.3.1.

As for the industrial responses, in Manalo et al. (2015), mining and manufacturing are the two most sensitive industries to the shock. As one of the top five industries, growth rates in the mining industry have large responses to the shock. However, growth rates in the manufacturing industry are much less sensitive to an exchange rate shock here. In the services sector, growth in distribution services such as the retail and wholesale industries is significantly impacted by the shock. The rental industry in business services also responds a lot to exchange rate shocks. Growth in public administration has the largest response to the shock, which appears to contrast with the findings in in Manalo et al. (2015) showing that social service contributes a small share for the shock impacts on GDP. The finance industry appears to experience negative growth from an appreciation of real exchange rate shock, but the impact is only significant at two standard deviation confidence. On the other hand, the level of the finance industry's output is positive in Manalo et al. (2015).

4.3.3 *Variance Decomposition*

In this section, the variance decomposition shows the role of real exchange rate shock. Whether the real exchange rate shock behaves like a source of volatility in the Australian economy, or whether it acts like a shock absorber as often discussed in the literature.

Table 4.6 shows the contribution of the real exchange rate to the variance of the GDP growth, the employment growth, the trimmed mean inflation, and the overnight cash rate from quarter 2 to quarter 40. According to the results, there is no evidence demonstrating that the real exchange rate shock explains much of the volatility of the four domestic variables.

Table 4.6 Variance Decomposition – Aggregate Variables

Proportion of forecast error variance explained by real exchange rate shocks				
Variable	**Horizon (Quarters)**			
	2	**10**	**20**	**40**
Real GDP	0.00	0.00	0.00	0.00
Employment	0.02	0.02	0.02	0.02
Inflation	0.03	0.03	0.03	0.03
Cash Rate	0.01	0.01	0.01	0.01

As for the output growth of the industry sectors, retail, pubadmin, education and wholesale are largely influenced by the real exchange rate shock (Table 4.7). The real exchange rate shock has relatively small effects on the growth of accommodation, finance, manufacturing, mining, other services and the retail industries. However, compared to the results of the impulse response function, the variance of the mining industry does not appear to be explained by the real exchange rate, and the real exchange rate does not explain the variance of the rest of the industries.

Table 4.7 Variance Decomposition on Output Growth – Industry Variables

Proportion of forecast error variance explained by real exchange rate shocks				
Variable	**Horizon (Quarters)**			
	2	**10**	**20**	**40**
Accommodation	0.01	0.01	0.01	0.01
Administration	0.00	0.00	0.00	0.00
Agriculture	0.00	0.00	0.00	0.00
Arts	0.00	0.00	0.00	0.00
Communication	0.00	0.01	0.01	0.01
Construction	0.00	0.00	0.00	0.00
Education	0.02	0.02	0.02	0.02
Electricity	0.00	0.00	0.00	0.00
Finance	0.01	0.01	0.01	0.01
Health	0.00	0.01	0.01	0.01
Manufacture	0.01	0.01	0.01	0.01
Mining	0.01	0.01	0.01	0.01
Other services	0.01	0.01	0.01	0.01
Professional	0.00	0.00	0.00	0.00
Pubadmin	0.03	0.03	0.03	0.03
Rental	0.01	0.01	0.01	0.01
Retail	0.05	0.05	0.05	0.05
Transport	0.00	0.00	0.00	0.00
Wholesale	0.02	0.02	0.02	0.02

The pattern of employment growth in the industrial sectors is similar to that shown in Table 4.8. Exchange rate shocks explain a modest proportion of the variance in the mining and agriculture industries. Arts, communication, education, health, pubadmin and wholesale are also affected by the real exchange rate shock, but the impacts are smaller. However, the exchange rate explains little about the impacts on the rest of the industries' employment growth.

Table 4.8 Variance Decomposition on Employment Growth– Industry Variables

Proportion of forecast error variance explained by real exchange rate shocks				
Variable	**Horizon (Quarters)**			
	2	**10**	**20**	**40**
Accommodation	0.00	0.00	0.00	0.00
Administration	0.00	0.00	0.00	0.00
Agriculture	0.02	0.02	0.02	0.02
Arts	0.01	0.01	0.01	0.01
Communication	0.01	0.01	0.01	0.01
Construction	0.00	0.00	0.00	0.00
Education	0.01	0.01	0.01	0.01
Electricity	0.00	0.00	0.00	0.00
Finance	0.00	0.00	0.00	0.00
Health	0.01	0.01	0.01	0.01
Manufacture	0.00	0.00	0.00	0.00
Mining	0.03	0.03	0.03	0.03
Other services	0.00	0.00	0.00	0.00
Professional	0.00	0.00	0.00	0.00
Pubadmin	0.01	0.01	0.01	0.01
Rental	0.00	0.00	0.00	0.00
Retail	0.00	0.00	0.00	0.00
Transport	0.00	0.00	0.00	0.00
Wholesale	0.01	0.01	0.01	0.01

Variance decomposition of the real exchange rate itself demonstrates the causes of the movement of the real exchange rate. The results in Table 4.9 show the growth of US GDP and the real exchange rate itself contributes a lot to the movement. Terms of trade explains a smaller proportion of the variance, but the rest of the variables explain little. It is consistent with the finding in Gruen and Wilkinson (2000), the Australian real exchange rate is explained by terms of trade and the difference between the domestic and foreign real interest rates. The findings share similar points with Manalo et al. (2015), in that other domestic shocks explain a small proportion of the movement of the real exchange rate and exchange rate is largely impacted by foreign variable shock.

Table 4.9 Variance Decomposition – Exchange Rate

Proportion of forecast error variance				
Variable	**Horizon (Quarters)**			
	2	**10**	**20**	**40**
US real GDP	0.60	0.60	0.60	0.60
Terms of trade	0.03	0.03	0.03	0.03
Real GDP	0.00	0.00	0.00	0.00
Employment	0.00	0.00	0.00	0.00
Inflation	0.01	0.01	0.01	0.01
Cash rate	0.01	0.01	0.01	0.01
Real exchange rate	0.35	0.35	0.35	0.35

4.4 Robustness

Results of the structural VAR model can be sensitive to the different specifications of the VAR model. In this section, we compare and discuss the robustness of our results to issues of alternative variables, identification and lag length. In detail, we have five alternative specifications:

i) The log change of Commodity Price Index replaces the log change of Australian terms of trade
ii) The log change of Nominal trade-weighted exchange rate replaces the log change of real trade-weighted exchange rate
iii) Major trading partners' GDP growth replaces US real GDP growth
iv) The real trade-weighted exchange rate is ordered before the cash rate in the identification scheme
v) Select 2 lags and 3 lags for the SVAR models

For the purpose of comparison with the baseline model, each model's results are presented in Appendix 4.

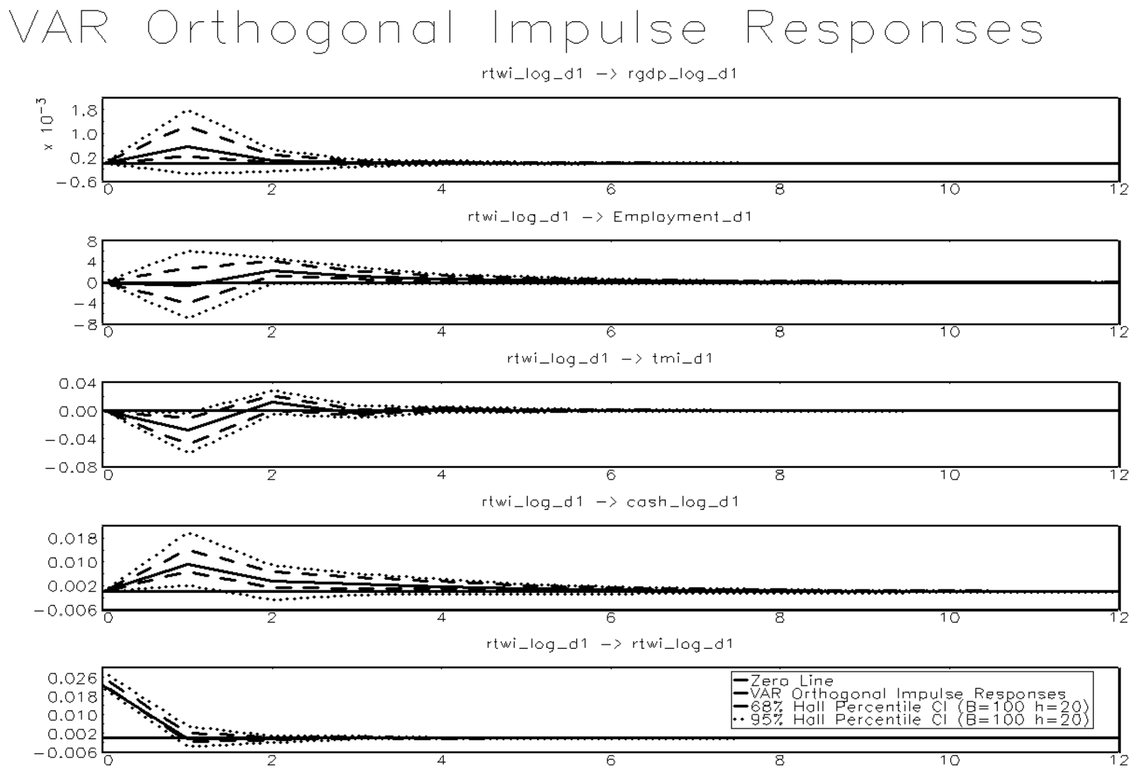
- **Commodity Price Index**

The robustness check in this section examines of one of the alternative variables: the substitution of Australian terms of trade by the Commodity Price Index. The recursive identification structure and ordering on both aggregate and sectoral level models remains the same. The purpose of using commodity price is to capture the impacts of the mining boom on the Australian economy since the early 2000s. Even the commodity price keeps declining due to the slowing down of GDP growth of one of Australia's major trading partner, China. Commodity exports recently account for more than 40 per cent in all goods exports, as pointed out by Atkin et al. (2014).

Figure 4.5 plots the impulse response to an unanticipated exchange rate for the aggregate model.

Figure 4.5 Robustness Exercise

Model with Commodity Price Index



Swapping the Australian terms of trade with the commodity price index lifts the impulse response of output growth by 0.0004 per cent to 0.0005 per cent. This impact is only significant at 68 per cent confidence interval. Employment growth does not show a decline at the first quarter, instead, it increases slightly at the second quarter. Such an effect dies out in about 2 years, however, this impact is insignificant at both the 68 per cent and 95 per cent confidence intervals. Apart from the growth of output and employment, the robustness check does not show much difference on the change of inflation, cash rate and the real exchange rate on the aggregate economy.

At the industry level, all industries share the same shape of those industries' responses under the baseline model. However, the magnitudes of impacts vary slightly across industries. Among all industries, pubadmin, rental, retail and wholesale are still the most responsive to an exchange rate shock. In addition, when we look at the 95 per cent significance level of each industry's output, the results of the model with the commodity price index does lead a change for the significance level of some industries' growth. It is noted that the mining and construction industries are two industries whose output growth has the largest change. The peak impact of the growth of the mining industry decreases from 0.0025 per cent to 0.0014 per cent. Meanwhile, the response to the growth of construction industry output is lifted by 0.0013 per cent at the first quarter. All these impacts are insignificant with 95 per cent confidence interval. Overall, the exchange rate responses are almost identical across the model on industry output growth.

There are more variations in the responses of employment growth. However, at the 95 per cent confidence level, there is no industry change significance level, except in the mining industry. Apparently, mining industry employment conditions will change when associated with the variation of the commodity price index. For the rest of the industries' employment growth, there is no significant variations noted.

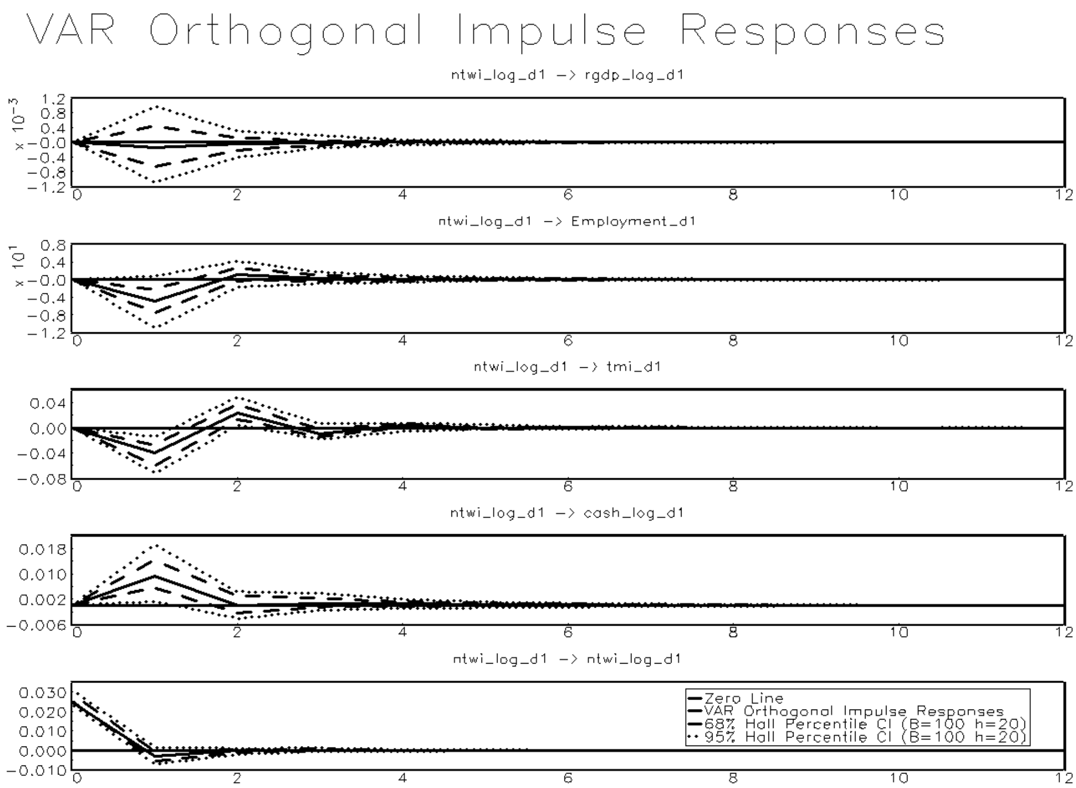
- **Nominal trade-weighted exchange rate**

In this section, the robustness checks one of the alternatives in the model: replacing the real trade-weighted exchange rate by the nominal trade-weighted exchange rate. This alternative reflects the fact that the nominal exchange rate flats freely on the foreign exchange market in Australia. The daily exchange rate could be observed directly, which is more useful for firms' decision-making processes. As mentioned in section 3.2.1, there are several studies that investigate the impacts of a nominal exchange rate shock. Hahn (2007) uses the nominal effective exchange rate to investigate an unanticipated exchange rate shock impact on the economy. Meanwhile, the nominal exchange rate is applied in the FAVAR model in Karagedikli et al. (2013) for the New Zealand economy.

Figure 4.6 plots the impulse response to an unanticipated exchange rate shock for the aggregate model.

Figure 4.6 Robustness Exercise

Model with Nominal Trade-weighted Exchange Rate



By replacing the real exchange rate with the nominal exchange rate, the output growth turns slightly negative to an appreciation which is -0.0001 per cent However, given the wide confidence interval, the impacts of a one-standard-deviation nominal exchange rate shock on aggregate output growth is insignificant. The response of employment growth is raised slightly from -5.2455 per cent to -4.8636 per cent. Associated with the 95 per cent confidence level, employment growth rates are not significant, which is the same as the baseline model.

In light of output growth, most industries do not change a lot with shock responses. Mining, pubadmin and rental are industries that have the largest response to a nominal exchange rate shock. The education industry's growth is increased from -0.0019 per cent to -0.0023 per cent. Meanwhile, the accommodation industry's growth is lifted from 0.0016 per cent to 0.0034 per cent. Both responses are significant at the 95 per cent confidence interval. On the other hand, the other industries' output growth is largely unaffected by changing the variable to the nominal exchange rate.

Education, health and pubadmin are the industries that respond most to a nominal exchange rate shock on employment growth. Compared to the baseline model, these three industries are also included in the top five industries with the largest response to employment growth. However, similar to output growth, the employment growth of accommodation industries is relatively sensitive to a nominal exchange rate shock. In employment growth, the accommodation industry increased from 0.3692 per cent to 1.0579 per cent. In addition, the mining industry's employment growth reduced by 0.1037 per cent to -1.1535 per cent in the model with the nominal exchange rate. The results of the rest of the industries are largely consistent with the results of the baseline model.

- **Major Trading Partners' GDP**

In this section, the robustness checks are for the last alternative variable: the substitution of US real GDP growth with Australian major trading partners' GDP growth. Australian major trading partners' GDP is a weighted GDP index of Australia's top six export markets according to Department of Foreign Affairs and Trade's report[25]. These top trading partners include the People's Republic of China, Japan,

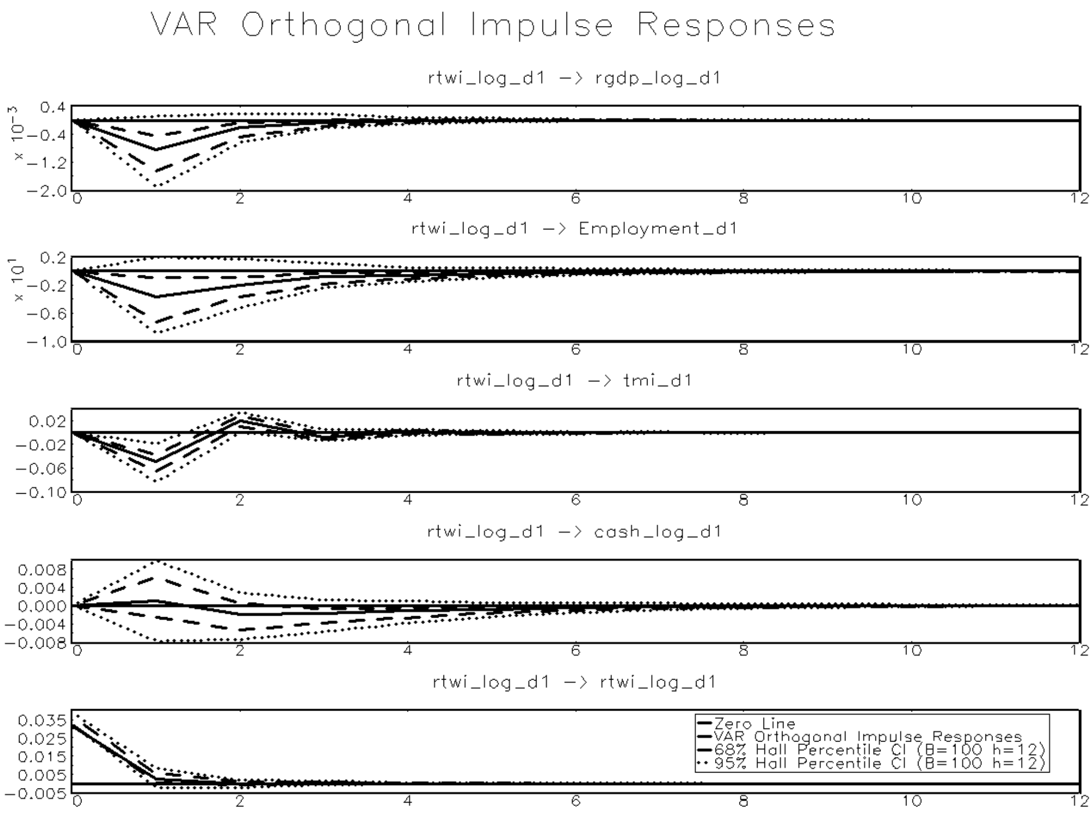
[25] Department of Foreign Affairs and Trade, Australia's Trade in goods and services 2014-15, http://dfat.gov.au/about-us/publications/trade-investment/australias-trade-in-goods-and services/Pages/australias-trade-in-goods-and-services-2014-15.aspx

Korea, Singapore, the United States and New Zealand. The weights are scaled based on ABS statistics[26]. According to Australian Industry Report 2015, customer demand is one of the main factors driving general business activities and performance. Even US real GDP has high correlation with Australian real output in business cycles, major trading partners' GDP is more appropriate for reflecting external demand for Australian export goods.

Figure 4.7 plots the impulse response to an unanticipated exchange rate for aggregate model.

Figure 4.7 Robustness Exercise

Model with Major Trading Partners' GDP



The model with the major trading partners' GDP growth has the largest impact on Australian real GDP. The response of GDP growth is 0.0008 per cent lower. This effect is statistically significant at a two-

[26] Australian Bureau of Statistics 2016, *International Trade in Goods and Services, Australia, Aug 2016*, Cat No. 5368.0, ABS, Canberra

standard-deviation confidence level (68 per cent confident interval) in the first quarter. On the other hand, compared to the baseline model, the impacts on employment growth are relatively smaller. At the first quarter, employment growth is 3.7226 per cent lower than the trend, which is also statistically significant at the 68 per cent confidence interval. When considering the significance of the impacts, both responses are insignificant at the 95 per cent confidence interval, which is identical to the baseline model.

As for the industry level output growth, the fact is that there is some variation of industry output in the model that replaces US real GDP growth with Australia's major trading partners' GDP growth. Compared to the baseline model, rental and wholesales are still two of the top five most responsive industries. However, the shock impacts on the administration, agriculture, and education industries become larger. Meanwhile, when compared to the significance level in the baseline model, only the education and wholesale industries' growth become significant at the 95 per cent confidence level, the rest of the industries are nearly indistinguishable from our baseline model results at a one-standard-deviation confidence level.

Although the education and health industries are the most responsive to the real exchange rate shock on employment growth as in the baseline model results, the arts, finance and manufacturing industries' shock impacts are relatively larger in the model with Australia's major trading partners' GDP growth. However, at the 95 per cent significant interval, only the arts and finance industries become statistically significant, while the rest of the industries' employment growth is indifferent with the baseline model results.

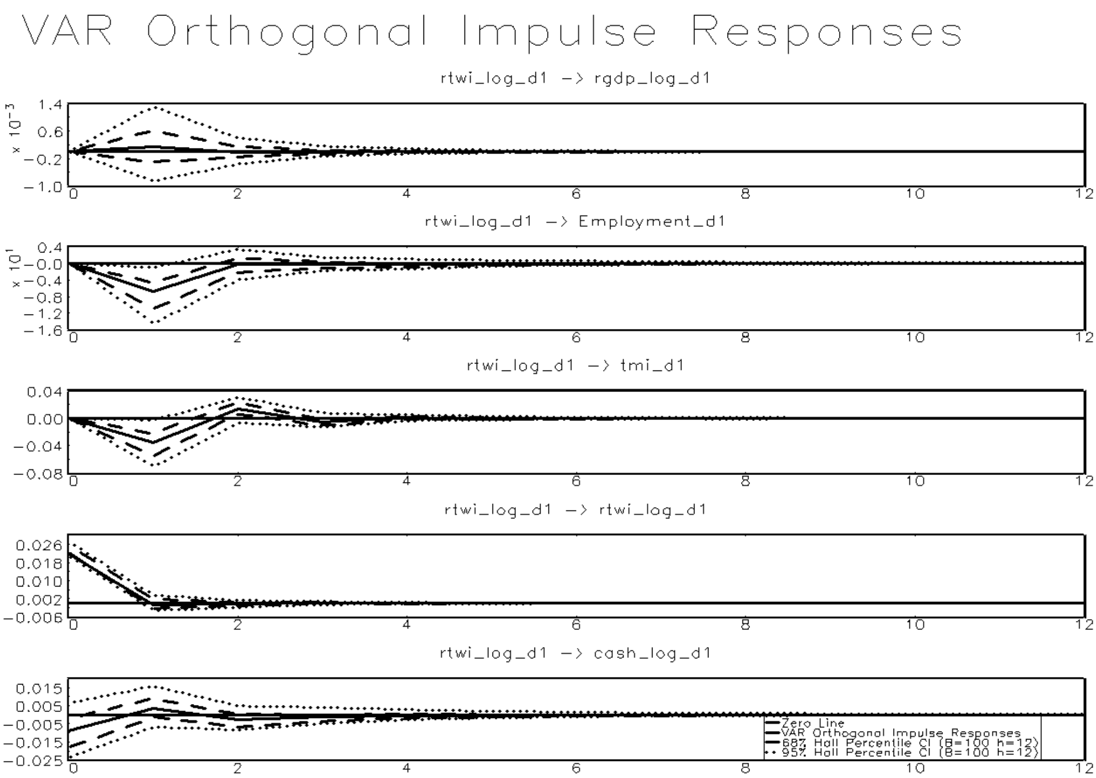
➢ **Identification**

A further check on the robustness of the results was completed with an alternative identification scheme: Order the real exchange rate before the overnight cash rate. In this case, the cash rate will have no contemporaneous impact on the real exchange rate. The findings of Lubik and Schorfheide (2007) claims that the Australian central bank does not react on nominal exchange rate movements. As Australia economy operates under a floating exchange rate regime, the results of Kim et al. (2009) show that stabilizing the real exchange rate does not appear to be a concern for Australian central bank.

Figure 4.8 plots the impulse response to an unanticipated exchange rate shock for the aggregate model.

Figure 4.8 Robustness Exercise

Different Identification Scheme



As shown in Figure 4.8, the response of GDP growth and employment growth to an exchange rate shock in specification of different identification schemes is almost identical to the baseline model results on the aggregate economy. Output growth is 0.0002 per cent higher than the trend, which is insignificant at the 68 per cent confidence interval. Employment growth is 6.7641 per cent below the trend and statistically significant at the 68 per cent confidence interval.

On industries' output growth, similar to the baseline model results, the pubadmin, rental, retail and wholesale industries experience the largest impacts from an exchange rate shock. The impact on the communication industry is a bit larger, 0.0019 per cent lower than the trend. When considering the confidence level at 95 per cent, almost all industries show the same as the baseline results.

Industrial employment growth is also nearly indistinguishable from the baseline model. The fact that ordering nominal cash rate prior to the real exchange rate does not affect the results suggests that allowing monetary policy to contemporaneously respond to real exchange rate shocks has little impact on the results. This finding is largely consistent with the existent literature as mentioned above.

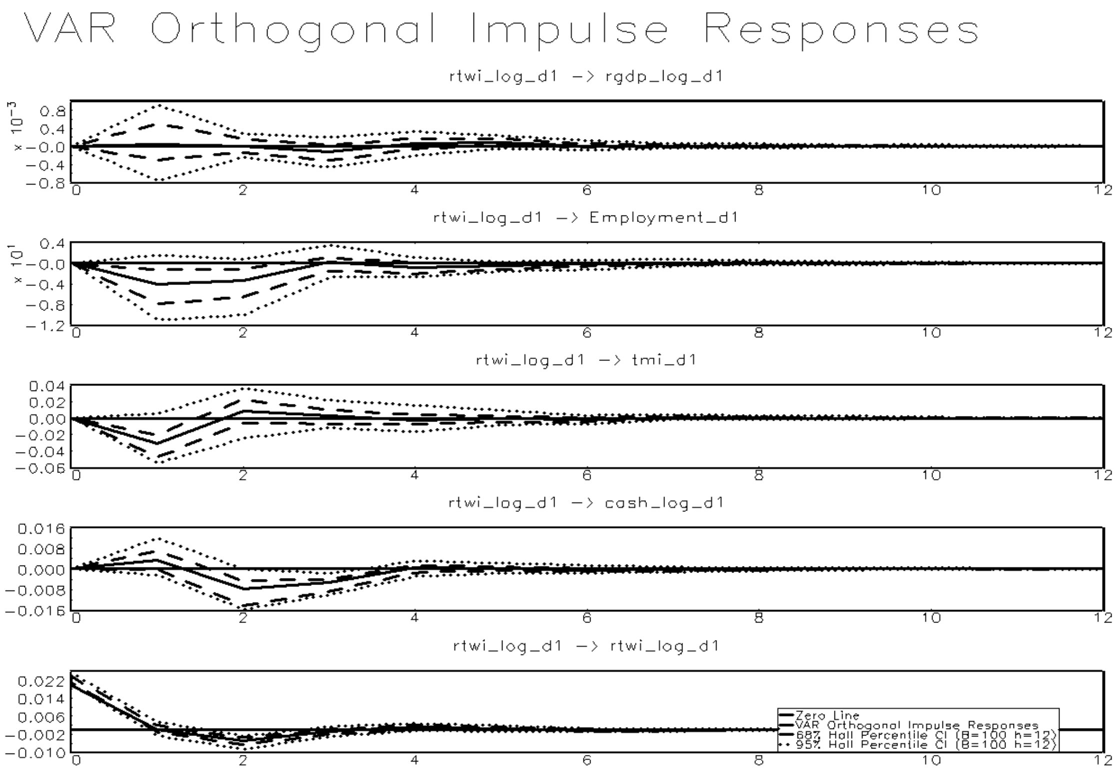
- **Lag Length**

The single lag applied in the baseline model is based on the information criteria, however, a single lag may miss dynamic relationships between the real exchange rate and other domestic variables. In such a case, the robustness check in this subsection presents the shock impacts in the model with two lags and three lags, and the comparison with the results of baseline model.

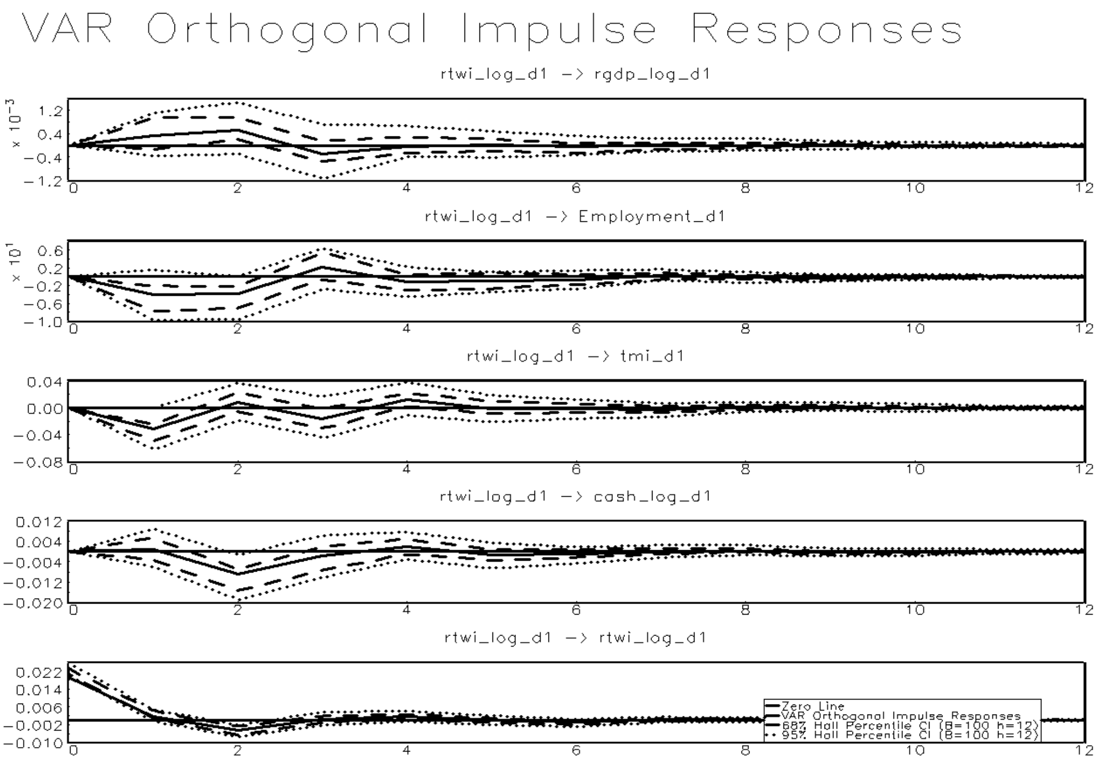
Figure 4.9 plots the impulse response to an unanticipated exchange rate shock for the aggregate model.

Figure 4.9 Robustness Exercise

Aggregate Model with 2 lags



Aggregate Model with 3 Lags



The shock responses of GDP growth in models with two lags and three lags are 0.0006 per cent and 0.0005 per cent, respectively. This effect is much larger than the responses of GDP growth in the baseline model. Meanwhile, the peak impacts occur a bit later in the model with larger lags than that of the baseline model. In the model with two lags and three lags, the peak impacts of GDP growth to an exchange rate shock are in the second quarter. In contrast, it takes only one quarter for GDP growth to reach its peak to the shock in the baseline model. In addition, the response of GDP growth in the model with three lags is significant at the 68 per cent confidence interval. Compared to the results of the baseline model, the impact on employment growth is a bit smaller at 4.0696 and 4.0863 lower, respectively.

At the industry level, there are some variations on the sectoral output growth. It is noted that the transport industry's response becomes larger in both models with large lags. At the same time, the impacts are significant at the 95 per cent confidence interval. In the model with two lags, shock impacts on the construction and education industries become significant at the 95 per cent confidence interval. The response of the agriculture industry's growth increased to 0.0025 per cent at the second quarter in the model with two lag. The response of the communication industry is reduced to 0.0026 per cent lower in the model with three lags.

Compared to the baseline model, the employment growth of agriculture, health, mining and pubadmin industries still experience the largest responses to the real exchange rate shock. The sectoral employment growth of otherservice industry responses are increasing in both models with larger lags. The shock impact on employment growth in the construction industry is 1.3854 per cent lower than the trend, which is a bit larger than the impact in the baseline model. The industrial significance level of the model with two lags is the same as the in the results of the baseline model. However, in the model with three lags, agriculture, communication, health and otherservice industries' responses are statistically significant at the 95 per cent confidence interval.

Chapter 5

Conclusions

In this thesis we have investigated an unanticipated real exchange rate shock on output growth and employment growth in Australia by using a data range from 1985 Q1 to 2015 Q2. The analysis comprises both aggregate impacts and sectoral impacts. An exchange rate shock does not cause a great impact on aggregate output growth, with the output growth being slightly higher than the trend in the short run. On the other hand, the results demonstrate that the more the industries are exposed to international trade, the larger the shock responses of these industries. We find that the mining industry's growth is largely affected by exchange rate movements as it is a most trade-exposed industry. Industries with little trade exposure, but are consumed more by households are also sensitive to exchange rate movements due to the cost effects. These industries include retail and wholesale industries. Furthermore, an industry such as the rental industry in the business service sector has moderate direct trade exposure but close links with the above industries, which respond a lot to the shocks, also responds to the exchange rate shock.

As for employment growth, the exchange rate shock has a substantial impact on aggregate employment growth, but is still statistically insignificant at the one-standard-deviation confidence interval. At the industrial level, as expected, the effect of an unanticipated exchange rate shock leads to shifts in the labour force across industries. We find that the most sensitive industries are agriculture, public admin, education, health and mining. As a consequence, the exchange rate shock on Australian output growth and employment growth tends to cause some sector shifts rather than aggregate disturbances.

In addition, the results of variance decomposition show that the real exchange rate only explains a little of the volatility in any of the aggregate domestic variables. At the industrial level, the exchange rate shock explains a moderate amount of the variance of most industries in Australia. The results confirm that the behaviour of the exchange rate is a shock absorber rather than a source of shock. Finally, variance decomposition also shows that the movement of the Australian exchange rate is largely explained by US real GDP growth and the change of real exchange rate itself.

This thesis extends the research of Manalo et al. (2015) to investigate the exchange rate shock on GDP growth and employment growth. We use similar strategies to those in Manalo et al. (2015) to set up a SVAR model, but add one more variable, employment, for the labour market. The contributions of the results are closely linked with monetary policy implication by providing some details for exchange rate impacts on industries. However, the investigation of real exchange rate shock impacts in this thesis is focused on short run effects, given the restrictions applied on the SVAR in this study. It is possible, in the future, to extend this study to long run shock impacts on levels by imposing different restrictions in relates to hysteresis. On the other hand, another extension could be to investigate more details of labour mobility caused by an exchange rate shock.

Appendix 1: Data

Table A1.1: Data

Variable Name	Definition	Data Source
US Real GDP	The quarterly seasonal adjusted US Real Gross domestic product.	Datastream code: USGDP…D
Australian Terms of Trade	Terms of Trade is defined as the dollar amount of exports over imports. Quarterly seasonally adjusted data.	ABS Cat No 5302.0
Australian Real GDP	The quarterly seasonal adjusted chain volume Australian Gross domestic product in real term.	ABS Cat No 5206.0
Australian Sectoral Production	Australian industry sectoral production is the chain volume gross value added for each industry.	ABS Cat No 5206.0
Australian Employment	Quarterly seasonally adjusted Australian employment. Quarterly seasonally adjusted data.	ABS Cat No
Australian Sectoral Employment	Quarterly seasonally adjusted Australian employment by industries.	ABS Cat No
Trimmed Mean Inflation	The trimmed mean consumer price index excluding interest and tax changes. Quarterly data.	RBA Statistical Table G1
The Overnight Cash Rate	The overnight interest rate which financial institutions pay to borrow or charge to lend funds. Averaged over the quarter.	RBA Statistical Table F1.1
The Real Trade-Weighted Exchange Rate Index	Quarterly real trade-weighted exchange rate index. The real exchange rate index is constructed by averaging bilateral real exchange rates using the geometric averaging procedure according to the RBA.	RBA Statistical Table F15
Commodity Price Index	RBA commodity price index is calculated using monthly average export value of Rural Commodities, Base Metals, Bulk Commodities and Other sources in 2013/14 and 2014/15. Averaged over the quarter.	RBA Statistical Table I2
The Nominal Trade-Weighted Exchange Rate Index	The monthly nominal trade-weighted exchange rate index is an exchange rate calculated by the weighted average of the Australian dollar and the currencies of Australia's major trading partners. Averaged over the quarter.	RBA Statistical Table F11
Major Trading Partners' GDP Index	Quarterly-weighted Real GDP of Australia's Major Trading Partners, which include China, South Korea, Japan, Singapore, New Zealand and United States.	Bloomberg IMF Real GDP Index

Table A1.2: Industry Classification Definitions

Industry Name	Definition
Accommodation	The Accommodation and Food Services Industry includes units mainly engaged in providing short-term accommodation for visitors. The industry-included units are mainly engaged in providing food and beverage services, such as the preparation and serving of meals and the serving of alcoholic beverages for consumption by customers, both on- and off-site.
Administration	The Administrative and Support Services industry includes units mainly engaged in performing routine support activities for the day-to-day operations of other businesses or organisations.
Agriculture	The Agriculture, Forestry and Fishing industry includes units mainly engaged in growing crops, raising animals, growing and harvesting timber, and harvesting fish and other animals from farms or their natural habitats. Agriculture industry involves both production and support services to production.
Arts	The Arts and Recreation Services industry includes units mainly engaged in the preservation and exhibition of objects and sites of historical, cultural or educational interest; the production of original artistic works and/or participation in live performances, events, or exhibits intended for public viewing; and the operation of facilities or the provision of services that enable patrons to participate in sporting or recreational activities, or to pursue amusement interests.
Communication	The Communications industry includes units mainly engaged in: 1) Creating, enhancing and storing information products in media that allows for their dissemination; 2) Transmitting information products using analogue and digital signals (via electronic, wireless, optical and other means); 3) Providing transmission services and/or operating the infrastructure to enable the transmission and storage of information and information products.
Construction	The Construction industry includes units mainly engaged in the construction of buildings and other structures, additions, alterations, reconstruction, installation, and maintenance and repairs of buildings and other structures. It also includes units engaged in blasting, test drilling, landfill, levelling, earthmoving, excavating, land drainage and other land preparation.
Education	The Education and Training industry includes units mainly engaged in the provision and support of education and training, except those engaged in the training of animals e.g. dog obedience training, horse training.
Electricity	The Electricity, Gas, Water and Waste Services Industry comprises units engaged in the provision of electricity; gas through main systems; water, drainage; and sewage services. This industry also includes units mainly engaged in the collection, treatment and disposal of waste materials; remediation of contaminated materials (including land); and materials recovery activities.
Finance	The Financial and Insurance Services industry includes units mainly engaged in financial transactions involving the creation, liquidation, or change in ownership of financial assets, and/or in facilitating financial transactions. Central banking, monetary control and the regulation of financial activities are also included in this industry.
Health	The Health Care and Social Assistance industry includes units mainly engaged in providing human health care and social assistance. Units engaged in providing these services apply common processes, where the labour inputs of practitioners with the requisite expertise and qualifications are integral to production or service delivery.
Manufacturing	The Manufacturing industry includes units mainly engaged in the physical or chemical transformation of materials, substances or components into new products (except agriculture and construction).
Mining	The Mining industry includes units that mainly extract naturally occurring mineral solids, such as coal and ores; liquid minerals, such as crude petroleum; and gases, such as natural gas. The Mining industry contains two activities: Mining Operation and Mining Support Activities (except geophysical surveying).

Table A1.2: Industry Classification Definitions (Con't)

Industry Name	Definition
Other Services	The Other Services industry includes a broad range of personal services; religious, civic, professional and other interest group services; selected repair and maintenance activities; and private households employing staff. Units in this division are mainly engaged in providing a range of personal care services, such as hair, beauty and diet and weight management services; providing death care services; promoting or administering religious events or activities; or promoting and defending the interests of their members.
Professional	The Professional, Scientific and Technical Services industry includes units mainly engaged in providing professional, scientific and technical services. Units engaged in providing these services apply common processes where labour inputs are integral to the production or service delivery. These services include scientific research, architecture, engineering, computer systems design, law, accountancy, advertising, market research, management and other consultancy, veterinary science and professional photography.
Public Administration	The Public Administration and Safety industry includes units mainly engaged in Central, State or Local Government legislative, executive and judicial activities; in providing physical, social, economic and general public safety and security services; and in enforcing regulations. Units of military defence, government representation and international government organisations are also included.
Rental	The Rental, Hiring and Real Estate Services industry includes units mainly engaged in renting, hiring, or otherwise allowing the use of tangible or intangible assets (except copyrights), and units providing related services.
Retail	The Retail industry includes units mainly engaged in the purchase and/or on-selling, the commission-based buying, and the commission-based selling of goods, without significant transformation, to the general public. The Retail industry also includes units that purchase and on-sell goods to the general public using non-traditional means, including the internet. Units are classified to the Retail industry if they buy finished goods and then on-sell them (including on a commission basis) to the general public.
Transport	The Transport, Postal and Warehousing industry includes units mainly engaged in providing transportation of passengers and freight by road, rail, water or air. Other transportation activities such as postal services, pipeline transport and scenic and sightseeing transport are included as well.
Wholesale	The Wholesale Trade Division includes units mainly engaged in the purchase and on-selling, commission-based buying, and the commission-based selling of goods, without significant transformation, to businesses. Wholesale industry are classified based on if they buy goods and then on-sell them (including on a commission basis) to businesses.

Note: The industries used in this thesis are from industry classifications in ANZSIC 2006 (Revision 2.0) published by Australian Bureau of Statistics.

Appendix 2 Tests

- **Lag select**

OPTIMAL ENDOGENOUS LAGS FROM INFORMATION CRITERIA

endogenous variables: usgdp_log_d1 TOT_log_d1 rgdp_log_d1 Employment_d1 tmi_d1 cash_log_d1 rtwi_log_d1

deterministic variables: d1 d2 d3 d4 d5 CONST

sample range: [1985 Q1, 2015 Q2], T = 112

optimal number of lags (searched up to 10 lags of levels):

Akaike Info Criterion: 10

Final Prediction Error: 1

Hannan-Quinn Criterion: 1

Schwarz Criterion: 0

- **Principles of determining the lag order of VAR**

In order to determine the lag order of VAR, lag selection criteria are used which include AIC, BIC and HQIC. According to Lutkepohl (2004), the lag selection criteria are in the general form as below

$$\mathrm{Cr(m)} = \log\det(\widetilde{\Sigma_u}\,(\mathrm{m})) + c_T\varphi(m)$$

where det(·) represents the determinant; log is the sign for natural logarithm, $\widetilde{\Sigma_u}(m)$ is the residual covariance matrix estimator for a model with lag m; c_T is a sequence that depends on the sample size *T*, and $\varphi(\mathrm{m})$ is a function that penalizes large VAR order.

AIC, BIC and HQIC could be generated on the general form descript above.

$$\mathrm{AIC(m)} = \log\det(\widetilde{\Sigma_u}\,(\mathrm{m})) + \frac{2}{T}mK^2$$

$$\mathrm{BIC(m)} = \log\det(\widetilde{\Sigma_u}\,(\mathrm{m})) + \frac{logT}{T}mK^2$$

$$\mathrm{HQIC(m)} = \log\det(\widetilde{\Sigma_u}\,(\mathrm{m})) + \frac{2loglogT}{T}mK^2$$

- **Breusch-Godfrey LM test for autocorrelation**

LM-TYPE TEST FOR AUTOCORRELATION with 5 lags

Reference: Doornik (1996), LM test and LMF test (with F-approximation)

LM statistic: 356.7831

p-value: 0.0000

df: 245.0000

LMF statistic not computed for subset model.

- **ARCH effects test**

MULTIVARIATE ARCH-LM TEST with 3 lags

VARCHLM test statistic: 2445.4757

p-value(chi^2): 0.0877

degrees of freedom: 2352.0000

- **Normality test (Doornik test)**

TESTS FOR NONNORMALITY

Reference: Doornik & Hansen (1994)

joint test statistic: 114.3743

p-value: 0.0000

degrees of freedom: 14.0000

skewness only: 27.2132

p-value: 0.0003

kurtosis only: 87.1611

p-value: 0.0000

Reference: Lütkepohl (1993), Introduction to Multiple Time Series Analysis, 2ed, p. 153

joint test statistic: 99.3699

p-value: 0.0000

degrees of freedom: 14.0000

skewness only: 26.7006

p-value: 0.0004

kurtosis only: 72.6693

p-value: 0.0000

Table A2.1: Kwiatkowski–Phillips–Schmidt–Shin test (KPSS test) Results

Variables (Level)	Level Stationary	Variables (1st difference)	Level Stationary
usgdp	2.0552***	usgdp(-1)	0.1456
TOT	3.1933***	TOT(-1)	0.1800
rgdp	4.1490***	rgdp(-1)	0.1836
employment	4.0951***	employment(-1)	0.1577
tmi	1.8783***	tmi(-1)	0.0526
cash	2.7151***	cash(-1)	0.0739
rtwi	2.5926***	rtwi(-1)	0.1728
accommodation	4.1158***	accommodation(-1)	0.2399
accommodation_E	4.0976***	accommodation_E(-1)	0.0299
administration	3.9963***	administration(-1)	0.7270**
administration_E	4.0351***	administration_E(-1)	0.1056
agriculture	3.8537***	agriculture(-1)	0.0253
agriculture_E	3.0557***	agriculture_E(-1)	0.0975
arts	4.0816***	arts(-1)	0.0325
arts_E	4.0955***	arts_E(-1)	0.0213
communication	4.1751***	communication(-1)	0.9685***
communication_E	3.0171***	communication_E(-1)	0.1166
construction	3.9040***	construction(-1)	0.0927
construction_E	3.9336***	construction_E(-1)	0.1146
education	4.1380***	education(-1)	0.2462
education_E	4.0587***	education_E(-1)	0.0709
electricity	4.0318***	electricity(-1)	0.4338*
electricity_E	1.0292***	electricity_E(-1)	0.5086**
finance	4.0926***	finance(-1)	0.3446
finance_E	3.0604***	finance_E(-1)	0.1103
health	4.0375***	health(-1)	0.0307
health_E	3.9759***	health_E(-1)	0.5730**
manufacturing	3.7089***	manufacturing(-1)	0.3716*
manufacturing_E	2.9854***	manufacturing_E(-1)	0.0693
mining	3.8013***	mining(-1)	0.0724
mining_E	2.6413***	mining_E(-1)	0.3639*
otherservices	4.1328***	otherservices(-1)	0.2531
otherservices_E	3.6641***	otherservices_E(-1)	0.0818
professional	4.1040***	professional(-1)	0.2918
professional_E	4.1059***	professional_E(-1)	0.1578
pubadmin	4.0996***	pubadmin(-1)	0.0142
pubadmin_E	3.9629***	pubadmin_E(-1)	0.0843
rental	3.9126***	rental(-1)	0.1993
rental_E	3.9379***	rental_E(-1)	0.0289
retail	4.1356***	retail(-1)	0.2608
retail_E	4.0986***	retail_E(-1)	0.1624
transport	4.1300***	transport(-1)	0.1127
transport_E	3.6639***	transport_E(-1)	0.1221
wholesale	4.1297***	wholesale(-1)	0.0924
wholesale_E	0.2990***	wholesale_E(-1)	0.0903
commodity	3.1803***	commodity(-1)	0.0588
ntwi	1.9817***	ntwi(-1)	0.2238
mtp gdp	2.6471***	mtp gdp(-1)	0.3707*

Notes: a) Critical Values for KPSS test for level stationary: 1%: 0.739; 5%: 0.463; 10%: 0.347. b) ***, **, * denote significance at 1%, 5% and 10% level, respectively. c). All results computed by J Multi.

- **The Principle of Augmented Dickey-Fuller test (ADF test)**

According to Hill et al. (2011), the Dickey-Fuller Test first assumes that y_t follows an AR(1) process,

$$y_t = \alpha + \rho y_{t-1} + e_t,\ t = 1,2, \ldots, \quad (1)$$

Where y_0 is the initial value through observations. $\{e_t\}$ is assumed to be i.i.d. with zero mean and independent of y_0 . In other words, $\{e_t\}$ is a martingale difference sequence with respect to $\{y_{t-1}, y_{t-2}, \ldots, \}$, as below:

$$\mathrm{E}(e_t | y_{t-1}, y_{t-2}, \ldots, y_0) = 0 \quad (2)$$

Subtract y_{t-1} from both sides, we have:

$$\Delta y_t = \alpha + (\rho - 1) y_{t-1} + e_t,\ t = 1,2, \ldots, \quad (3)$$

If $\{y_t\}$ follows Eq. (4.3), there is a unit root if, and only if, $\rho = 1$. In the first case $\{y_t\}$ satisfies Weakly Stationary Process with a constant mean and variance during the sample period. $\{y_t\}$ follows a random walk without drift if $\alpha = 0$ and $\rho = 1$. In the second case, though the mean is constant, the variance increases over time. $\{y_t\}$ follows a random walk with drift if $\alpha \neq 0$ and $\rho = 1$. α is the drift component. In the last case, both mean and variance are time variant.

Through the Dicky-Fuller test, it tests the null hypothesis $\{y_t\}$ has a unit root, $H_0\!: \rho = 1$, against the alternative hypothesis, $H_1\!: \rho < 1$. $\{y_t\}$ satisfies the requirement of stationary process when null hypothesis is rejected, $|\rho| < 1$. According to Dickey and Fuller (1979), the asymptotic distribution under H_0 follows the Dickey-Fuller distribution with τ-statistics.

With the extension of the Dickey-Fuller test, the Augmented Dickey-Fuller tests (ADF), the error terms may be autocorrelated. The test model under ADF test is:

$$\Delta y_t = \alpha + \gamma y_{t-1} + \textstyle\sum_{s=1}^{m} a_s \Delta y_{t-s} + v_t \quad (4)$$

Numbers of lagged first difference terms are added in order to ensure that the residuals are not autocorrelated. When $\gamma = 0$, we do not reject the null and the series has a unit root. The alternative hypothesis is $\gamma < 0$ when the series is stationary.

Appendix 3: Estimation Results for Aggregate Model

	usgdp_log_d1	TOT_log_d1	rgdp_log_d1	Employment_d1	tmi_d1	cash_log_d1	rtwi_log_d1
usgdp_log_d1 (t-1)	**0.047**	**-0.094**	**0.032**	**-77.346**	**0.078**	**0.269**	**-0.101**
	(0.096)	(0.063)	(0.017)	(100.422)	(0.530)	(0.167)	(0.086)
	{0.628}	{0.134}	{0.066}	{0.441}	{0.884}	{0.107}	{0.240}
	[0.485]	[-1.498]	[1.839]	[-0.770]	[0.146]	[1.610]	[-1.176]
TOT_log_d1 (t-1)	**0.013**	**0.167**	**0.033**	**543.860**	**0.815**	**0.430**	**0.036**
	(0.146)	(0.096)	(0.019)	(110.392)	(0.581)	(0.183)	(0.111)
	{0.931}	{0.082}	{0.087}	{0.000}	{0.161}	{0.019}	{0.749}
	[0.086]	[1.739]	[1.709]	[4.927]	[1.403]	[2.350]	[0.320]
rgdp_log_d1 (t-1)	**---**	**---**	**0.149**	**1520.546**	**-4.748**	**0.012**	**-0.150**
	( )	( )	(0.089)	(511.231)	(2.710)	(0.855)	(0.332)
	{ }	{ }	{0.092}	{0.003}	{0.080}	{0.989}	{0.650}
	[ ]	[ ]	[1.683]	[2.974]	[-1.752]	[0.014]	[-0.454]
Employment_d1(t-1)	**---**	**---**	**0.000**	**0.127**	**0.000**	**0.001**	**0.000**
	( )	( )	(0.000)	(0.076)	(0.000)	(0.000)	(0.000)
	{ }	{ }	{0.520}	{0.092}	{0.611}	{0.000}	{0.695}
	[ ]	[ ]	[0.643]	[1.684]	[0.508]	[4.185]	[-0.392]
tmi_d1 (t-1)	**---**	**---**	**-0.001**	**6.754**	**-0.394**	**0.007**	**0.010**
	( )	( )	(0.003)	(15.198)	(0.081)	(0.025)	(0.010)
	{ }	{ }	{0.768}	{0.657}	{0.000}	{0.773}	{0.315}
	[ ]	[ ]	[-0.295]	[0.444]	[-4.890]	[0.288]	[1.004]
cash_log_d1 (t-1)	**---**	**---**	**-0.002**	**167.735**	**0.348**	**0.412**	**-0.004**
	( )	( )	(0.008)	(44.837)	(0.238)	(0.075)	(0.029)
	{ }	{ }	{0.783}	{0.000}	{0.143}	{0.000}	{0.878}
	[ ]	[ ]	[-0.276]	[3.741]	[1.464]	[5.495]	[-0.153]
rtwi_log_d1 (t-1)	**---**	**---**	**0.006**	**-239.865**	**-1.488**	**0.311**	**-0.024**
	( )	( )	(0.025)	(142.340)	(0.755)	(0.238)	(0.092)
	{ }	{ }	{0.807}	{0.092}	{0.049}	{0.192}	{0.794}
	[ ]	[ ]	[0.245]	[-1.685]	[-1.972]	[1.304]	[-0.260]

Note: Standard deviation is provided in parenthesis. P-value is shown in curly brackets and t-value is presented in square brackets. All results are computed by Jmulti.

Appendix 4: Model Results Comparison

Table A4.1: Peak Impacts and Quarter – Industrial Output Growth

	1) Baseline Model		2) Commodity Price		3) Nominal Ex Rate		4) MTPs GDP		5) Different Identification		6) 2 lags length		7) 3 lags length	
Industry	**Peak Impact**	**Quarter**	**Peak Impact**	**Quarter**	**Peak Impact**	**Quarter**	**Peak Impact**	**Quarter**	**Peak Impact**	**Quarter**	**Peak Impact**	**Quarter**	**Peak Impact**	**Quarter**
Accommodation	0.0016	1	0.0022	1	0.0034	1	-0.0005	2	0.0017	1	0.0012	1&2	0.0017	2
Administration	0.0007	2	0.0009	2	0.0007/-0.0007	2&1	-0.0020	1	-0.0008	1	0.0005	3	0.0011	3
Agriculture	-0.0006	1	-0.0007	2	-0.0007	1	-0.0039	1	-0.0009	1	0.0025	2	0.0021	2
Arts	0.0007	1	0.0011	1	0.0008	1	0.0003/-0.0003	2,1&3	0.0006	1	-0.0010	2	0.0012/-0.0012	4&2
Communication	0.0014/-0.0014	2&1	0.0019	2	0.0014/-0.0014	2&1	-0.0017	1	-0.0019	1	0.0009	2	-0.0026	1
Construction	0.0004/-0.0004	1&2	0.0017	1	-0.0007	2	-0.0015	2	0.0007	1	0.0020	4	-0.0018	5
Education	-0.0019	1	-0.0011	1	-0.0023	1	-0.0023	1	-0.0018	1	0.0012	1&3	-0.0010	1
Electricity	0.0005	1	0.0006	1	0.0006	1	0.0008	1	0.0003	1	0.0005	1	0.0009	1
Finance	-0.0011	1	-0.0014	1	-0.0015	1	-0.0009	1	-0.0011	1	-0.0014	2	-0.0014	2&3
Health	-0.0012	2	-0.0018	2	-0.0008	2	0.0012	1	-0.0012	2	0.0012	1	0.0025	1
Manufacture	0.0012	1	0.0012	1	0.0005	1	0.0021	1	0.0013	1	0.0005	1&2	0.0005/-0.0005	2&4
Mining	0.0025	1	0.0014	1	0.0023	1	-0.0005	1	0.0018	1	0.0035	2	-0.0043	3
Otherservices	0.0018	1	0.0026	1	0.0024	1	0.0004/-0.0004	1&2	0.0014	1	0.0018	1	-0.0020	3
Professional	0.0012	1	0.0015	1	0.0009	1	0.0005	1	0.0007	1	0.0010	1	0.0015	1
Pubadmin	-0.0037	1	-0.0033	1	-0.0032	1	-0.0018	1	-0.0032	1	-0.0030	1	-0.0035	1
Rental	-0.0027	1	-0.0026	1	-0.0029	1	-0.0022	1	-0.0028	1	-0.0022	1	-0.0024	1
Retail	0.0023	1	0.0026	1	0.0022	1	0.0014	1	0.0026	1	0.0020	1	0.0023	1
Transport	0.0006	1	0.0008	1	-0.0006	1	0.0014	1	0.0004	1	0.0025	2	0.0024	2
Wholesale	0.0022	1	0.0029	1	0.0016	1	0.0029	1	0.0023	1	0.0017	1	-0.0023	3

Table A4.2: Peak Impacts and Quarter – Industrial Employment Growth

	1) Baseline Model		2) Commodity Price		3) Nominal Ex Rate		4) MTPs GDP		5) Different Identification		6) 2 lags length		7) 3 lags length	
Industry	**Peak Impact**	**Quarter**	**Peak Impact**	**Quarter**	**Peak Impact**	**Quarter**	**Peak Impact**	**Quarter**	**Peak Impact**	**Quarter**	**Peak Impact**	**Quarter**	**Peak Impact**	**Quarter**
Accommodation	0.3692	1	0.1653	1	1.0579	1	0.7715	1	0.3489	1	0.2603	1	0.3794	3
Administration	0.2883	1	0.8704	1	0.3406	1	-0.1436	2	0.1825	1	-0.5187	2	0.7518	3
Agriculture	-1.7355	1	-1.4942	1	-0.7813	1	-0.4795	1	-1.7578	1	-1.6316	2	-1.8440	2
Arts	0.5803	1	0.5155	1	0.5860	1	1.0164	1	0.5439	1	0.7107	1	0.5119	1
Communication	0.7324	1	0.6736	1	0.7548	1	0.4679	1	0.6081	1	0.6432	1	-1.1212	3
Construction	0.3372	3	1.1793	1	0.4700	3	-0.6068	2	-0.3737	2	-1.3854	2	-1.0380	3
Education	-1.3184	1	-0.4774	1	-1.2749	1	-0.9985	1	-1.4659	1	-1.0105	1	-1.1638	1
Electricity	-0.2681	1	0.1663	2	-0.4109	1	-0.2695	1	-0.396	1	-0.3583	1	0.1774	3
Finance	0.6149	1	0.6886	1	0.2866	1	1.6474	1	0.3786	1	0.6984	2	-0.8183	4
Health	-1.2674	1	-0.8658	1	-1.3733	1	-2.3967	1	-1.6228	1	1.7778	2	1.7264	3
Manufacture	-0.3088	1	0.9959	1	-0.6119	1	-1.3427	1	-0.3707	1	0.6017	2	0.9689	3
Mining	-1.0498	1	-0.7626	1	-1.1535	1	-0.7466	1	-1.2001	1	-1.0856	1	-1.2973	1
Otherservices	0.6842	1	0.7294	1	0.6895	1	0.8282	1	0.8368	1	-1.5360	2	-1.8112	2
Professional	0.1625	3	-0.341	1	-0.7924	1	0.8680	1	-0.2014	1	0.4358	2	1.1888	2
Pubadmin	-1.4438	1	-1.4157	1	-1.9245	1	-0.9531	1	-1.4237	1	-1.3567	1	-1.7173	1
Rental	0.4996	1	0.6005	1	0.7122	1	-0.3462	1	0.3807	1	0.7478	1	0.6424	1
Retail	-0.7707	1	0.4871	2	0.1956	2	-0.8923	1	-0.8141	1	-0.7176	2	-0.6563	2
Transport	0.3332	2	-0.8648	1	-0.8734	1	-0.6872	1	-0.3925	1	-0.3212	1	-0.2279	2
Wholesale	-1.0046	1	-0.4969	1	-0.9286	1	0.6755	1	-1.0786	1	-0.6657	1	-0.8275	2

Table A4.3: Peak Impacts and Quarter – Aggregate Model

1) Baseline Model			2) Commodity Price			3) Nominal Ex Rate			4) MTPs GDP		
Variables	**Peak Impacts**	**Quarter**	**Variables**	**Peak Impacts**	**Quarter**	**Variables**	**Peak Impacts**	**Quarter**	**Variables**	**Peak Impacts**	**Quarter**
Output	0.0001	1	**Output**	0.0005	1	**Output**	-0.0001	1	**Output**	-0.0008	1
Employment	-5.2455	1	**Employment**	2.2424	2	**Employment**	-4.8636	1	**Employment**	-3.7226	1
Inflation	-0.0325	1	**Inflation**	-0.0281	1	**Inflation**	-0.0400	1	**Inflation**	-0.0482	1
Cash rate	0.0068	1	**Cash rate**	0.0093	1	**Cash rate**	0.0093	1	**Cash rate**	-0.002	2
Real Ex rate	0.0219	0	**Real Ex rate**	0.0225	0	**Nominal Ex rate**	0.0248	0	**Real Ex rate**	0.0315	0

5) Different Identification			6) 2 lags length			7) 3 lags length		
Variables	**Peak Impacts**	**Quarter**	**Variables**	**Peak Impacts**	**Quarter**	**Variables**	**Peak Impacts**	**Quarter**
Output	0.0002	1	**Output**	0.0006	2	**Output**	0.0005	2
Employment	-6.7641	1	**Employment**	-4.0696	1	**Employment**	-4.0863	1
Inflation	-0.036	1	**Inflation**	-0.031	1	**Inflation**	-0.0319	1
Cash rate	-0.0087	0	**Cash rate**	-0.0078	2	**Cash rate**	-0.009	2
Real Ex rate	0.0221	0	**Real Ex rate**	0.02	0	**Real Ex rate**	0.0193	0

References

Abraham, K & Katz, L 1986, 'Cyclical Unemployment: Sectoral Shifts or Aggregate Disturbances?', *The Journal of Political Economy,* Vol.94, No.3, pp 507-522.

Atkin, T, Caputo, M, Robinson, T & Wang, H 2014, 'Macroeconomic Consequences of Terms of Trade Episodes, Past and Present', *RBA research discussion paper,* No. 2014-01

Australian Productivity Commission, *Annual Report 2011-2012,* http://www.pc.gov.au/about/governance/annual-reports/2011-12/annual-report-2011-12.pdf

Baldwin, R & Krugman, P 1989, 'Persistent Trade Effects of Large Exchange Rate Shocks', *the Quarterly Journal of Economics,* Vol.104, No.4, (Nov 1989), pp 635-654

Battersby, B, Kouparitsas, M, & Munro, J 2013, 'Uncovering The Source of Sectoral Employment Fluctutations', *Australian Treasury Working Paper*, No. 2013-03

Beechey, M, Bharucha, N, Cagliarini, A, Gruen, D & Thompson, C 2000, 'A Small Model of the Australian Macroeconomy', *RBA research discussion paper,* No. 2005-05

Berkelmans, L 2005, 'Credit and Monetary Policy: An Australian SVAR', *RBA research discussion paper,* No. 2005-06

Blanchard, O & Sheen, J 2013, *Macroeconomics: Australasian Edition*, 4th Edition, Pearson Education, Frenchs Forest, NSW.

Blundell-Wignall, A, Fahrer, J & Heath, A 1993, 'Major Influences on Australian Dollar Exchange Rate', in A Blundell-Wignall (ed), *The Exchange Rate, International Trade and the Balance of Payments*, Proceedings of a Conference, Reserve Bank of Australia, Sydney, pp 30-78

Cagliarini, A & McKibbin, W 2009, 'Global Relative Price Shocks: The Role of Macroeconomic Policies', *RBA research discussion paper,* No. 2009-10

Carroll, N & Poehl, J 2007, 'Job mobility in Australia', *Economic Research and Analysis Unit, Department of Employment and Workplace Relations*

Chen, Y-C & Rogoff, K 2002, 'Commidity Currencies', *Journal of International Economics,* 60(1), pp 133-160

Chung, E, Kohler, M & Lewis, C 2011, 'The Exchange Rate and Consumer Prices', *RBA Bulletin,* September, pp 9-16

Cross, R 2011, 'In Memory of Alexei Pokrovskii: his Hysteresis effect on economics', *Journal of Physics,* Conference Series 268(2011) 011004

D'Arcy, P, Gustaffsson, L, Lewis, C & Wiltshire, T 2012, 'Labour Market Turnover and Mobility', *RBA Bulletin,* December Quarter

Department of Industry, Innovation and Science, Office of Chief Economist, *Australian Industry Report 2015*, available at: http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/AIR2015.pdf

Downes, P, Hanslow, K & Tulip, P 2014, 'The Effect of the Mining Boom on the Australian Economy', *RBA research discussion paper,* No. 2014-08

Dungey, M & Pagan, A 2009, 'A Structural VAR model of the Australian Economy', *Economic Record,* 85 (268), pp 1-20

Ellis, L 2001, 'Measuring the Real Exchange Rate: Pitfalls and Practicalities', *RBA research discussion paper,* No. 2001-04

Enders, W 2014, *Applied Econometrics Time Series,* 4th Edition, Wiley

Freeman, R 2008, 'Labour economics', *The New Palgrave Dictionary of Economics*, 2nd Edition, 2008

Greuen, D & Wilkinson, J 1994, 'Australia's Real Exchange Rate – Is it Explained by the Terms of Trade or by Real Interest Differentials?', *Economic Record,* 70 (209), pp 204-219

Gocke, M 2002, 'Various Concepts of Hysteresis Applied in Economics', *Journal of Economic Surveys,* Vol.16, No.2

Hahn, E 2007, 'The Impact of Exchange Rate Shocks on Sectoral Activity and Prices in the Euro Area', *European Central Bank,* Working Paper Series No 796

Hill, R, Griffiths, W & Lim, G 2011, *Principles of Econometrics,* 4th Edition, John Wiley & Sons, Inc.

Huh, H 1999, 'How well does the Mundell-Fleming model fit Australian data since the collapse of Bretton Woods?', *Applied Economics,* 1999, 31, 397-407

Jaaskela, J & Nimark, K 2011, 'A Medium-Scale New Keynesian Open Economy Model of Australia', *The Economic Record*, Vol.87, No. 276, March, 2011, pp. 11-36.

Kam, T, Lees, K & Liu, P 2009, 'Uncovering the Hit-List for Small Inflation Targeters: A Bayesian Structural Analysis', *Journal of Money, Credit and Banking,* 41(4) pp 583-618

Karagedikli, O, Ryan, M, Steenkamp, D & Vehbi, T 2013, 'What Happens When the Kiwi Flies? Sectoral Effects of the Exchange Rate Shocks', *Reserve Bank of New Zealand Discussion Paper,* Series DP2013/05

Kelly, G & La Cava, G 2014, 'International Trade Costs, Global Supply Chains and Value-added Trade in Australia', *RBA research discussion paper,* No. 2014-07

Kilian, L 1998, 'Small-Sample Confidence Intervals for Impulse Responses Functions', *The Review of Economics and Statistics,* 80(2), pp 218-230

Kilpatrick, S & Felminghan, B 1996, 'Labour Mobility in Australian Industry', *Applied Economics Letters,* Vol.3, pp 577-579

Kohler, M, Manalo, J & Perera, D 2014, 'Exchange Rate Movements and Economic Activity', *RBA Bulletin,* March, pp 47-54

Krugman, P 1986, 'Pricing to Market When the Exchange Rate Changes', *National Bureau of Economic Research,* Working Paper No.1926

Krugman, P, Obstfeld, M, & Melitz, M 2015, *International Economics: Theory & Policy*, 10th Edition, Pearson Education, London, UK.

Lawson, J & Rees, D 2008, 'A Sectoral Model of the Australian Economy', *RBA research discussion paper,* No. 2008-01

Lubik, T & Schorfheide, F 2007, ' Do Central Banks Respond to Exchange Rate Movements? A Structural Investigation', *Journal of Monetary Economics,* 54(4), pp 1069-1087

Lutkepohl, H 2005, New Introduction to Multiple Time Series Analysis, Springer

Lutkepohl, H 2008, 'Variance decomposition", The New Palgrave Dictionary of Economics, 2nd Edition, 2008

Lutkepohl, H 2008, 'Impulse response function", The New Palgrave Dictionary of Economics, 2nd Edition, 2008

Lutkepohl, H & Kraetzig, M 2004, Applied Time Series Econometrics, 1st Edition, Cambridge University Press

Norris, D 2013, 'An Investigation of Exchange Rate Pass-Through in Australia', Macquarie University, Honours Degree Thesis

Macfarlane, I 2005, 'Statement to Parliamentary Committee', *RBA Bulletin,* March, pp 5-8

Manalo, J, Perera, D, & Rees, D 2015, 'Exchange Rate Movements and the Australian Economy', *Economic Modelling,* Vol.47, June, 2015, pp. 53-62.

Meese, RA & Rogoff, K 1983, 'Empirical Exchange Rate Models of the Seventies: Do They Fit Out of Sample', *Journal of International Economics,* 14(1-2), pp 3-24

Obstfeld, M 2001, 'International Macroeconomics: Beyond the Mundell-Fleming Model', *NBER Working Paper,* No. 8369

Otto, G, Voss, G & Willard, L 2001, 'Understanding OECD Output Correlations', *RBA research discussion paper,* No. 2001-05

Plumb, M, Kent, C & Bishop, J 2013, 'Implications for the Australian Economy of Strong Growth in Asia', *RBA research discussion paper,* No. 2013-03

Rayner, V & Bishop, J 2013, 'Industry Dimensions of the Resource Boom: An Input-Output Analysis', *RBA research discussion paper,* No. 2013-02

Reserve Bank of Australia, *Statement on Monetary Policy August 2016,* available at: http://www.rba.gov.au/publications/smp/2016/aug/

Reserve Bank of Australia, *Statement on Monetary Policy May 2016,* available at: http://www.rba.gov.au/publications/smp/2016/may/

Reserve Bank of Australia, *Statement on Monetary Policy February 2016,* available at:

http://www.rba.gov.au/publications/smp/2016/feb/

Reserve Bank of Australia, *About Monetary Policy,* available at:

http://www.rba.gov.au/monetary-policy/about.html [accessed 1 October 2016].

Reserve Bank of Australia, *Monetary Policy,* available at:

http//www.rba.gov.au/education/monetary-policy.html

Reserve Bank of Australia, *RBA Minutes of the Monetary Policy Meeting on 5th April 2016,* available at:

http://www.rba.gov.au/monetary-policy/rba-board-minutes/2016/2016-04-05.html

Sims, C 1980, 'Macroeconomics and Reality', *Econometrica,* Vol.48, January 1980, No.1s

Stevens, G 2013, 'The Australian Dollar: Thirty Years of Floating', Speech to the Australian Business Economists' Annual Dinner, Sydney, 21 November

Taylor, J 2001, 'The Role of the Exchange Rate in Monetary Policy Rules', *American Economic Review,* Vol.91, No.2.

Thomas, A 1997, 'Is the Exchange Rate a Shock Absorber? The Case of Sweden.', *International Monetary Fund*, WP/97/176.

Voss, G & Willard, L 2009, 'Monetary Policy and the Exchange Rate: Evidence from a Two-Country Model', *Journal of Macroeconomics,* 31(4), pp 708-720.