Dutch Disease in Australia: A Structural VAR model with Multi-Sector[†]

Farhana Abedin[‡]

Abstract

The contribution of this paper is to provide a macro-econometric analysis of a mining boom and Dutch disease for a small open economy. In the early 2000s, Australia experienced a remarkable turnaround in terms of trade due to sudden rise in commodity prices. Increased resource exports drove; higher real GDP growth rates and appreciation of the exchange rate, but other non-resource sectors might not have benefited from those changes. To investigate the Dutch disease, the paper uses a Structural Vector Autoregressions (SVAR) model of the Australian economy by incorporating multiple production sectors, resource sector, non-resource tradeable sector, and non-tradeable sector. The estimation found evidence of Dutch disease in Australia. The commodity price shock increased the real exchange rate by 1.2% point more than five years, which had immediate positive effect on the level domestic real GDP and resource output. Domestic output increased by 0.27% and resource output by 0.2% over the subsequent period one year of the shock , but the output of non-resource tradeable sector and the non-tradeable sector was reduced by -0.2 percentage point and -0.3 percentage point, respectively over the longer horizon of five years. The inflation was -0.01% from subsequent one year after the shock to more than five years. The strong institutional management and adoption of floating exchange rate served as a shock absorber to the economy. However, the management of resource windfall is important to overcome the Dutch disease, as long term de-industrialization is harmful to the economy.

Keywords: Australia**,** Dutch disease, Multi-sector model, small open economy, structural VAR model.

JEL classification: C32; C55; Q33; F41, O41.

Introduction:

Australia is a resource rich country and has experienced resource booms several times in its history, for example, the major booms were considered the Gold rush 1850's, the mining booms in the late 1800's, the late 1960/early 1970's and the late 1970s/early 1980s and the recent boom in early 2000's. These booms took place over the period of 160 years and caused significant economic change in the country. The sources of those booms are different but there are similarities as well. The boom usually brings prosperity to the whole economy, however, non-resource sectors of the economy required structural adjustments due to the resource boom, which might not benefit those sectors of the economy. For example, the gold rush adversely affected wool industries and manufacturing industries in Australia, and the wool and grains industries were damaged in the late 19th century's mineral boom (Battellino, 2010).

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[‡] Farhana Abedin (email: farhana.abedin@adelaide.edu.au) is at Department of Economics, University of Adelaide, South Australia, Australia.

The resource booms in Australia ended up causing high wage growth, and appreciation of the exchange rate. The appreciation of exchange rate reduces the relative price of imports and weakens the competitiveness of non-mining industries and of import-competing industries, such as agriculture and manufacture and the service sector. This transmission mechanism is commonly known as a ‘Dutch Disease’, where a resource boom leads to real exchange rate appreciation and to crowding out of the tradable manufacturing sector. Krugman (1987) described this phenomenon as a disease when the manufacturing sector of a country does not ricochet after the resource boom; assuming dynamic scale economies and other positive externalities for non-resource sectors, such as manufacturing de-industrialization might be harmful to the whole economy in the long-run.

The resource boom in the first decade of the twenty-first century (from 2003 to 2011) caused rapid rise in Australia’s terms of trade (figure 1). This remarkable increase in terms of trade was caused by soaring global commodity prices during the 2000’s due to the emerging commodity demand from Asian economies.

Figure 1: Terms of trade, 1947-2013, Source: http://www.rba.gov.au/chart-pack/commodity-prices.html

The value of Australia’s resource exports increased more than 300 percent (in US$) 2003 to 2011, and resource exports contribute about 57 percent of total exports, with iron ore the largest and coal the second largest export. The price of iron ore has risen at an average annual rate of 23 percent and the price of coal by about 8 percent (measured in AUD) over the period of 2005 and 2010. The economy experienced a substantial swing in the value of nominal and real exchange rates (Connolly and Orsmond, 2011).

The aim of the paper is to empirically investigate the question, whether the recent mining boom in Australia has adversely affected the non-resource tradeable sectors or not. This paper provides a macro-econometric analysis of the mining boom and Dutch disease for a small open economy.[1] This empirical investigation has another significance, in the sense that, during the period of recent boom, the world faced a global financial crisis and Australia

[1] There is long history of study of the Dutch disease, which focused on sectoral analysis of how a small open economy adjusts to its resource boom. The first sectoral model was proposed by the Australian economists Salter (1959) and Swan (1960). The most citied papers on Dutch disease or the ‘Dutch disease model’ were introduced by Gregory (1976); Corden and Neary (1982); Corden (1984), who extended Salter-Swan model to include three sectors – a booming tradable sector, a lagging tradable sector and a non-tradable sector.

has adopted flexible exchange rate since 1983.[2] To investigate the Dutch disease, the paper proposes a Structural Vector Autoregressions model of the Australian economy by incorporating multiple production sectors, which includes resource sector, non-resource tradeable sector, and non-tradeable sector.

The contribution of this paper is not to propose a theory on Dutch disease, rather to find out whether Australia suffered from a Dutch disease during this historical episode of mining boom. To answer this question, the paper uses a Structural Vector Autoregressions (SVAR) model of the Australian economy by incorporating multiple production sectors, which includes resource sector, non-resource tradeable sector, and non-tradeable sector. The SVAR multi-sector model of the Australian economy identifies structural shocks and computes the impulse response functions, and the contributions of each shocks to endogenous variables are estimated using variance decompositions of the forecast error. Analyses of the dymanics of the exogenous commodity price shock, exchange rate shock and foreign demand shocks are important because, as noted earlier, the rise in terms of trade in the recent boom was caused by increased commodity price. We added foreign demand shock to the model because global financial crisis in 2007/2008 affected trade of Australia's major trading partner and mining investment. Australia had projected around $35 billion worth of iron ore investment projects, which were projected to increase the export capacity further 50% between the periods of 2011 to 2015, but many investors ceased production in 2009 (Connolly and Orsmond, 2011).

The paper estimated the results using the data from Australian Bureau of Statistics and Reserve Bank of Australia. Quarterly data are observed from the period 1984: Q1 to 2016: Q4. We found an evidence of Dutch disease effects in Australia. The commodity price shock had a positive effect on domestic real GDP and resource output, but non-resource tradables sector and non-tradeable sector were not benefited from mining boom. From the sectoral output decomposition, it is evident that, the mining boom has a significant negative affect on the output of non-resource tradeable and non-tradeable sector.

The research contributes to the existing literature in three ways. The first contribution is a quantitative or econometric approach of Dutch disease analysis in a small open economy. The theoretical conclusion that real exchange rate appreciation negatively affects import-competing industries, (manufacturing and agriculture), and leads to a de-industrialisation in the long-run has been known since Gregory (1976), Corden and Neary (1982) and Corden (1984). Sheehan and Gregory (2012) and Freebairn (2014), have analysed the recent mining boom with macroeconomic models, but without econometric analysis of the existence or magnitude of Dutch disease effects.[3] This paper contributes empirical evidence about the practical significance of the theorical construction.

[2] See: https://www.rba.gov.au/mkt-operations/ex-rate-rba-role-fx-mkt.html

[3] Downes, Hanson and Tulip (2014) estimated the effect of the mining boom with a large quarterly time series model of the Australian economy, called 'the Australian Macroeconomic (AUS-M) model', originally developed by the Australian Treasury. Their paper concludes that the deindustrialization or Dutch disease effect has not been strong because manufacturing benefits from higher demand for inputs to mining and the Australian macroeconomic performance during the decade was much more stable than during the earlier mining boom, reflecting a stronger institutional framework.

The second contrubution is to extend the existing literature on applying SVAR models to the Australian economy Dungey and Pagan (2000), Dungey and Pagan (2009), and Dungey *et al* (2014).

The third contribution of this paper is to illustrate the dynamics of commodity shock and exchange rate shock using multi-sector model. This is related to research which has documented industry-level effects of exchange rate shocks, e.g. Manalo *et al* (2015) have estimated a SVAR model to examine exchange rate shock on Australian economy at aggregate and industry-level.

The rest of the paper has the following structure. The methodology is described in Section 2, including, a brief description of the structure of the SVAR model, identification,and description of the data. Section 3 reports the results. Section 4 outlines the sensitivily analysis or robustness checks of the model. Section 5 concludes.

2. Methodology:

2.1 The model

The paper applies a Structural VAR model to examine exchange rate shocks to understand the transmission mechanism of Dutch disease in Australia. It uses a recursive ordering placing restrictions informed by economic theory on the contemporeneous structural parameters.[4] The results have been calculated using impulse response functions of the structural shocks of the system, the Cholesky variance decomposition of the key variables in the model from the parameters of the SVAR (Hamilton, 1994).

Let, $Z_t = [F_t D_t]$ be a vector of foreign (F_t) and domestic (D_t) variables.

The Structural Vector Autoregressions system of order p is defined as follows (Hamilton, 1994).

$$A_0 Z_t = C + A_1 Z_{t-1} + \dots\dots\dots + A_p Z_{t-p} + \varepsilon_t \quad (1)$$

Where, Z_t is a $(n \; x \; 1)$ vector of endogenous macroeconomic variables. ε_t is $(n \; x \; 1)$ vector of serially uncorrelated structural shocks, i.e. $E(\varepsilon_t) = 0 \; and \; E(\varepsilon_t \varepsilon'_\tau) = \Omega \; for \; t = \tau$, $E(\varepsilon_t \varepsilon'_\tau) = 0$ $for \; t \neq \tau$. Ω is a symmetric, positive diagonal covariance matrix, contains the variances of the structural disturbances in the diagonal and C = ($\beta_{10}, \dots\dots\dots, \beta_{p0}$)'.

$$A(L) z_t = C + \varepsilon_t \quad (2)$$

$A(L)$ is a p^{th} order matrix polynomial in the lag operator L , i.e.

$$A(L) = A_0 - A_1 L^1 - A_2 L^2 - \dots\dots\dots\dots - A_p L^p$$

[4] Fry and Pagan (2011) list five methods of identifying the parameters in the structural form equations from the estimated parameters in the reduced form equation.

A_0 is a non-singular matrix, took the following form, summarizes the contemporaneous relationships between the endogenous variables in Z_t .

$$A_0 = \begin{bmatrix} a_{11}{}^0 & \cdots & a_{1n}{}^0 \\ \vdots & \ddots & \vdots \\ a_{n1}{}^0 & \cdots & a_{nn}{}^0 \end{bmatrix}$$

When the contemporaneous matrix A_0 normalized to have ones on the diagonals, implies that every equation in the system has a dependent variable and every shock ε_{it} has a variance of ${\sigma_i}^2$. A_s is a *(n x n)* matrix whose, row *i, column j* element is given by $a_{ij}{}^s$ for *s = 1, 2, … , p.* Generalization of equation (1) requires, a sufficient number of lags of p are included, so that ε_t would be a vector of white noise.

Let, ε_t followed a q^{th} order Vector Autoregression, with,

$$\varepsilon_t = X_1\,\varepsilon_{t-1} + X_2\varepsilon_{t-2} + \ldots\ldots\ldots\ldots + X_q\varepsilon_{t-q} + u_t \qquad (3)$$

Equation (1) could be multiplied by $\left(I_n - X_1L^1 - X_2L^2 - \ldots\ldots\ldots\ldots - X_qL^q\right)$, to get at a system of the same basic form of equation (1), and *p* could be replaced by *(p+q)* and ε_t by the white noise disturbance u_t.

The reduced-form of the SVAR, a standard VAR model could be found by multiplying both side of equation (1) by ${A_0}^{-1}$

$$Z_t = B_0 + B_1Z_{t-1} + \cdots \ldots \ldots + B_p\,Z_{t-p} + u_t \qquad (4)$$

$$or, B(L)\,Z_t = B_0 + u_t \qquad (5)$$

where, $B_0 = {A_0}^{-1}C$; $B_s = {A_0}^{-1}A_s \;\; for\; s = 1, 2, \ldots \ldots, p$; and $u_t = {A_0}^{-1}\,\varepsilon_t$.

Identification of matrix A_0 and multiplying ${A_0}^{-1}$ in equation (1), we will uncover the structural model, the structural shocks and the contemporaneous relations among variables. The Structural VAR identification consists of seting the structural model. The structural model is useful as it isolates structural shocks and follows the dynamics of the variables after one of the shocks hits the economy.

2.2. The data and sample

The model is estimated using seasonally adjusted data at quarterly frequencies for the period 1984:Q1 to 2016:Q4.[5] The variables are observed for a total of 124 quarters. The model includes two blocks of variables, foreign block (F_t) and domestic block (D_t). In the domestic block, the model includes aggregate and three separate sectors, resource sector, non-resource tradable sector, non-tradable sector. There are eight variables in the model. The foreign sector variables include the growth rate of Autralia's major tradeing partners (MTP) real GDP (y^*), index of Australian non-rural commodity price in \$A (p^*), growth rate of resource export (z^x) and growth rate of non-resource export (m^x). The domestic variables

[5] Dungey *et al*, (2014) have used dataset from 1988:Q4 to 2011:Q2, Manalo *et al.*(2015) have estimated result using data from 1985:Q1 to 2013:Q2. Jääskelä and Smith (2011) estimated SVAR with data 1984:Q1 to 2010:Q2.

includes, the growth of Australian real GDP (y), the growth rate of value added output in the Australian resource (y_z), non-resource (y_m) and non-tradeable sectors (y_n), CPI inflation (π), interest rate (i) and Australian dollar trade-weighted exchange rate index, adjusted for relative consumer price levels (r).[6]

In the SVAR literature including real GDP, inflation, interest rate, and the real exchange rate are standard. The Inflation rate is the objective of monetary policy in Australia in the Inflation target. The overnight cash rate is used as the interest rate variable as it is the main monetary policy instrument since the floating of the Australian dollar has been adopted in December 1983. The exchange rate is represented by Reserve Bank of Australia's real trade-weighted index in Australian dollar. As Australia is a small open economy, fluctuations of foreign GDP have an impact on the Australian business cycle and also the demand side effects of foreign economic growth has a relationship with foreign interest rate and inflation, which may have an impact on the value of Australian real exchange rate through an uncovered interest rate parity condition.[7] The variable MTP RGDP calculated manually by aggregating the RGDP of Australia's major trading partners, which is percentage change of Australia's major trading partners RGDP. MTP's RGDP have collected from Penn World Table 9.0 and trade-weights have used from Reserve bank of Australia.

2.3. Estimation method:

The paper estimates a separate VAR for each production sector of the Australian economy and also for the aggregate level. A recursive method is used to identify parameters and structural shocks by placing restrictions on the comtemporaneous A_0 matrix. There is linear relationship between A_0 matrix, structural shocks and forecast error, which is defined as, $e_t = {A_0}^{-1}\, u_t$.

The Structural model consists of more parameters to be estimated than reduced-form VAR model. The identification will be based on recursive ordering, i.e. there is a sequential change of movement of the variable in the timeline of the event. The recursive method assumes that the variable which is placed first affects the economy first and is not contemporaneously afftected by the variables which are ordered lower, but it may be affected by the other variables with lags. When shocks hits the economy, the magnitude of the contemporaneous effects of the variable depend on the size of coefficients in the ${A_0}^{-1}$ matrix. The recursive method of identifying the A_0 matrix involves placing restrictions on the A_0 matrix. The imposition of restrictions on the structural parameters or on the contemporaneous relations among the endogeneous variables of the structural model is particular on setting some cofficients to zero based on economic intuition. The imposition of restriction A_0 matix, imples restriction should be placed on ${A_0}^{-1}$ matrix, i.e. ${A_0}^{-1}$ has zeros

[6] A description of the data series used in estimation are reported in appendix I.

[7] Dungey and Pagan (2009) used US real GDP and real interest rate as a foreign variable. Manalo *et al* (2015) used US real GDP and mentioned it is ideal to add foreign interest rate and inflation as foreign variables. Dungey and Pagan (2009) and Manalo *et al* (2015) have used Australian terms of trade as a proxy variable for commodity price fluctuations. Dungey *et al* (2014) have chosen Reserve Bank of Australia's Index of Commodity Price in US dollars as the real commodity price variable. Dungey and Pagan (2009) and, Dungey *et al* (2014) use Australian exports as a foreign variable.

above the diagonal. So, ${A_0}^{-1}$ matrix is a lower triangular matrix.[8] The matrix ${A_0}^{-1}$ can be decomposed into two triangular factors, known as Choleski factors of the variance-covariance martix. The structural shocks ε_t are orthonormal, such that the covariance matrix is an identity matrix $E(\varepsilon_t {\varepsilon'}_t) = D = I$.

Let n be the number of variables in the SVAR. The diagonal elements on the A matrix are ones and A has $(n^2 - n)$ unknown elements and n unknown structural innovations, so, there are $(n^2 - n + n) = n^2$ unknown elements and $\left(\frac{n^2 + n}{2}\right)$ known elements, which requires at least ($\frac{n^2 - n}{2}$) restrictions to be imposed on the parameters of the $A \: and \: B$ matrics.

The commodity price (p^*) is contemporaneously affected by foreign GDP $(y)^*$ and its own lags. The resource export (z^x) and non-resource export (m^x) is contemporaneously affected by foreign GDP (y^*) and commodity price p^* . The growth rate of value added output in the Australian sectoral GDP depends on changes in commodity price (p^*), inflation (π), interest rate and r plus lags and exogenous variables. The monetary policy variable (cash rate(i)) has no contemporaneous effect upon inflation. The interest rate rule does not depend contemporaneously upon the real exchange rate. The inflation does not depend contemporaneously upon the real exchange rate. The inflation and moneraty policy variable will not react contemporenuously to the foreign GDP and resource export and non-resource export, however, inflation react immidiately to the domestic demand.

3. Results:

The model is estimated using statistical package Eviews 10 following Ouliaris, Pagan and Restrepo (2016). The estimation of SVAR and VAR required the data has to be stationary. In the first stage of the analysis, the paper examines a set of unit-root tests, including the Augmented Dickey-Fuller (ADF), Phillip-Perron and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) and breakpoint unit root tests to assess whether or not the series is $I(1)$ when first differenced. In the second stage, the paper estimated VAR to choose the optimal lag-lengths (p) associated with Structural VAR and to test the inverse roots of AR characteristic polynomial for stationarity. The autoregressive lag length specification test suggests to choose lag 'one' based on Schwartz Bayesian Information criterion. Hannan-Quinn Information criterion, Akaike Information Criteria and Final Prediction error suggest to choose 'two', and the likelyhood ratio test suggests to choose 'six' autoreggresive lag length. The paper choses lag length 'two'. In the third stage, the paper estimated the impulse response of the variables, which are presented below in figures 2 to 4. In the fourth stage, the structural parameters of the contemporaneous matrix and covariance matrix of the structural

[8] The estimation of structural model is based on identification of the A_0 matrix. Australia is a small open economy, and therefore it does not affect external sector contemporaneously but may be with lags as a commodity exporting country might have some market power in the resource sector by increasing domestic cost (Dungey *et al*, 2014).

innovations were estimated, which are presented in the appendix II. Finally, forecast error variance decompositions were estimated, and are reported in the appendix III.[9]

Impulse-responses trace the effects of structural shocks on the endogeneous variables. Each response includes the effect of a specific shock on one of the variables of the system at impact time 't', then on '$t+1$' and so on. After identifying the structural parameteres, the impulse response functions transform the structural autoregressive vector into a sum of shocks, commonly known as Wold representation. The figures of impulse response of variables show the dynamic response of those variables when an exogeneous shock hits the economy. The estimated results of this research has covered the longer time horizon, that from 1984:Q1 to 2016:Q4. The estimated figures of impulse responses included asympototic standard error's of one standard deviations. The impulse response functions, calculated over 20 quarters or 5 years in figures 2, 3 and 4, show the dynamic response of all the endogenous variables when an exogeneous shock to MTP's RGDP, commodity price and real exchange rate hits the economy.

3.1. Shock to Foreign output:

The inclusion of the Australia's major trading partner's (MTP) real GDP as foreign output variable is intended to illustrate the economic conditions of advanced economies on Australia. The US GDP has strong relationship by which US monetary conditions might impact on Australia's real exchange rate through the uncovered interest rate parity (UIP) condition, the North-Atlantic financial crisis and strong growth in Asian economies has an impact on Australia's macroeconomic variables.

In the figure 2, the solid line depicts the point estimates and dotted lines are confidence bands at two standard deviation. According to the recursive ordering, the MTP real GDP is placed first, so it does not affect contemporaneously by other variables which are ordered below.

In figure 2, the impulse response functions of the variables due to a shock to foreign demand showed that, the shock first affects MTP real GDP, then raises the commodity price, domestic real GDP, non-tradeable sector output, real exchange rate, resource export and non-resource export. The response of impulse response function of overnight cash rate and CPI inflation is less to the foreign demand shock. The non-tradeable output rises more compared to the domestic real GDP, and non-resource tradeable output.

[9] The estimation of contemporaneous A_0 matrix and Covariance matrix of structural innovations (aggregate and sectoral) are reported in appendix II and appendix III contains the estimation of the forecast error variance decompostion of the endogeneous variables for forecast horizon 2, 4, 12 and 24 quarters ahead.

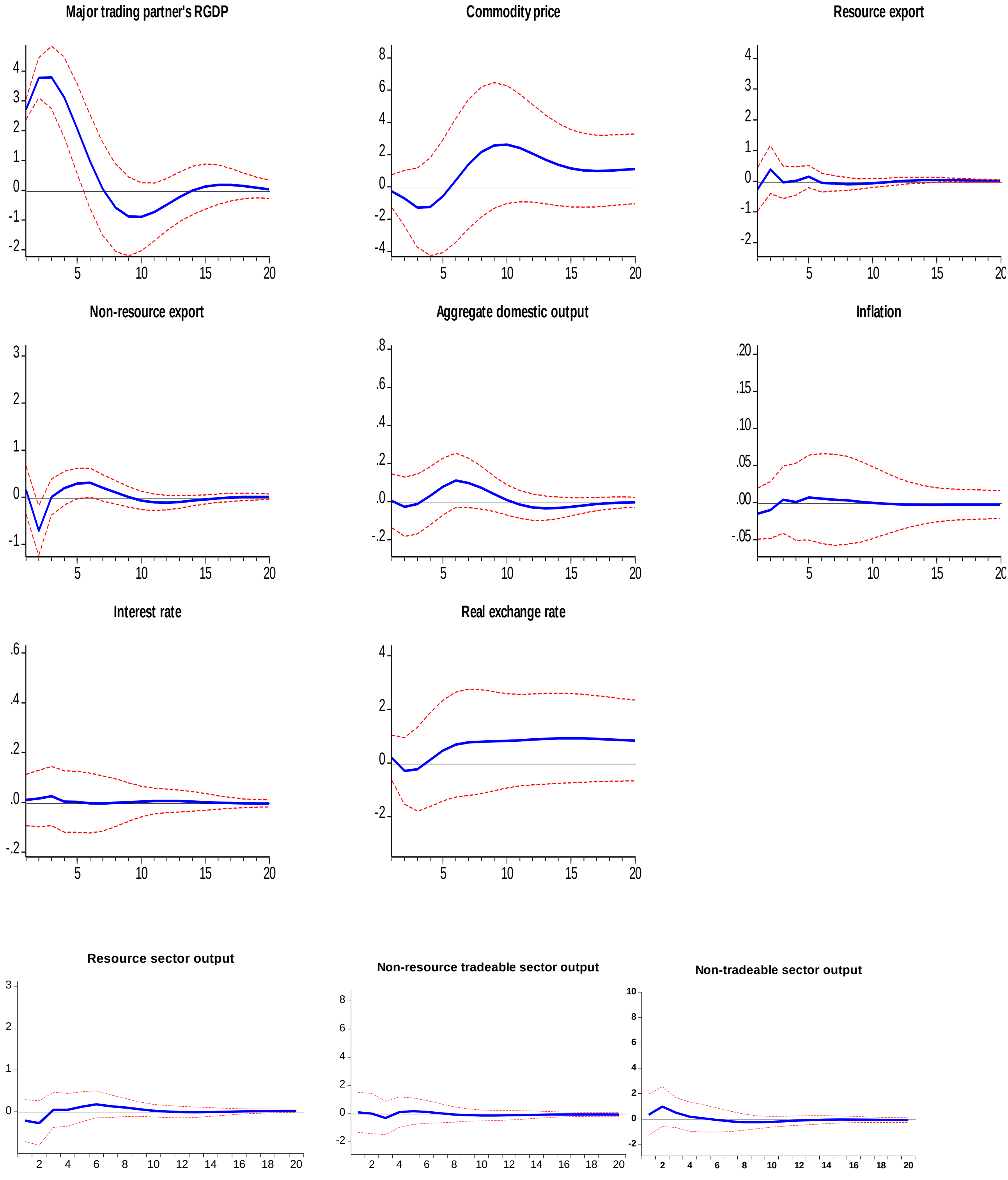

Figure 2: Impulse responses to shock to Foreign Output (Aggregate and Multisector model)

Due to one SD innovations to foreign demand shock, the point estimates suggests that the Australia's major trading partner's RGDP has increased by 3.8% in quarter three and gradually falls to –0.9% in quarter ten. Then the impulse response function goes back to baseline level in quarter tweenty. The impulse response function of the Australian non-rural commodity price initially falls -1.3% in quarter three after the foreign demand shock hits the economy, however, peaking 2.6% above the baseline at quarter ten, then gradually decreases but remain high 1.1% till five years ahead of the forecast horizon. We know from the recent mining boom literaturs that, the cause of strong growth of commodity price originated from higher resource demand from foreign economy (Connolly and Orsmond, 2011).

The rise in commodity price results in rise in resource export around 0.4% in quarter two. Resource export volume become negative -0.2% from quarter five to quarter eleven and shock die out at quarter thirteen. The non-resource exports falls sharply -.7% in quarter two after the foreign demand shock, in quarter five the non-resource export volume rised 0.3%, and again falls below the baseline level -0.1 from quarter ten to fourteen, then the shock die out 20 periods ahead. The higher external demand for mineral, high resource commodity commodity price and appreciation of real exchange rate results a reduction of resource export and affected the non-resource export by reducing competiveness of manufacturing sector and construction and accomodation (Dungey *et al*, 2014).

The impulse response function of domestic output follows a similar pattren of the impulse response function of the commodity price, though magnitude of the response of those two variables are different. The foreign demand shock results in rise in the domestic output 0.11% after quarter six. Bofore the shock die out at quarter twenty, the domestic output decreases -0.03% in quarter fifteen. Unlike domestic output, the sectoral output react differently due to the foreign demand shock. After the shock, the resource sector output and the non-resource tradeable sector output growth both remains -0.3 below the baseline level till quarter two and quarter three,respectively. The resource sector output growth shows positive trend between quarter three to quarter eight, reaches maximum 0.2% at quarter six, the schock die out from quarter ten. The non-resource sector output remains positive at 0.1% before output growth become negative -0.3% at quarter three, however, shows positive response 0.2% at quarter five and remains positive 0.1% till quarter six. On the other hand, the non-tradeable sector remain above the baselive till quarter five, the resonse rises maximum 1.0% at quarter two, but the impulse response decreses -0.1% at quarter six, -0.3% at quarter three, -0.2% at quarter ten and eleven and from quarter twelve to tweenty remain -0.1% below the baseline level. The CPI inflation and overnight cash rate do not response mush to the foreign demand shock. The inflation goes below -0.01% at quarter one and interest rate remains 0.03% till quarter three and then almost remain at the baseline level over the horizon. The foreign demand results depreaction of real exchange rate -0.3% upto quarter two and reaches maximum 0.8% at quarter seven and remains higher at 0.8% more than 5 years.

3.2. Shock to Commodity price:

The impulse response funtions to commodity price are presented in figure 3. A one SD innovation to commodity price shock does not effect contemporaneously foreign output but with lags in the system. Due to commodity price shock, the Australian MTP's real GDP raised 0.2% after quarter four, but at quarter ten it goes below -0.1% before goes back to initial level after quarter thirteen. The paper's result is consistent with Dungey *et al*, (2014) and Jääskelä and Smith (2011) that the rise in resource commodity price, increases the cost of production of those industries, which uses resources as input, results fall in foreign output.

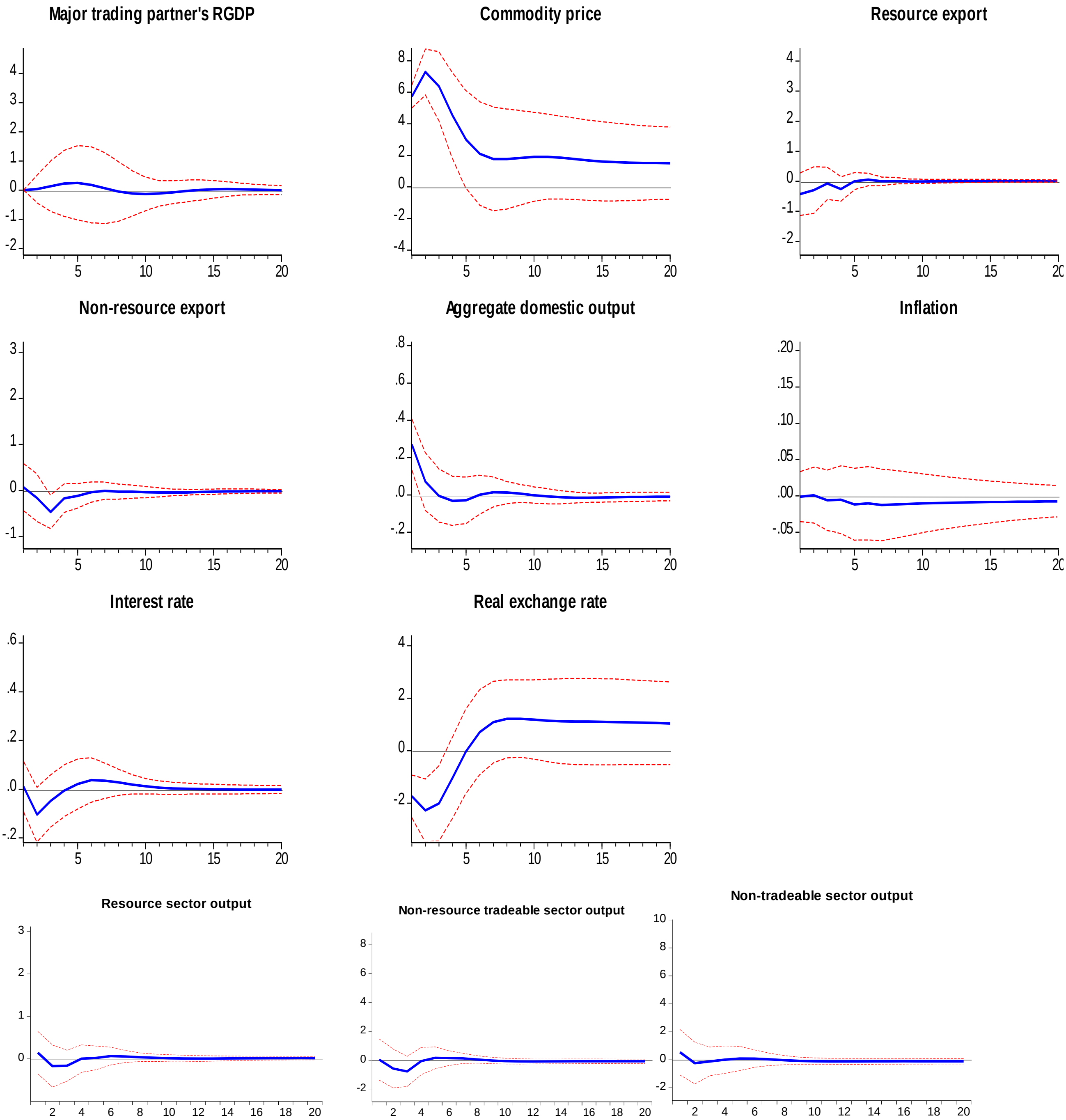

Figure 3: Impulse responses to shocks to Commodity price (Aggreagte model and Multi-sector model)

The commodity price reached 7.3% higher above the baselive after quarter one, then falls 1.8% at quarter seven, and remain higher 1.5% more than 5 years. The shock to commodity price reduces the export volume -0.4% below the baseline at quarter one and at quarter four goes to minimum -0.3%, the response goes to steady state at quarter five. The commodity price shock also reduces the non-resource export volume -0.5% at quarter three, then goes back to initial level at quarter six. The high commodity price increase the input cost and reduces the output of foreign demand, which might reduces the resource and non-resource export volume. However, they stabilize when foreign out stabilizes with more supply for resources due to mining investment.

There has been a sharp rise in aggregate domestic output 0.27% at quarter one due to the non-rural commodity price. However, aggregate GDP drops off -0.03% at quarter four, and goes slightly above the baseline 0.02% at seven quarter, then remain below -0.01% upto five years. The sectoral decomposition shows that, at quarter one, the commodity price shock raised the resource sector output and the non-tradeable tradeable sector 0.1% and 0.5% respectively, [10] and at quarter three the response of the resource sector output, non-resource sector output and non-tradeable sector output drops off -0.2 percentage point, -0.8 percentage point and -0.1 percentage point respectively. At quarter seven, the resource sector output rise 0.1% and goes back to equilibrium at quarter nine. The non-resource sector output also increase 0.2% at quarter five, the reponse of non-resource sector output remains constant at point 0.1% during quarter six to eight and does not move from baseline from quarter nine to onwards. The response of non-tradeable sector output peak a bit 0.1% between quarter five and six, however, the non-tradeable output falls below -0.1% from the baseline at quarter nine and remain at that point more than 5 years. The results suggests that, the high commodity price reduces the demand for non-resource sector and non-tradeable sector.

The commodity price shock results in deflation -0.01% from quarter five to more than five years. According to the literatures, due to adoption of floating exchange rate, this recent boom does not end up with higher inflation (Plumb *et al*, 2013, Downes *et al*, 2014).

The interest rate decreases by -0.10% at quarter two, possibly due to expansionary monetary policy to stimulate non-resource and non-tradeable sector. But there is a interest rate rise maximum 0.04% at quarter six and reached the baseline from quarter twelve to quarter twenty. The rise in interest rate due to appreciation of exchange rate and higher demand for finance from the resource sector. The real exchange rate depreciated to -2.3% just after the commodity price shock hits the economy. The response of real exchange rate gradually raises, and it appreciated to maximum 1.2% at quarter eight and remain higher at 1.0% more than 5 years.[11]

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[10] Downes, Hanslow and Tulip (2014) estimated that, the mining boom, raised Australian per capita income by 13% and manufacturing benefit from its higher demand as input to the mining industries.

[11] Connolly and Orsmond (2011), Plumb, Kent and Bishop (2013), Downes, Hanslow and Tulip (2014) mentioned their paper that, this mining boom has appreciated exchange rate but Australia has managed it macroeconomic perfermance better through floating exchange rate and inflation was under control.

3.3: Shock to Exchange rate:

The responses of the one SD innovations to real exchange rate are captured in the figure 4. Due to one standard deviation shocks to real exchange rate results in -0.6% decrease of MTP's RGDP at quarter 4, the response of the shock increases to 0.1% between period quarter eight and eleven, and the shock die out from quarter nine to onwards.

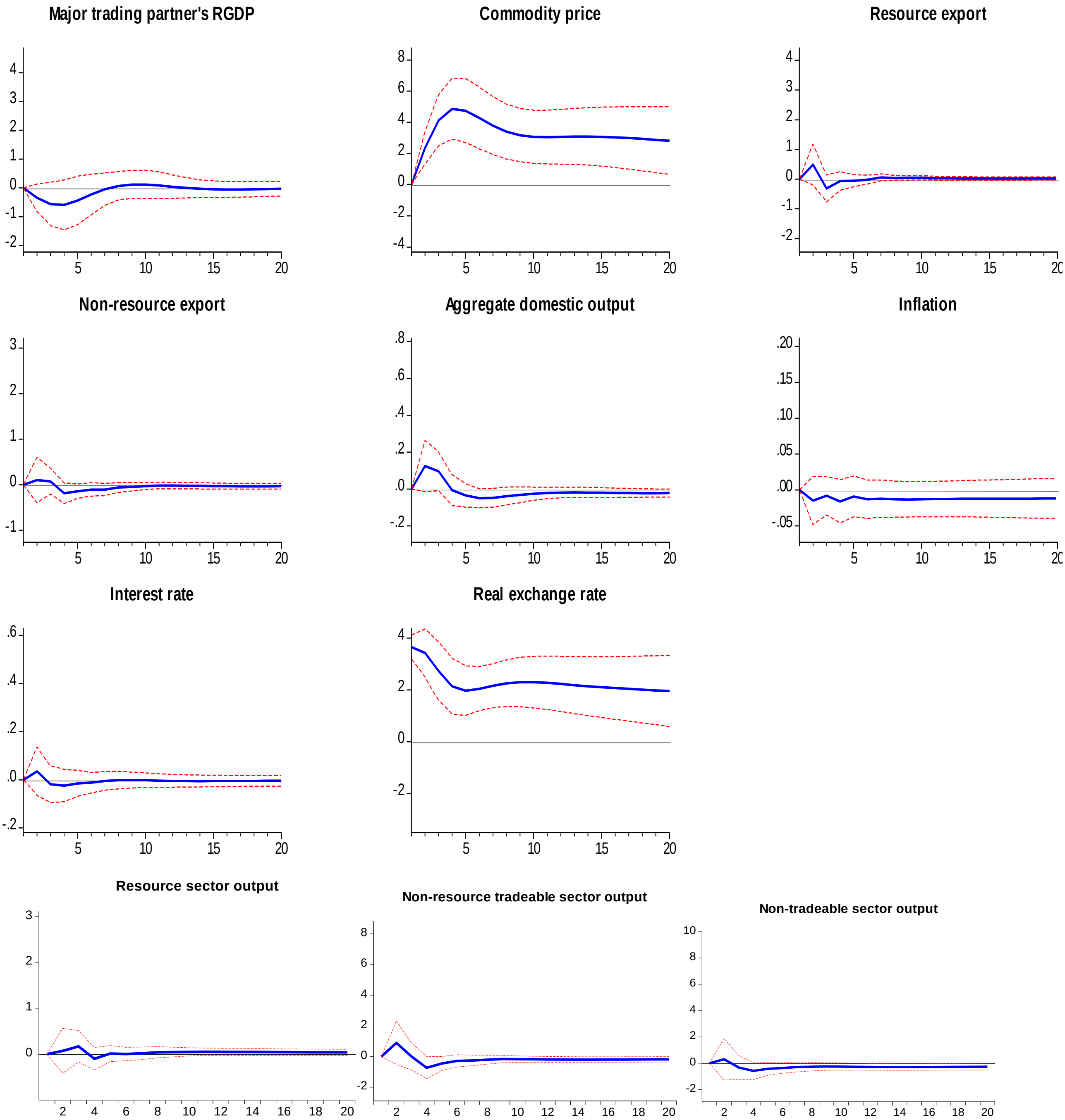

Figure 4: Impulse responses to shocks to real exchange rate (Aggreagte model and Multi-sector model)

The shock to real exchange rate raises the commodity price 4.9% at quarter four and the response drops off to 3.4% at quarter eight and stays 2.8% above the baseline over tweenty quarters. Higher commodity price raises the Auatralian terms of trade, and hence resource export increased 0.5% after the shock, but the response become negative -0.3% at quarter three and returns to baseline from quarter five. The non-resource export volume also increased 0.1% at quarter two and decreased -0.2% at quarter four, again drops off -0.1% in period five and six quarter and goes back to baseline at quarter seven.

The aggregate domestic real GDP increased 0.12% at quarter two, due to revenue gain from resource and non-resource export. The response of the domestic output falls below the baseline -0.04% at quarter five, drops off more -0.05% at quarter seven and -0.02% at quarter eleven and the goes back to baseline at quarter thirteen. The reason behind fall of domestic output from quarter five would be the reduction of resource export volume and non-resource export volume from quareter three and two respectively. The impulse response of the sectoral decomposition shows that, the non-resource sector output and non-tradable sector output increased 0.9% and 0.3% respectively at quarter two after the real exchange rate shock. The resource sector output also increased 0.2% at quarter three. All the three sectors output drops at quarter four. The resource sector output drops to -0.1%, the non-resource sector falls -0.7% and non-tradeable sector output reduces to -0.6%. The resource sector output goes back to baseline from quarter five. However, the non-resource sector output decreases -0.4% at quarter five, -0.3% at quarter six and remain lower -0.2% from quarter eight to tweenty. Similar reponse we observe from the non-tradeable sector output, it stays below the baseline -0.3% from quarter seven to tweenty.

Due to the real exchange rate shock, the impulse response function of CPI inflation shows deflation -0.01% from period two to the following 20 quarters and the interest rate increase 0.04% at quarter two, then drops off to -0.02% at quarter four, and die out from quarter seven. According to macroeconomic principles, there is a positive relationship between interest rate and exchange rate, and rise in interest rate usually reduces inflation. [12]

3.4: Forecast error variance decomposition:

The knowlegde of forecast error is useful to understand the relationships among endogeneous variables. In a sequence of movements of a variable, the forecast error variance decomposition demonstrates the proportion of those movements due to shocks to itself and shocks to other variables. That is, when fundamental shocks have found through recursive system, then forecast error variance helps to understands the importance of one shock to another explaining the endogeneous variables. According to the construction of the recursive method, the forecast errors take on a recursive ordering, meaning, there is sequential change of the variables. If there is a timeline of events, all of the one period forecast-error variance of the variable is due to itself. That is, foreign output will not be affected by commodity price shock contemporeneously, as it is placed first in the ordering of the matrix. Similarly, the shock to resource export does not effect commodity price contemporeneously, and so on. At longer time horizons, the explanatory share of shocks to variables will diminish and variance of forecast errors should rise, as there is more uncertainty the further ahead the forecast. In

[12] Amano and Van Norden (1995), Beine, Bos, and Coulombe (2012), Rapach and Wohar (2002) and Balazs (2012) and the literature on the monetary model of exchange rate determination have shown that bilateral exchange rates are influnced by interest rate differentials.

this paper, the forecast error variance was estimated up to quarter 24, and results are presented in the appendix III for forecast horizon 2, 4, 12 and 24 quarters ahead.

The estimated results shows that, over the longer horizons, using the ordering of the variables in the recursive system, the percentage of the variance of the 24 period ahead forecast for Australia's MTP real GDP explained by the orthogonal shock to itself is 98.97% and only 4.36% is explained by domestic output (1.14%), inflation (1.29%) and real exchange rate (1.93%).

For commodity price at 2nd quarters, 90.46% the forecast error variance is attributable by shock to itself, 5.87% by real exchange rate, and only 2.37% by domestic real GDP. However, over the longer horizon at 24 quarters, 27.87% the forecast error variance of variable commodity price is attributable by shock to itself, 33.51% by exchange rate, 20.55% by domestic demand shock, 6.88% is contributable by foreign demand, 6.50% by non-resource tradeable sector and 4.36% by non-tradeable sector.

The percentage of the variance of the 24 periods ahead forecast error for real exchange rate explained by 2nd orthogonal commodity price shock in the system is 12.74%, by domestic demand shock is 24.48%, 5.02% by foreign demand shock, 7.13% by non-resource export, 6.56% and 4.36% by non-resource sector output and non-tradeable sector output respectively and 44.60% by shock to itself. The estimated results of the forecast error variance decomposition of commodity price and real exchange rate suggests us that, there is strong relationship between non-rural commodity price and real exchange rate. The commodity price influnced by foreign demand shock and price influnded the real exchange rate to appreciate.

Focussing on the aggregate domestic output and sectoral outputs, the contribution of percentage of the variance of the 24 periods ahead forecast error for domestic demand, resource output, non-resource tradeable output and non-tradeable output by real exchange rate shock in the system are 4.25%, 0.74%, 2.98% and 2.30% respectively. The results showed that, non-resource tradeable sector output is about 3% volatile due to real exchnage rate compared to resource sector output (less than 1%). On the otherhand, over the longer horizon, the orthogonal commodity price shock attributed to forecast error variance for domestic demand, resource output, non-resource tradeable output and non-tradeable output are 8.81%, 0.89%, 1.46% and 0.63% respectively. Therefore, commodity price shock is important to explain the aggregate output. The percentage of the variance of the forecast error for domestic real GDP is explained by 69.08% by shock to itself, the 77.13% variance for resource output is attributed by itself, the 84.31% variance for non-resource output is contributed by itself and the 87.89% variance for non-tradeable output is contributed by itself. The orthogonal resource export shock attributed to forecast error variance for domestic demand, resource output, non-resource tradeable output and non-tradeable output are 8.17%, 12.28%, 4.34% and 3.15% respectively. The orthogonal non-resource export shock attributed to forecast error variance for domestic demand, resource output, non-resource tradeable output and non-tradeable output are 2.33%, 1.20%, 4.03% and 2.45% respectively. The orthogonal monetary policy shock contributed to forecast error variance for domestic demand, resource output, non-resource tradeable output and non-tradeable output are

2.47%, 3.96%, 1.93% and 1.40% respectively. From the sectoral output decomposition, it is evident that, the mining boom has a significant affect on the output of the non-resource tradeable and non-tradeable sectors.

At the 24 quarters, the variance of resource exports is dominated by shock to itself 82.56%, by 9% interest rate shock and by 5.44% non-tradeable sector output shock. However, 80.65% of the forecast error variance for non-resource export is explained by itself, 7.83% by foreign demand shock, 4.62% by domestic real GDP and 2.64% by resource sector output.

The percentage of the forecast error variance for inflation is attributable mostly by shock to itself 85.58%, by the monetary policy shock (interest rate) 5.85%, by the resource output shock 3.58%, by non-resource export shock 3.31%, by non-tradeable sector output 2.53% and 2.47% is explained by real exchange rate.

The percantage variance of the 24 periods ahead forecast error for monetary policy variable explained by own shock is 77.01%, by the domestic demand shock is 12.95%, by the non-resource tradeable output is 4.57%, by the inflationary shock is 3.75% and by the commodity price shock is 3.55%.

4. Robustness check:

Following Manalo, Perera and Rees (2015), the SVAR model was estimated including in the foreign block the variables foreign inflation (π^*), federal funds rate as a proxy for foreign interest rate (i^*) and US inflation in foreign block. However, including too many endogeneous variable was leading to some of the eigenvalues out of the unit circle and non-significant estimation result.[13] Therefore, for considering the parsimony of the model, the paper has dropped those variables. The paper has estimated the model by changing the ordering of the real exchange rate. The article has not found any change of the estimated results due to the change of ordering of contemporeneours relationship of the endogeneous variables.

In the first estimation, the paper has estimated the model foreign output variable as US real GDP.[14] For robustness check, the paper has constructed the foreign output by calculating Australia's major trading partner countries (17 countries and Euro area's 19 countries) real GDP from the Pen World Table 9.0 (Feenstra, Inklaar and Timmer, 2015), and aggregated the real GDP's of Australia's major trading partners. The trade weights have used to weight the MTP's real GDP. The paper has used the weights from https://www.rba.gov.au/statistics/frequency/twi/twi-20171130.html . In theory, the weights should change each year, therefore, used the average weights for 2015 and 2016 to weight the 2016 data, the average weights for 2014 and 2015 to weight the 2015 data and so on.

[14] Dungey, Fry-MacKibbin and Linehan (2014) and Manalo, Perera and Rees (2015) have used Australia's Major trading partner RGDP as a foreign variable in their paper. This paper has used US real GDP as a proxy for Australia's Major trading Partner RGDP.

Before, Europeran Union the weights have collected from Germany and France's trade-weighted index.

The paper examines a set of unit-root tests, including the Augmented Dickey-Fuller (ADF), Phillip-Perron and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests to assess whether or not the series is $I(1)$ when first differenced and transformed the $I(1)$ series to their first dfferenced. For sensitivity analysis, all the series again examined with addition unit root test, called 'breakpoint unit root', to check the structural break in the series. The breakpoint unit root corrects the structural break and allow the series to consider as stationrary if Augmented Dickey-Fuller (ADF), Phillip-Perron and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests considered those series as non-stationary. The paper found over night cash rate is non-stationary and transformed to its first differenced.

The paper first estimated the model with quarterly data are observed from the period 1980: Q1 to 2017: Q4. As Australia has adopted flexible exchange rate since 1983, therefore, the paper re-estimated the model with quarterly data observed from the period 1984: Q1 to 2016: Q4. The SVAR model was first estimated with lag length 'one' based on lag specification test Schwartz Bayesian Information criterion, Hannan-Quinn Information criterion, and Akaike Information Criteria. Later the model has estimated with lag lenghts 'two' based on Hannan-Quinn Information criterion, Akaike Information Criteria and Final Prediction error autoregressive lag length specification test.

5. Conclusion:

The analysis of Dutch disease effects is important for policy implications and management of a resource windfall. If non-resource sectors have dynamic scale economies and other positive externalities, as in Krugman (1987), de-industrialisation might be harmful to the whole economy in the long-run.

This paper empirically estimated a multi-sector SVAR model of the Australian economy, including three production sectors: i) traded resource sector ii) non-resource traded sector iii) non-traded commodities and services sector. Using quarterly data from the Australian Bureau of statistics and Reserve Bank of Australia from the period 1980: Q1 to 2017: Q4, the research found evidence of Dutch disease in Australia. The commodity price shock had a positive effect on domestic real GDP and resource output, but non-tradeable output was reduced, and exchange rate appreciation reduced non-resource exports and adversely affected non-resource tradeable output and non-tradeable output. From the sectoral output decomposition, it is evident that, the mining boom has a significant affect on the output of the non-resource tradeable and non-tradeable sectors.

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Appendix I: Description of the data and their sources.

The data are seasonally adjusted at quarterly frequencies for the period 1992:Q1 to 2013:Q4. The variables are observed for a total of 88 quarters.

1. **Foreign GDP:** Percentage change of United States Real Gross domestic product. Quarterly seasonally adjusted.
   Source: Federal Reserve Bank of St. Louis, Economic Research Division.
2. **MTP RGDP:** Percentage change of Australia's major trading partners RGDP. The variable MTP RGDP calculated manually by aggregating the RGDP of Australia's major trading partners. MTP's RGDP have collected from Penn World Table 9.0 and weights have used from https://www.rba.gov.au/statistics/frequency/twi/twi-20171130.html.
3. **Foreign Interest rate**: Monthly and not seasonally adjusted Effective Federal Funds rate.
   Source: Federal Reserve Bank of St. Louis, Economic Research Division.
4. **Foreign Inflation:** Trimmed Mean PCE inflation rate of United States, monthly and seasonally adjusted.
   Source: Federal Reserve Bank of St. Louis, Economic Research Division.
5. **Resource prices:** Percentage change in the RBA non-rural commodity price index measured in Special Drawing Rights.
   Source: Reserve Bank of Australia, Statistical Table: I2 Commodity prices.
6. **Resource exports:** Percentage change in resource export volumes.
   Source: Reserve Bank of Australia, Statistical table I1, International Trade and Balance of Payments.
7. **Non-resource export:** Percentage change in non-resource export volumes. It is calculated as the difference between total exports volumes and resource export volumes.
   Source: Reserve Bank of Australia, Statistical table I1, International Trade and Balance of Payments.
8. **Australian Real GDP:** Percentage change in real gross domestic product.
   Source: Australian Bureau of Statistics, Cat. No. 5206.0, 'Australian National Accounts: National Income, Expenditure and Product.
9. **Resource Value added:** Quarterly growth rate of value added production in the mining industry.
   Source: Australian Bureau of Statistics, Cat. No. 5206.0, 'Australian National Accounts: National Income, Expenditure and Product.
10. **Non-resource tradeable value added:** Quarterly growth rate of value added production in the non-resource tradeable sector. The non-resource sector consists of agriculture, forestry and fishing industry, the manufacturing industry, transport industry, the wholesale trade industry, the accommodation and food service industry. The growth rate of this series has calculated by summing the growth rates of each industry weigted by that industry's share of non-resource tradeable value added.

Source: Australian Bureau of Statistics, Cat. Nos. 5204.0 and 5206.0.

11. **Non-tradeable value added:** Quaterly grwth rate of value added production in the non-tradeable sector. The non-tradeable sector includes the gas, electricity, water and waste industry, the construction industry, the retail trade industry, the information, media and telecommunications industry, the finance and insurance industry, the real estate industry, the professional services industry, the administrative service industry, the public administration industry, the education industry, the healthcare industry, the arts and recreation industry, the other service industry and ownership of dwellings. The growth rate of this series has calculated by summing the growth rates of each industry weigted by that industry's share of non-tradeable value added.
    Source: Australian Bureau of Statistics, Cat. Nos. 5204.0 and 5206.0.
12. **Inflation:** Quarterly trimmed mean inflation excluding interest and tax changes.
    Source: Reserve Bank of Australia, Statistical table G1: Consumer Price Inflation.
13. **Cash rate:** Quarterly average interbank overnight cash rate.
    Source: Reserve Bank of Australia, Statistical table F1.1, Interest Rates and Yields – Money Market.
14. **Real Exchange rate:** Quarterly average (original) Australian dollar trade-weighted exchange rate index, adjusted for relative consumer price levels.
    Source: Reserve Bank of Australia, Statistical table F15, Real Exchange Rate Measures. Quarterly percentage change in the average nominal exchange rate.

Appendix II: Estimates of the parameters of matrix A_0 and Covariance matrix of structural shocks.

- The estimates of the strucural parameters of the contemporaneous matrix A_0 for Aggregate model.

$$A_0 Z_t = \begin{bmatrix} 1.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.100 & 1.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.103 & 0.074 & 1.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ -0.062 & -0.015 & -0.031 & 1.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ -0.005 & -0.046 & 0.024 & 0.038 & 1.000 & 0.000 & 0.000 & 0.000 \\ 0.004 & 0.000 & -0.006 & 0.011 & -0.016 & 1.000 & 0.000 & 0.000 \\ -0.004 & 0.005 & -0.000 & -0.002 & -0.168 & -0.326 & 1.000 & 0.000 \\ -0.049 & 0.428 & -0.072 & 0.231 & -2.790 & -0.953 & -0.574 & 1.000 \end{bmatrix} \begin{bmatrix} y^* \\ p^* \\ z^* \\ m^* \\ y \\ \pi \\ i \\ r \end{bmatrix}$$

Non-unit symetric, positive diagonal covariance martix (B) of structural disturbances from aggregate SVAR model.

$$B = \begin{bmatrix} 2.713 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 5.722 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 3.907 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 2.847 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.723 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.187 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.556 & 0.000 \\ 0.000 & 0.00 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 3.656 \end{bmatrix}$$

- The estimates of the strucural parameters of the contemporaneous matrix A_0 for Resource sector.

$$A_0 Z_t = \begin{bmatrix} 1.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.088 & 1.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.103 & 0.075 & 1.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ -0.063 & -0.007 & -0.054 & 1.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.066 & -0.027 & -0.014 & 0.128 & 1.000 & 0.000 & 0.000 & 0.000 \\ 0.003 & 0.000 & -0.006 & 0.013 & 0.005 & 1.000 & 0.000 & 0.000 \\ -0.006 & -0.000 & 0.008 & 0.008 & -0.008 & -0.280 & 1.000 & 0.000 \\ -0.043 & 0.285 & -0.023 & 0.270 & 0.058 & -1.730 & -1.332 & 1.000 \end{bmatrix} \begin{bmatrix} y^* \\ p^* \\ z^x \\ dm \\ y_z \\ \pi \\ i \\ r \end{bmatrix}$$

Non-unit symetric, positive diagonal covariance martix (B) of structural disturbances from Resource sector SVAR model.

$$B = \begin{bmatrix} 2.713 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 5.642 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 3.994 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 2.867 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 2.760 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.183 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.574 & 0.000 \\ 0.000 & 0.00 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 4.217 \end{bmatrix}$$

- The estimates of the strucural parameters of the contemporaneous matrix A_0 for Non-resource tradeable sector.

$$A_0 Z_t = \begin{bmatrix} 1.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.094 & 1.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.110 & 0.068 & 1.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ -0.063 & -0.019 & -0.062 & 1.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.012 & 0.016 & 0.294 & -0.262 & 1.000 & 0.000 & 0.000 & 0.000 \\ 0.003 & -0.000 & -0.006 & 0.011 & -0.000 & 1.000 & 0.000 & 0.000 \\ -0.005 & -0.000 & 0.006 & 0.013 & -0.007 & -0.300 & 1.000 & 0.000 \\ -0.069 & 0.300 & -0.063 & 0.299 & -0.082 & -1.194 & -1.005 & 1.000 \end{bmatrix} \begin{bmatrix} y^* \\ p^* \\ z^x \\ dm \\ y_m \\ \pi \\ i \\ r \end{bmatrix}$$

Non-unit symetric, positive diagonal covariance martix (B) of structural disturbances from Non-resource tradeable sector SVAR model.

$$B = \begin{bmatrix} 2.710 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 5.708 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 3.985 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 2.915 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 7.825 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.188 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.570 & 0.000 \\ 0.000 & 0.00 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 4.164 \end{bmatrix}$$

- The estimates of the strucural parameters of the contemporaneous matrix A_0 for Non-tradeable sector.

$$A_0 Z_t = \begin{bmatrix} 1.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.166 & 1.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.151 & 0.100 & 1.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ -0.072 & -0.024 & -0.066 & 1.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ -0.119 & -0.074 & 0.300 & 0.435 & 1.000 & 0.000 & 0.000 & 0.000 \\ 0.003 & -0.001 & -0.007 & 0.010 & -0.000 & 1.000 & 0.000 & 0.000 \\ -0.000 & 0.000 & 0.013 & 0.008 & 0.003 & -0.342 & 1.000 & 0.000 \\ -0.062 & 0.302 & -0.019 & 0.299 & 0.017 & -1.465 & -1.365 & 1.000 \end{bmatrix} \begin{bmatrix} y^* \\ p^* \\ z^x \\ dm \\ y_n \\ \pi \\ i \\ r \end{bmatrix}$$

Non-unit symetric, positive diagonal covariance martix (B) of structural disturbances from Non-tradeable sector SVAR model.

$$B = \begin{bmatrix} 2.682 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 5.601 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 3.923 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 2.901 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 8.874 & 0.000 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.188 & 0.000 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.570 & 0.000 \\ 0.000 & 0.00 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 4.146 \end{bmatrix}$$

Appendix III: Forecast error variance decomposition of the variables

Variable	Shock	2	4	12	24	Variable	Shock	2	4	12	24
$\boldsymbol{y^*}$	y^*	98.98	96.76	94.73	94.27	$\boldsymbol{p^*}$	y^*	0.61	1.60	6.76	6.87
	p^*	.006	0.15	0.38	0.39		p^*	90.46	62.65	35.39	27.87
	z^x	0.09	0.15	0.14	0.14		z^x	0.12	0.92	2.32	2.68
	m^x	0.09	0.41	0.64	0.68		m^x	0.42	2.83	5.20	5.80
	y	0.33	0.76	1.03	1.14		y	2.37	10.35	17.86	20.55
	y_z	0.06	0.19	0.50	0.50		y_z	1.05	1.77	1.01	0.70
	y_m	0.20	0.44	0.47	0.48		y_m	0.87	4.35	6.18	6.50
	y_n	0.57	0.70	0.91	0.92		y_n	0.19	1.78	3.91	4.36
	π	0.02	0.08	1.09	1.29		π	0.00	0.13	0.17	0.16
	i	1.01	0.00	0.06	0.14		i	0.13	1.80	2.69	2.54
	r	0.55	1.69	1.91	1.93		r	5.87	19.71	29.60	33.51

Variable	Shock	2	4	12	24	Variable	Shock	2	4	12	24
$\boldsymbol{z^x}$	y^*	1.06	0.97	1.21	1.24	$\boldsymbol{m^x}$	y^*	5.64	5.52	7.69	7.83
	p^*	1.36	1.57	1.58	1.58		p^*	0.33	2.67	2.72	2.76
	z^x	91.00	83.44	82.70	82.56		z^x	0.19	0.52	0.76	0.77
	m^x	0.10	0.87	1.09	1.10		m^x	92.69	84.88	80.97	80.65
	y	1.03	1.82	1.85	1.87		y	0.12	3.84	4.58	4.62
	y_z	0.02	0.46	0.64	0.64		y_z	1.43	2.64	2.66	2.64
	y_m	0.63	0.67	0.68	0.69		y_m	0.23	0.39	0.62	0.64
	y_n	1.05	5.41	5.45	5.44		y_n	0.56	0.97	1.07	1.08
	π	0.01	0.78	0.93	0.98		π	0.70	1.14	1.12	1.13
	i	4.21	8.60	9.00	9.00		i	0.20	0.94	1.20	1.20
	r	1.20	1.56	1.61	1.63		r	0.11	0.50	0.94	1.02

Variable	Shock	2	4	12	24	Variable	Shock	2	4	12	24
$\boldsymbol{y}$	y^*	0.09	0.21	4.14	4.47	$\boldsymbol{y_z}$	y^*	1.27	1.26	2.00	2.02
	p^*	9.90	9.20	8.81	8.81		p^*	0.54	0.78	0.86	0.89
	z^x	7.23	8.78	8.28	8.17		z^x	13.03	12.53	12.32	12.28
	m^x	2.02	2.17	2.18	2.33		m^x	1.53	1.78	1.96	1.20
	y	77.03	74.29	70.07	69.08		y_z	82.63	78.96	77.50	77.13
	π	0.002	0.01	0.29	0.40		π	0.08	0.43	0.87	0.97
	i	1.75	2.46	2.43	2.47		i	0.84	3.80	3.90	3.96
	r	1.94	2.85	3.77	4.25		r	0.05	0.45	0.55	0.74

Variable	Shock	2	4	12	24	Variable	Shock	2	4	12	24
$\boldsymbol{y_m}$	y^*	0.01	0.16	0.29	0.36	$\boldsymbol{y_n}$	y^*	1.23	1.52	1.81	1.87
	p^*	0.49	1.29	1.38	1.46		p^*	0.41	0.42	0.48	0.63
	z^x	3.72	4.18	4.36	4.34		z^x	2.75	3.17	3.15	3.15
	m^x	2.55	3.77	3.97	4.03		m^x	2.27	2.24	2.34	2.45

	y_m	90.39	86.77	85.17	84.31		y_n	92.25	90.64	89.27	87.89
	π	0.01	0.21	0.50	0.57		π	0.04	0.19	0.27	0.29
	i	1.62	1.77	1.84	1.93		i	0.91	1.22	1.27	1.40
	r	1.17	1.82	2.47	2.98		r	0.11	0.60	1.39	2.30

Variable	Shock	2	4	12	24	Variable	Shock	2	4	12	24
$\boldsymbol{\pi}$	y^*	0.67	0.44	0.36	0.38	$\boldsymbol{i}$	y^*	0.07	0.20	0.22	0.24
	p^*	0.00	0.08	0.81	1.25		p^*	2.64	2.81	3.59	3.55
	z^x	0.88	1.00	0.62	0.60		z^x	0.07	0.25	0.25	0.25
	m^x	4.50	4.07	3.63	3.31		m^x	1.06	1.34	1.59	1.66
	y	0.90	0.65	0.43	0.53		y	7.99	12.92	13.02	12.95
	y_z	3.55	3.81	3.69	3.58		y_z	0.43	1.86	1.99	2.00
	y_m	0.19	0.23	0.22	0.21		y_m	2.48	4.80	4.60	4.57
	y_n	0.12	0.92	2.12	2.53		y_n	1.57	1.57	1.66	1.65
	π	89.91	88.72	86.89	85.58		π	0.90	1.03	2.99	3.75
	i	2.65	4.29	5.83	5.85		i	86.94	80.97	77.80	77.01
	r	0.46	0.71	1.41	2.47		r	0.30	0.46	0.52	0.57

Variable	Shock	2	4	12	24
$\boldsymbol{r}$	y^*	0.25	0.26	3.10	5.02
	p^*	16.76	17.60	13.66	12.74
	z^x	0.65	2.00	2.73	3.05
	m^x	5.00	5.18	6.75	7.13
	y	23.24	22.59	23.49	24.48
	y_z	0.47	0.62	0.39	0.24
	y_m	4.28	5.01	6.05	6.56
	y_n	1.52	3.77	3.97	4.36
	π	0.89	1.05	0.98	0.60
	i	1.70	2.02	2.16	2.35
	r	51.48	49.28	47.12	44.60