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Recovery from Dutch Disease*

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Dutch Disease is thought to have ongoing negative effects on resource rich open economies. There is little evidence on how economies recover. We document the Australian case in the aftermath of the commodities price boom resulting from high input demand from China. We show that where the boom is contained in an export-oriented, small-employment sector of the economy and driven by external demand rather than price shocks, the economy recovers to its equilibrium relatively quickly. To show this we add a new tool to the SVAR toolbox which enables us to assess the source of deviations in the observed outcomes from an empirical steady-state implied by the model.

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1 Introduction

Despite the large literature on identifying and preventing the emergence of Dutch Disease in resource intensive economies very little has been written on the recovery from a temporary boom for these economies. Most of the existing literature warns of dire outcomes, with an all but destroyed non-resource based trading sector (traditionally denoted manufacturing in earlier literature) and variable outcomes for the domestic non-tradeable sector depending on income and substitution effects as in Corden (1984).

The aim of this paper is to investigate the recovery of the Australian economy from the effects of the resource boom of 2003 to 2012[1]. A large component of the resource boom for Australia resulted from demand for Australian iron ore (and other minerals) sourced to fulfill unprecedented excess demand for steel in China. Ultimately the Chinese demand resulted from a rapid rate of domestic development and relatively high demand for exported manufacturing products from China, requiring the development of new Chinese infrastructure. In an earlier paper Dungey et al. (2014), we provide empirical evidence of Dutch Disease effects in Australia and the emergence of a two-speed economy during the period of the boom. Bjørnland and Thorsrud (2016) reach the same conclusion over a similar period. By 2013 Downes et al. (2014) estimate a small effect of Dutch Disease in reducing manufacturing output. This paper supports the conclusion of Kulish and Rees (2017) that despite its longevity, the Australian economy has largely behaved as though the commodity price boom was a temporary bonanza and not a permanent one.

This paper considers the performance of the Australian economy over the period from 1988Q1 to 2016Q4 using a small open economy VAR, as specified in Dungey et al. (2014). In extending the sample we observe that the impulse responses and forecast error variance decompositions have shifted in the direction of an economy performing in a manner more theoretically coherent with responses to a temporary commodity price shock (see Kulish and Rees, 2017). There is reduced evidence of decreased domestic production associated with commodity price shocks - or the Dutch Disease - and export and international demand shocks are accompanied by growth in the Australian economy. The results nicely collaborate the effects of separating demand and exogenous price effects in propagating Dutch Disease proposed in Bjørnland and Thorsrud (2016). Our evidence confirms theirs in that during price booms, pure price effects, unaccompanied by underlying demand, can lead to Dutch Disease conditions. We add to this the observation that the economy can recover in the post-boom period, so that both price and demand effects have the expected effects on domestic demand, without resulting in crowding out of domestic production in other sectors.

The rapid resumption of normal conditions, despite evidence of the presence of Dutch Disease during the boom, provides considerable hope that Dutch Disease is not an incurable anathema to a resource rich country. We postulate that sufficiently flexible adjustment conditions within the economy allow for accommodation of the boom, consistent with the classic work summarized in Corden (1984). A number of critical conditions are present: the booming sector has been largely

[1] The start date is taken from Kulish and Rees (2017), and the end date from the point at which the commodity price index compiled by the Reserve Bank of Australia as used in this paper peaked.

affected by an exogenous shock meaning there has not been significant displacement of domestic demand for the booming sector product, the labour market employment in the booming sector is a relatively small part of domestic employment, and yet the production value of the mining sector is a relatively large component of the domestic economy. Each of these conditions is consistent with those identified in Corden (1984) as useful in minimizing the effects of Dutch Disease.

An alternative framework for avoiding Dutch Disease due to Bjørnland and Thorsrud (2016) relies on high-tech productivity spillovers from the booming sector to other domestic sectors. Evidence for technology transfers in Norway from the off-shore oil industry, the active use of a sovereign wealth fund, and the significantly larger employment of the Norwegian government sector are all posited as reasons for the absence of Dutch Disease in Norway compared with Australia. The absence of trickle down effects from the mining boom in Australia is also supported by Bashar (2015).

We introduce the concept of an empirical steady-state gap. This gap describes the deviation of the empirical model from its projection. These deviations represent the combined contribution of shocks identified by the model. In particular we use generalized historical decomposition spillovers which show how shocks from different sectors of the economy impact on the evolution of the conditions experienced in Australia. The method builds on the spillover indices proposed by Diebold and Yilmaz (2009, 2014), which are expressed in absolute terms, and extended in Dungey et al. (2017) to distinguish positive and negative contributions. These contributions reveal how shocks push the economy away from its empirical steady-state. In addition, the source of these shocks can be identified. In this application we concentrate upon how the international and domestic shocks experienced over the last 25 years have contributed to the production of either a negative or positive empirical steady-state gap for the Australian domestic economy.

Our empirical steady-state gap analysis shows where the international and domestic components of the model have contributed to deviations from the model description of the empirical steady-state of the Australian economy. In particular, we show that the economy has been in empirical steady-state approximately 4 times during the sample period, the most recent being in 2015 as the economy recovered from the effects of the commodity price boom which created a positive empirical steady-state gap. Unusually, in 2015 both the international and domestic empirical steady-state gaps were zero, that is both were contemporaneously internally consistent with the empirical steady-state of the economy as described by the domestic economy variables in the model. In all other instances where there is an overall empirical steady-state gap this has been achieved by an international empirical steady-state gap being offset by a domestic empirical steady-state gap. The adjustment of the economy back to empirical equilibrium at the end of the sample reinforces the resilience of both the economic framework proposed as a description of the Australian economy, and of the robustness of the Australian economy in weathering the changing international conditions over the past two decades.

Our results bear out theoretical claims that when world demand, rather than commodity prices and exchange rates, have been the important long term determinant of the commodity boom we can anticipate relatively quick recovery from Dutch Disease. Only a few years after the end of the boom in commodity prices the Australian economy has returned towards a more balanced pathway, and the shocks contributing to push the economy off this pathway have receded. While the previous research on the mining boom in Australia shows that shocks to Chinese steel production and commodity prices resulted in increases in commodity prices and mining investment which were sustained over decades, the evidence now suggests the economy did see through to the temporary nature of these effects.

The article proceeds as follows. Section 2 briefly presents the empirical SVAR framework and provides more detail about the new methods for identifying the contributions of shocks pushing the economy away from its empirical steady-state. Section 3 presents results illustrating the effects of the resource boom via impulse responses, forecast error variance decompositions and the newly introduced generalized historical decompositions. Section 4 concludes.

2 Empirical framework

The SVAR model of the set of variables X_t is

$$B(L)X_t = \epsilon_t, \tag{1}$$

where B(L) is a p^{th} order matrix polynomial in the lag operator L, $B(L) = B_0 - B_1 L - B_2 L^2 - ... - B_p L^p$. B_0 summarizes the relationships between the variables contemporaneously and is nonsingular and normalized to have ones on the diagonal. The $n \times 1$ vector ϵ_t contains structural shocks where $E(\epsilon_t \epsilon_t') = D$ and $E(\epsilon_t \epsilon_{t+s}') = 0$, for all $s \neq 0$. The variances of the structural disturbances are contained in the diagonal matrix D. The reduced form representation of the model is

$$A(L)X_t = u_t, \tag{2}$$

where $A(L) = B_0^{-1} B(L) = I - A_1 L - A_2 L^2 - ... - A_p L^p$. The reduced form residuals are related to the structural residuals as $u_t = B_0 \epsilon$ and $E(u_t u_t') = \Sigma$, and $E(u_t u_{t+s}') = 0$ for all $s \neq 0$[2].

2.1 Historical Decompositions

An alternative means of organizing the estimated parameter matrices when the estimated shocks are orthogonal (as they are in a VAR with a Cholesky representation as here) is via a historical decomposition. Using the moving average specification of the VAR, we can write the observed variables X_t as

$$X_t = \text{initial values} + \sum_{i=0}^{\infty} S_i u_{t-i}, \tag{3}$$

[2]The model is estimated using the AB form of the SVAR of Amisano and Giannini (1997).

where $S_i = \sum_{j=1}^{i} A_j S_{i-j}$ where $A_j = 0, j > p$ with $S_0 = I_n$ and $S_j = 0$ for $j < 0$ and S_j are causal and square-summable. The historical decomposition of X_t defined in equation (3) is a standard tool for decomposing any observed variable, at any point in time (see Dungey and Pagan, 2000 for example). To take into account the contemporaneous structural restrictions captured by matrix B_0, equation (3) can be represented as

$$X_t = \text{initial values} + \sum_{i=0}^{\infty} \tilde{S}_i \epsilon_{t-i}, \tag{4}$$

where $\tilde{S}_i = S_i B_0$. The impact of the initial values on the estimate of X_t will vanish as time progresses, meaning that as long as analysis is restricted to beyond an initial period when these effects dominate (and the data are stationary) then (4) can be also rewritten as

$$X_{t+j} = \sum_{i=0}^{j-1} \tilde{S}_i \epsilon_{t+j-i} + \sum_{i=j}^{\infty} \tilde{S}_i \epsilon_{t+j-i}. \tag{5}$$

The historical decomposition of X_{t+j} defined in (5) contains two terms. The far right term represents the expectation of X_{t+j} given information available at time t, which is the base projection of X_t. The first term on the right-hand side shows the difference between the actual series and the base projection due to innovations subsequent to period t. In particular, it shows that the gap between an actual series and its base projection is the sum of the weighted contributions of the innovations to the individual series. This reveals the dynamic properties of the system that evolves over time by deviating from its empirical steady-state. We denote the projection as the empirical steady-state (describing the empirical model coherent steady-state of the framework over the sample period) and the deviations from the projections as an empirical steady-state gap[3].

The empirical steady-state gap can be considered as a measure of interconnectedness between the macroeconomic variables in the system, as represented by the way in which shocks flow through the system. To do so a system wide representation of (5) is defined as

$$GHD_{t+j} = \sum_{i=0}^{\infty} IRF_i \circ \Upsilon_{t+j-i} = \sum_{i=0}^{j-1} IRF_i \circ \Upsilon_{t+j-i} + \sum_{i=j}^{\infty} IRF_i \circ \Upsilon_{t+j-i}, \tag{6}$$

where GHD_t is a generalized historical decomposition matrix at time t, IRF_i are orthogonalized impulse response matrices, $\circ$ is a Hadamard product, and $\Upsilon_{t+j-i} = [\epsilon_{t+j-i}, ..., \epsilon_{t+j-i}]$ is the $n \times n$ matrix containing structural residuals. Equation (6) allows us to identify different components of the empirical steady-state gap. That is, we can examine which subsets of shocks are more influential in the model. In the empirical section we will examine how domestic shocks (made up of the combined effects of resource export, mining investment, domestic output, inflation, interest rate, exchange rate shocks) and international shocks (made up of the combined effects

[3]Note that for stationary data what we describe is essentially a combination of all the demeaned relationships in the empirical sample. The advantage is that it is a way of visualizing the shocks impacting the economic model in terms of their combined effects in locating the economy off its empirical steady-state - thus the terminology empirical steady-state gap.

of Chinese steel production, real commodity prices, and foreign output shocks) contribute to the empirical steady-state gap of the Australian economy.

Our approach is related to the spillovers and interconnectedness measures of Diebold and Yilmaz (2009, 2014). They summarize the off-diagonal elements of a forecast error variance decomposition matrix for specifications where the elements of X_t are all of the same measure, for example international stock returns. Our extension allows for the elements of X_t to come from different aspects of the economy where the variables are not measuring the same concept (for example a system including GDP, inflation and an interest rate). In addition, an index constructed from GHD matrices takes into account the innovation in Dungey et al. (2017) on signing the contributions of the shocks to the system, whereas spillover indices constructed from forecast error variance decompositions as in Diebold and Yilmaz (2009, 2014) do not allow the detection of changes in signs and hence the detection of dampening or amplifying shocks.

In constructing indices from the GHD we consider components related to the own-shocks and shocks between the variables. Consequently, we use the GHD to develop the concept of the empirical steady-state gap due to spillovers (the off-diagonal shocks). The corresponding Diebold and Yılmaz (2009) spillover indexes are net of own-shocks. That is, they do not consider the unexplained component of each variable in the VAR which is usually attributed to the own-shocks in a VAR. The empirical steady-state gaps due to shocks from other variables and due to own-shocks are defined respectively as

$$SSG_t^{others} = \sum_{i,j=1,j\neq i}^{n} GHD_{t,ij}, \tag{7}$$

$$SSG_t^{own} = \sum_{i=1}^{n} GHD_{t,ii}. \tag{8}$$

The SSG measures from equations (7) and (8) are used to examine how the Australian economy sector recovered from Dutch Disease.

3 Recovery from a resource boom for a resource rich economy

The model specification and the choice and treatment of the variables are the same as in Dungey et al. (2014), but with the sample period extended to 2016 Quarter 4, rather than finishing in Quarter 1 in 2011. This section briefly describes the data set and identification strategy and then proceeds to analysis. We focus on the differences betweeen the 2011 and 2016 models and the generalized historical decomposition and associated empirical steady-state gaps generated by domestic and international shocks to the economy.

3.1 Empirical setup

Four external variables and five domestic variables are included in the set of variables X_t with ordering as follows: Chinese resource demand (csp_t), real commodity prices (pc_t), foreign output (yw_t), the real value of Australian resource exports ($resx_t$), mining investment ($mininv_t$), domestic output (yd_t), the inflation rate (pd_t), the cash rate (rd_t), and the real exchange rate (q_t). All data are quarterly. The non-stationary variables are detrended consistent with Dungey et al. (2014), while the inflation rate is expressed in percentage terms. Appendix A contains a full description of the data and sources. The Chinese resource demand variable (csp_t) is Chinese steel production, which is a proxy for China's overall demand for inputs into steel production[4]. The Reserve Bank of Australia's (RBA) Index of Commodity Prices in USD is the commodity price variable (pc_t), while foreign output (yw_t) is the export-weighted real GDP of Australia's major trading partners. Resources exports ($resx_t$) consists mainly of metal ores and minerals, as well as coal. Domestic output (yd_t) is non farm GDP. Inflation (pd_t) is preferred to the price level as it is the target of Australian monetary policy, while the overnight cash rate is the interest rate variable (rd_t) as it has been the main monetary policy instrument since the floating of the Australian dollar in December 1983. The exchange rate (q_t) is represented by the real trade-weighted index calculated by the RBA.

The selection of variables and choices of ordering of the variables for the model identification particularly for the domestic macroeconomic component of the model are standard in SVAR modeling of the Australian economy. Previous literature supporting the specification adopted here include Brischetto and Voss (1999), Dungey and Pagan (2000, 2009), Berkelmans (2005), Lawson and Rees (2008), Jääskelä and Smith (2011) and Dungey et al. (2014). The identification assumptions reflect the small open economy nature of the Australian economy where the contemporaneous impact matrix is lower triangular with Australian variables not affecting the foreign variables, but with the foreign variables affecting the Australian domestic variables contemporaneously. The exception is that Chinese steel demand, foreign output and resource exports only affect the Australian interest rate and inflation through the lag structure as it is assumed that these variables will only respond to the foreign variables with a lag. Unlike most other SVAR models for small open economies, the Australian variables are able to affect the foreign variables with a lag given the possibility of commodity exporting countries having some degree of market power[5].

The contemporaneous identification of the model is given by

$$B_0 X_t = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ b_{41} & b_{42} & b_{43} & 1 & 0 & 0 & 0 & 0 & 0 \\ b_{51} & b_{52} & b_{53} & b_{54} & 1 & 0 & 0 & 0 & 0 \\ b_{61} & b_{62} & b_{63} & b_{64} & b_{65} & 1 & 0 & 0 & 0 \\ 0 & b_{72} & 0 & 0 & b_{75} & b_{76} & 1 & 0 & 0 \\ 0 & b_{82} & 0 & 0 & b_{85} & b_{86} & b_{87} & 1 & 0 \\ b_{91} & b_{92} & b_{93} & b_{94} & b_{95} & b_{96} & b_{97} & b_{98} & 1 \end{bmatrix} \begin{bmatrix} csp_t \\ pc_t \\ yw_t \\ resx_t \\ mininv_t \\ yd_t \\ pd_t \\ rd_t \\ q_t \end{bmatrix}.$$

For further details see Dungey et al. (2014).

[4] Alternatives for this measure were considered in Dungey et al. (2014) including Chinese manufacturing exports and a Chinese industrial production index. See also Roberts and Rush (2010).

[5] Dungey et al. (2014), as well as suggested in Dornbusch (1987), Sjaastad (1998a, 1998b) and Clements and Fry (2008).

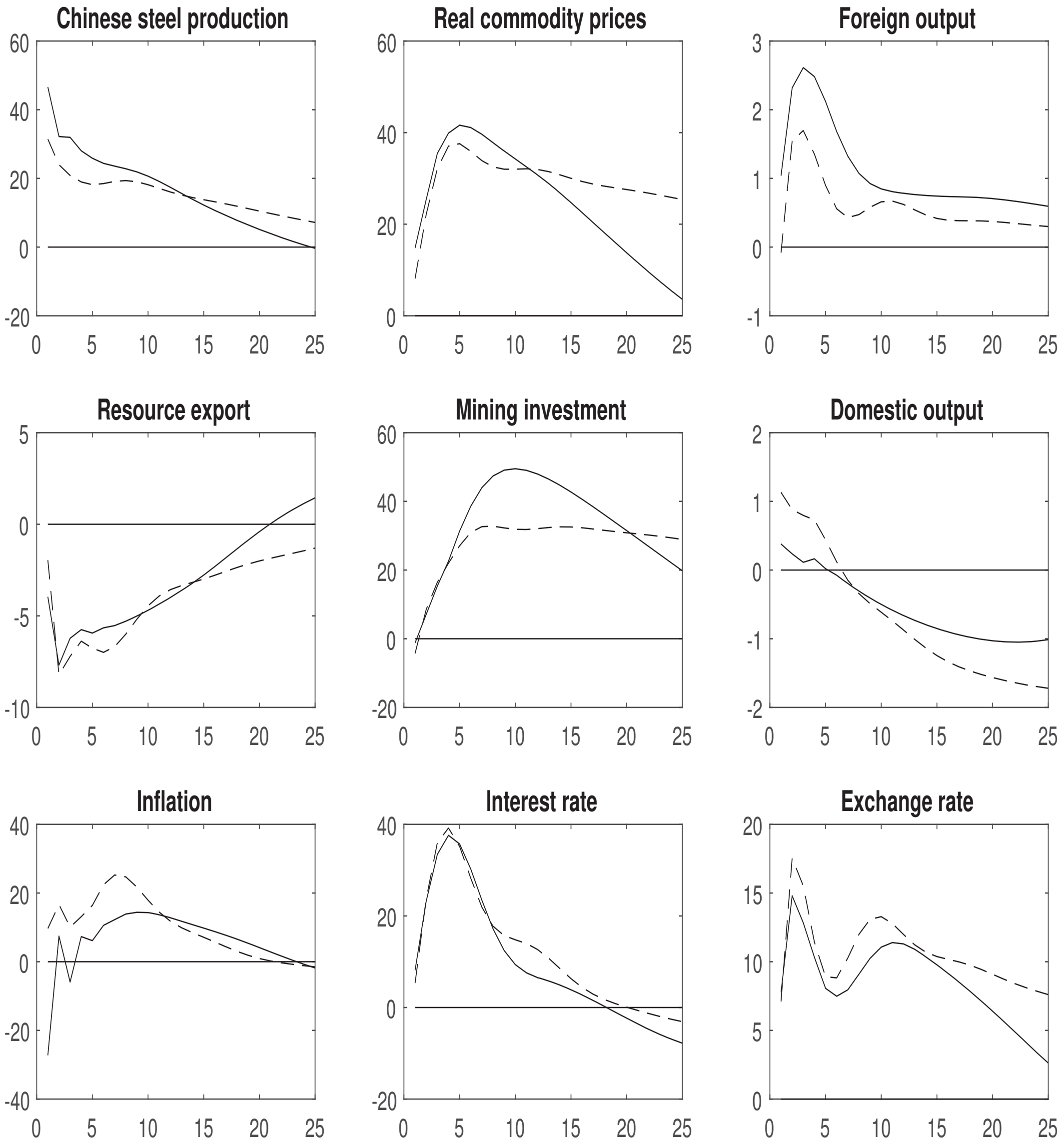

Figure 1: Impulse response functions to shocks to Chinese steel production. The solid line is the 2016 model and the dashed line is the 2011 model. The impulses are scaled by 1000.

3.2 Impulse response functions

This section compares the impulse responses of one standard deviation innovations to the foreign sector of Chinese resource demand (csp_t), commodity prices (pc_t) and foreign output (yw_t) for the 2011 model where the boom peaks and the 2016 model which contains the recovery period. The solid line in the figures correspond to the 2016 model, and the dashed line to the 2011 model. The impulse response functions are presented over 24 quarters or 6 years.

Shock to Chinese resource demand

Comparing the one standard deviation shock to Chinese resource demand (csp_t) over the two sample periods shows that the initial shock is 1.6 times larger for the 2016 model than for the 2011 model (Figure 1). Although the initial shock is larger in the sample containing the recovery period, the later sample Chinese resource demand shock dies out much faster than when the boom is at its peak. After 6 years the 2016 model has returned to baseline, while the 2011 shock shows remarkable persistence.

In line with the 2011 model the shocks to Chinese resource demand in 2016 appear to be commodity demand shocks, as commodity prices received by Australian resource exporters rise (pc_t). The rise in commodity prices peaks five quarters after the shock for both models. However, commodity prices return to baseline much faster in the 2016 recovery period model than in the 2011 model. Real commodity prices are almost at baseline at the end of the six year period, while for the 2011 model the shock takes a long 40 years to die out. The shapes of the impulse response functions of foreign output to Chinese resource demand are quite similar in 2016 compared to 2011, with the difference in the two mainly reflecting the initial size of the shock to Chinese resource demand. If the resource demand shocks are scaled to be the same size (not shown) there is very little difference.

The Chinese resource demand shock initially has an expansionary effect on the Australian economy in both the 2011 and 2016 models in terms of domestic output, although the response is substantially muted in the recovery period even though the initial shock is larger. In both models output declines after approximately seven quarters as factors of production move into the resources sector and out of the non-resources sectors, and as the higher exchange rate leads to a reduction in resource exports despite the higher resource demand. This effect is stronger in the 2011 model, providing evidence of less Dutch Disease during the recovery period. The appreciation of the Australian dollar in response to Chinese resource demand is also more sustained in the 2011 boom period than in the 2016 recovery period, further affecting the non-tradeable sector and hence the recovery of output (Connolly and Orsmond, 2011). The interest rate responds to the initial increase in output by a similar magnitude in both samples. However, the inflation response is quite different in 2016 compared to 2011. In 2011 monetary policy has little effect on inflation, while in the 2016 model it appears to be operating normally, with inflation falling in response to the rise in interest rates. These results confirm the findings in Vespignani (2013) that monetary policy is less effective during commodity booms.

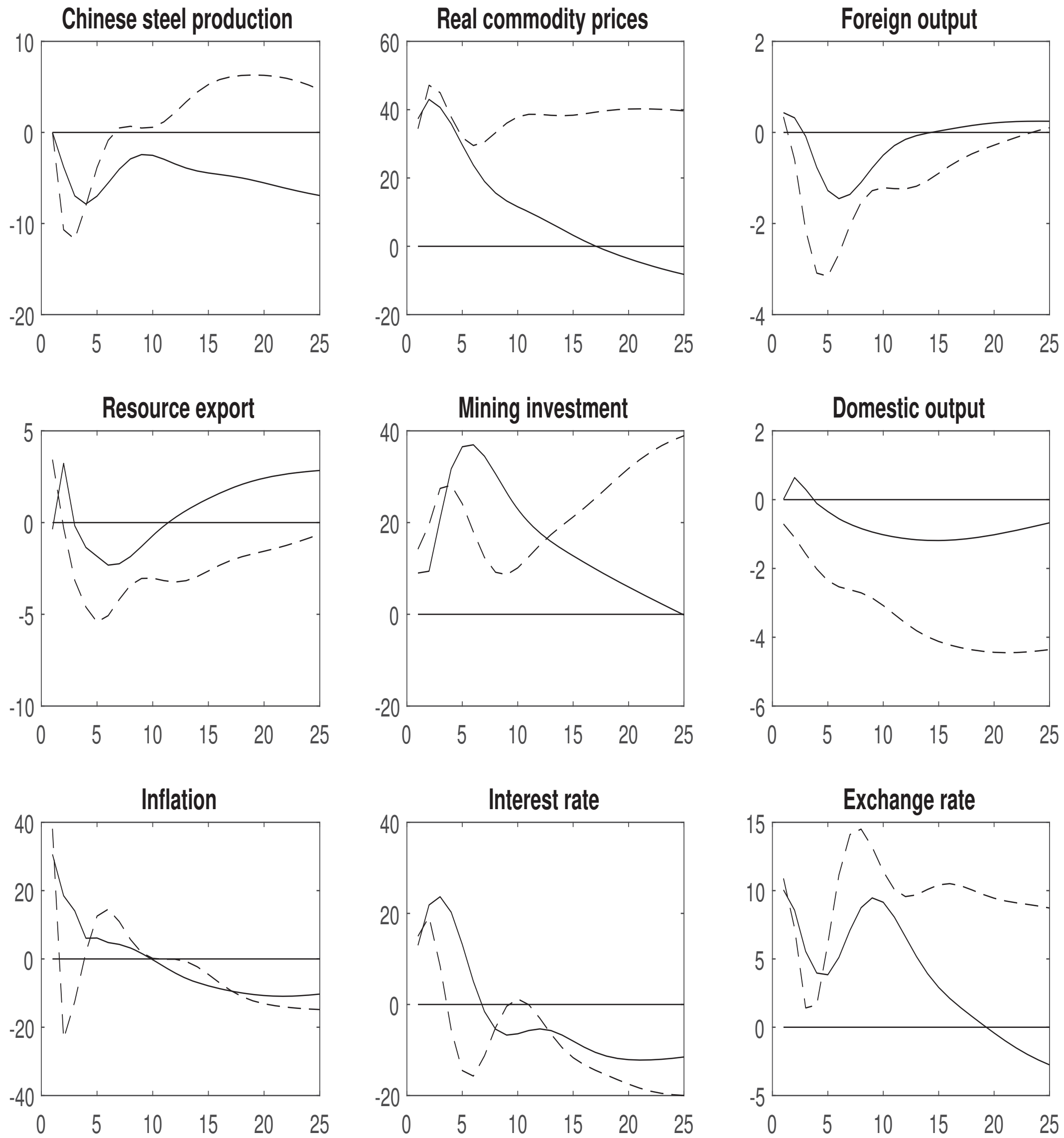

Figure 2: Impulse response functions to shocks to commodity prices. The solid line is the 2016 model and the dashed line is the 2011 model. The impulses are scaled by 1000.

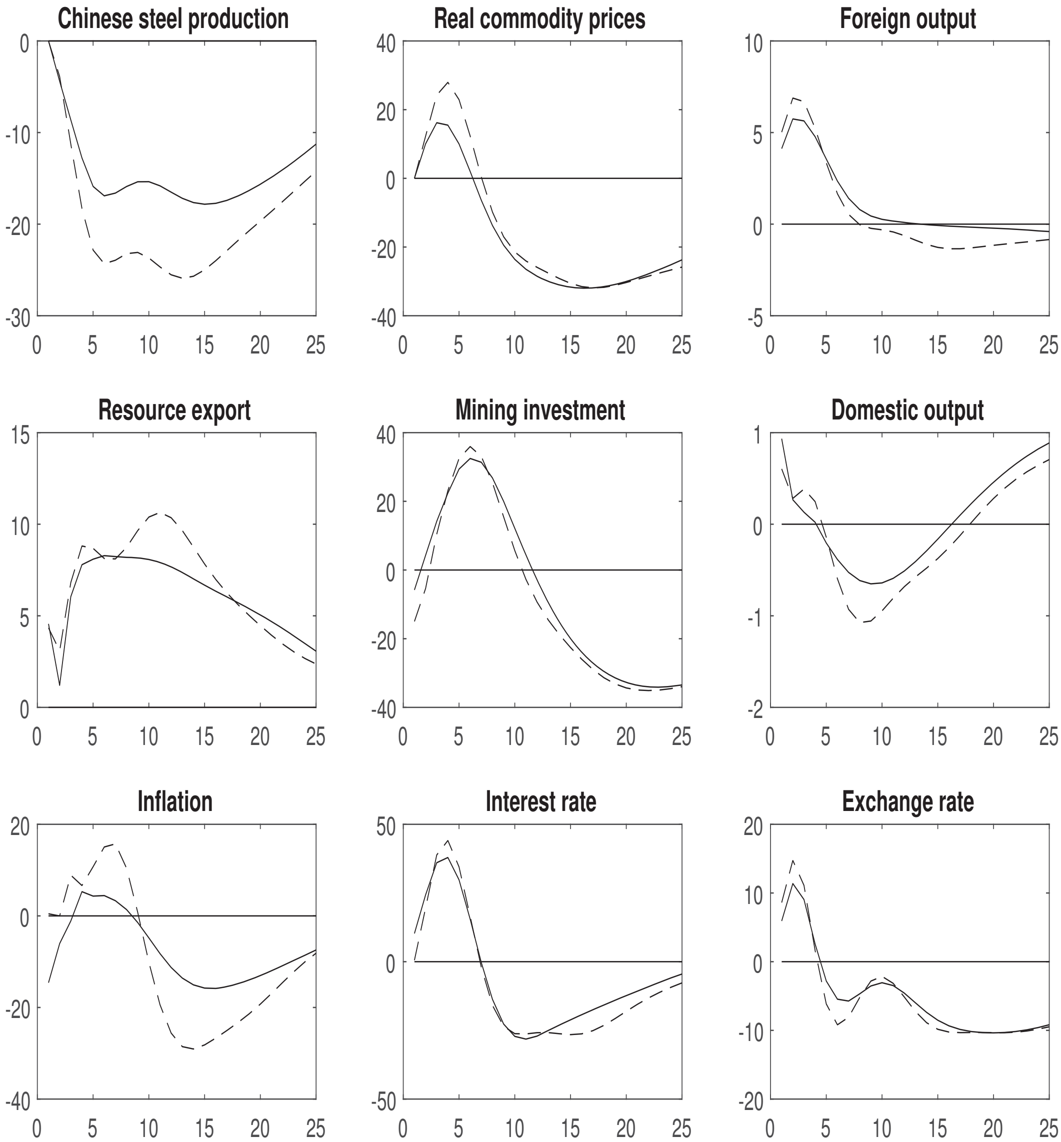

Figure 3: Impulse response functions to shocks to foreign output. The solid line is the 2016 model and the dashed line is the 2011 model. The impulses are scaled by 1000.

Shock to commodity prices

The shocks to commodity prices in the 2011 and 2016 versions of the model are of approximately the same size, but the temporary nature of the shock in 2016 is far more evident. The shocks estimated for the 2016 model die out within a 4 year horizon unlike in 2011 where the shock takes 18 years to return to baseline. The consequence of this is that the crowding out of domestic output is lower in the 2016 model and the domestic currency appreciation is not sustained. A notable aspect is that the higher commodity prices in 2016 result in a reduction of Chinese steel production in line with the expected consequence of higher input prices, rather than exhibiting the effects of the booming Chinese steel demand despite rising prices evident in the medium term in the 2011 model. As a consequence mining investment is sustained only for a short period following the commodity price rise in 2016, as opposed to the sustained rise using the 2011 model.

Shock to foreign output

The shock to foreign output in the 2016 model is slightly higher than the corresponding shock in 2011, and this small difference is reflected in the response of domestic output. However, inflationary effects are lower in the first year and half after the shock, while the interest rate response is virtually identical. This means that there is a stronger real interest rate response in the 2016 sample than in the 2011 period. In the longer horizon, there is still a deflationary impact of the shock as resource demand and domestic output fall below baseline and commodity prices rise above it, but the deflationary impact is muted in 2016 compared to 2011, despite a similar exchange rate response. This is again consistent with the ineffectiveness of monetary policy argument in commodity booms compared to normal periods (Vespignani, 2013).

In general the effects of a foreign output shock on the Australian economy are not importantly different in the 2011 model compared to the 2016 model. This is in contrast to what the models show for the commodity price shocks, whose temporary nature are now more clearly revealed, and the shocks from Chinese resource demand. The changed nature of the Chinese resource demand shocks most clearly demonstrates that the Dutch Disease evident in the Australian economy was being driven by foreign resource demand. The change in the response of domestic output to a Chinese steel production shock between the 2011 and 2016 models is far more profound than the change due to a real commodity price shock (contrast the impulse responses for domestic output in Figures 2 and 3). This result aligns with that of both the theory in Corden (1984) and the more recent paper by Bjørnland and Thorsrud (2016) that where demand (rather than prices) is the root cause of the boom, the effects are less likely to cause long-term damage in the form of Dutch Disease.

3.3 Variance decompositions

Table 1 presents the variance decomposition of the variables in the model from the 2011 dataset reported in Dungey et al. (2014) and the corresponding decompositions for the updated data set to 2016. An analysis of the estimated VAR residuals show that they empirically conform to the assumption of independent shocks[6]. The decompositions show the percentage contributions of each shock to the variance of the observed variable for forecast horizons of 1, 4, 12 and 24 quarters ahead. Table 1 presents the results for the external sector variables, while Table 2 presents the results for the domestic variables.

[6]The largest empirical correlation is 0.21 and they are all statistically insignificant at the 1% level.

Table 1: Forecast error variance decomposition of the external variables in per cent

		2011				2016			
Variable	Shock	1	4	12	24	1	4	12	24
csp_t	csp_t	100.00	57.87	36.49	26.81	100.00	88.53	70.79	46.39
	pc_t	0.00	7.76	2.47	2.90	0.00	2.07	1.90	2.74
	yw_t	0.00	11.69	36.82	42.53	0.00	4.11	19.96	26.40
	$resx_t$	0.00	5.81	3.82	3.73	0.00	1.31	0.76	0.68
	$mininv_t$	0.00	1.64	0.92	1.90	0.00	1.68	1.09	0.83
	yd_t	0.00	0.19	0.28	6.79	0.00	0.01	2.02	19.49
	pd_t	0.00	14.70	15.08	10.17	0.00	0.96	2.35	1.87
	rd_t	0.00	0.04	2.68	1.89	0.00	1.03	0.52	1.10
	q_t	0.00	0.29	1.45	3.29	0.00	0.30	0.61	0.51
pc_t	csp_t	5.26	22.92	27.13	22.51	13.58	31.15	42.10	29.13
	pc_t	94.74	53.11	37.41	36.57	86.42	58.41	31.55	17.67
	yw_t	0.00	11.75	9.73	15.48	0.00	4.43	11.71	25.53
	$resx_t$	0.00	1.53	4.26	2.84	0.00	0.06	0.26	0.41
	$mininv_t$	0.00	0.20	0.49	1.16	0.00	0.86	1.03	0.81
	yd_t	0.00	0.20	0.13	0.45	0.00	0.27	2.13	16.26
	pd_t	0.00	5.66	16.86	12.80	0.00	1.85	9.05	7.59
	rd_t	0.00	1.76	0.96	0.71	0.00	0.67	0.48	1.11
	q_t	0.00	2.87	3.03	7.48	0.00	2.30	1.70	1.48
yw_t	csp_t	0.03	3.95	3.78	3.94	5.91	27.60	15.01	15.76
	pc_t	0.46	8.14	16.42	16.00	1.03	1.37	4.16	3.81
	yw_t	99.51	80.61	59.07	57.18	93.05	153.12	58.73	51.80
	$resx_t$	0.00	1.39	2.30	2.05	0.00	5.52	6.34	5.63
	$mininv_t$	0.00	0.48	0.79	1.42	0.00	0.82	0.96	1.53
	yd_t	0.00	0.04	1.97	3.98	0.00	0.30	7.15	13.63
	pd_t	0.00	3.15	6.80	6.30	0.00	4.15	0.68	0.60
	rd_t	0.00	2.06	2.55	3.19	0.00	5.90	5.48	5.32
	q_t	0.00	0.18	6.31	5.93	0.00	1.24	1.50	1.90
$resx_t$	csp_t	0.30	7.74	11.32	10.56	1.43	8.35	11.68	8.88
	pc_t	0.93	2.02	4.54	4.71	0.01	0.77	1.27	2.14
	yw_t	1.49	7.18	23.43	28.30	1.90	8.26	22.02	23.65
	$resx_t$	97.28	66.03	40.54	32.70	96.66	76.52	46.73	32.22
	$mininv_t$	0.00	0.98	1.15	2.62	0.00	0.20	0.27	0.47
	yd_t	0.00	5.27	8.36	10.66	0.00	2.45	11.26	25.85
	pd_t	0.00	6.47	6.70	5.67	0.00	0.29	1.86	2.06
	rd_t	0.00	1.08	1.46	1.22	0.00	1.47	3.68	3.75
	q_t	0.00	3.23	2.51	3.57	0.00	1.69	1.23	0.97

The external sector decomposition given in Table 1 illustrates how macroeconomic environment have altered between 2011 and 2016. In 2011 the largest determinants of the Chinese steel production shocks were world demand beyond the 3 month horizon, but in 2016 the own shock effects are dominant, remaining at almost half of the variance decomposition by the 6 year horizon. This points to the reduced demand pressures on Chinese steel production during the post-boom years. At the same time the effect of shocks to Australian output also affects the forecast error variance decomposition of Chinese steel production by almost 20 percent at the 2

Table 2: Forecast error variance decomposition of the domestic variables in per cent

		2011				2016			
Variable	Shock	1	4	12	24	1	4	12	24
$mininv_t$	csp_t	0.23	3.56	16.77	20.25	0.02	3.74	28.50	32.99
	pc_t	2.57	8.98	7.33	13.79	1.35	8.97	18.74	13.14
	$usip_t$	2.86	3.78	10.22	15.85	0.56	4.11	9.28	18.42
	$resx_t$	0.10	0.86	1.06	1.20	0.80	1.09	0.94	1.02
	$mininv_t$	94.24	78.21	39.61	20.49	97.26	79.10	31.73	20.28
	yd_t	0.00	0.48	4.45	4.88	0.00	1.71	1.46	2.58
	pd_t	0.00	3.95	18.40	16.38	0.00	0.57	7.43	8.65
	rd_t	0.00	0.13	2.04	3.23	0.00	0.14	0.52	0.41
	q_t	0.00	0.04	0.12	3.93	0.00	0.57	1.40	2.51
yd_t	csp_t	3.31	2.11	1.31	4.23	0.50	0.13	0.65	3.36
	pc_t	1.29	5.39	18.17	40.48	0.00	0.46	1.99	5.11
	yw_t	0.94	0.43	1.47	1.12	3.02	0.84	0.59	1.29
	$resx_t$	1.32	6.40	4.36	2.76	2.21	2.09	1.72	1.41
	$mininv_t$	0.00	3.15	5.58	3.61	0.17	3.34	4.78	5.36
	yd_t	93.14	81.08	58.78	34.96	94.11	90.05	79.51	71.60
	pd_t	0.00	0.04	0.15	1.76	0.00	0.76	1.56	1.51
	rd_t	0.00	0.92	4.36	2.89	0.00	0.95	4.89	5.68
	q_t	0.00	0.50	5.82	8.19	0.00	1.38	4.32	4.69
pd_t	csp_t	0.27	1.37	4.77	4.40	0.13	1.65	3.81	3.89
	pc_t	4.12	4.59	3.37	4.41	0.99	1.10	0.80	1.90
	yw_t	0.00	0.26	2.45	8.46	0.03	0.13	0.30	2.10
	$resx_t$	0.00	3.60	8.28	7.31	0.02	7.63	14.41	12.71
	$mininv_t$	0.00	1.66	1.86	2.96	1.61	1.34	1.11	1.15
	yd_t	0.02	6.64	25.08	24.06	2.37	1.80	10.19	14.60
	pd_t	95.59	77.07	46.77	40.55	94.84	84.81	62.66	54.86
	rd_t	0.00	3.90	4.70	5.17	0.00	1.07	1.87	3.46
	q_t	0.00	0.91	2.73	2.68	0.00	0.48	4.85	5.33
rd_t	csp_t	1.21	14.86	11.75	9.84	1.98	14.71	12.95	9.87
	pc_t	9.57	3.03	2.19	5.71	9.73	9.42	4.37	5.66
	yw_t	0.01	16.66	13.55	18.02	0.16	9.07	11.07	12.13
	$resx_t$	0.04	4.48	11.01	9.12	0.12	3.41	7.54	6.46
	$mininv_t$	0.25	0.12	1.53	3.05	0.03	0.91	0.92	1.41
	yd_t	3.67	8.88	31.23	29.37	4.51	12.40	33.06	38.83
	pd_t	6.48	4.07	4.96	4.33	0.17	0.04	4.91	1.47
	rd_t	78.77	45.48	20.44	17.58	83.30	47.86	23.73	20.66
	q_t	0.00	2.43	3.34	2.97	0.00	2.19	3.01	3.51
q_t	csp_t	3.96	15.52	19.78	20.46	5.06	15.37	21.64	19.86
	pc_t	9.34	3.74	13.74	16.88	9.87	7.17	13.47	9.23
	yw_t	5.83	8.88	7.53	13.14	1.23	5.53	7.21	16.05
	$resx_t$	0.10	4.85	4.71	4.31	0.22	2.68	2.17	1.38
	$mininv_t$	1.04	4.14	7.15	6.41	0.23	2.75	4.40	2.72
	yd_t	0.28	1.49	3.49	4.02	0.33	1.12	6.06	18.62
	pd_t	0.88	5.09	10.83	11.55	0.00	0.40	1.75	4.33
	rd_t	5.41	2.39	2.33	1.51	11.54	5.91	5.54	4.53
	q_t	73.17	53.90	30.44	21.73	71.51	59.06	37.77	23.28

year horizon during 2016 whereas this was less than 7 percent in the 2011 scenario. This points to the emergence of more normal supply and demand side pressures interacting to determine steel production. Commodity prices have also settled to be less determined by their own shocks - suggesting that any tendencies to bubble have been diminished[7]. Australian exports are more determined by Australian output conditions in 2016 than in the 2011 results, with one-quarter of the forecast error variance decomposition at the 2 year horizon due to domestic demand shocks.

The changes between the 2011 and 2016 models are also evident in Table 2 which decomposes the forecast error variance for the domestic variables. Mining investment has been a significant drag on GDP growth in the post-boom period, Kent (2017). However, 2016 results show it is no longer relying to the same extent on domestic conditions. This is partial evidence to support reduced Dutch Disease, although in the case of forecast error variance decompositions this effect is not explicitly signed.

The effects of the falling mining investment on GDP are evident in the increased effect of mining investment on domestic output at longer horizons, although that seems to be easing at shorter horizons; see also Kent (2017). Domestic output is far more dependent on own shocks in the 2016 model at over 70 percent, compared with a contribution of approximately half of that in 2011. In 2011, a substantial 40 percent of the domestic output decomposition was due to commodity prices, and by 2016 this has reduced to only 5 percent. This dramatic change is part of the narrative of recovery of the Australian economy from Dutch Disease.

The falling influence of commodity prices on domestic inflation is also evident in the decompositions, although it is not on the same scale as for output. There also appears to have been a considerable easing of domestic output pressure on inflation between 2011 and 2016, although exchange rate contributions have increased slightly. Interest rate decompositions have responded accordingly, responding more to own shocks and domestic demand conditions in 2016 than 2011.

3.4 Analysis of GHD results

The previous sections highlighted how the Australian economy seems to have recovered from Dutch Disease evident in Dungey et al. (2014) based on data up to the peak of the commodity price boom in 2011. We turn now to the new tool of the GHD to examine the empirical steady-state gap for the domestic economy and the contributions of foreign and domestic shocks to its evolution over the sample period including the extended sample period up to 2016.

The empirical steady-state gap for the domestic economy represents the difference between the projection of the model for the domestic variables considered jointly and the cumulative impact of the unanticipated shocks captured by the model. Figure 4 shows the empirical steady-state spillover gap for the Australian economy sector of the model, formally including all of the spillovers from the Australian based components of the model

[7]Phillips et al. (2015) use these self-exciting type characteristics to detect bubbles

$$SSG_t^{dom} = \sum_{i,j=5,j\neq i}^{9} GHD_{t,ij}, \qquad (9)$$

as well as from all of the spillovers from the international components of the model

$$SSG_t^{int} = \sum_{i=1}^{4}\sum_{j=5}^{9} GHD_{t,ij}. \qquad (10)$$

The line corresponding to the zero axis represents the empirical steady-state. The large dashed line represents the contribution of the domestic sector spillover shocks to the steady-state spillover gap over the sample period. The dotted line represents the empirical steady-state spillover gap from the international shocks. The solid line gives the combination of these two gaps. Reading these gaps is not the same as, for example, an output-gap analysis. The deviation from steady-state at any point represents the cumulation of the shocks over the immediate past acting on the economy. Take for example, the total empirical steady-state gap from mid-2006 onwards. After this point until approximately 2008 the overall empirical steady-state gap from both sources is positive and rising. This means that the conditions in the economy are acting in a way which places the economy above the empirical steady-state. A reasonable interpretation is that from mid-2006 onwards there were sufficient positive shocks, with positive impact on the economy, to produce an overall positive gap. Note that as this gap rises it indicates a preponderance of shocks moving in the same direction. At each point in time previous shocks continue to influence the steady-stage gap, but with generally decreasing weight, as revealed by the weightings matrices.[8] This combination of the impulse response function weights and the sizes of the estimated shocks gives the path of the empirical steady-state gaps. When the empirical steady-state gaps peak, for example as in 2008 and 2012 for the total gap in Figure 4, this indicates that negative shocks are beginning to dominate the impact of former shocks. The empirical steady-state gaps, then, cannot be read off as simple measures of how much deviation a shock at time t has caused from equilibrium. Instead, it is a measure of the cumulative influence of shocks and the response of the economy to those shocks in returning towards the empirical steady-state equilibrium. As a consequence we are able to observe the periods of sustained positive empirical steady-state gap shown in the diagram. There is no constraint requiring the empirical steady-state gap to balance out over the sample period.

[8]Recall these are impulse response functions as shown in (6), and as each of these converge back to zero over time, as in Figures 1-3, the weight on past shocks decreases after approximately 2 years.

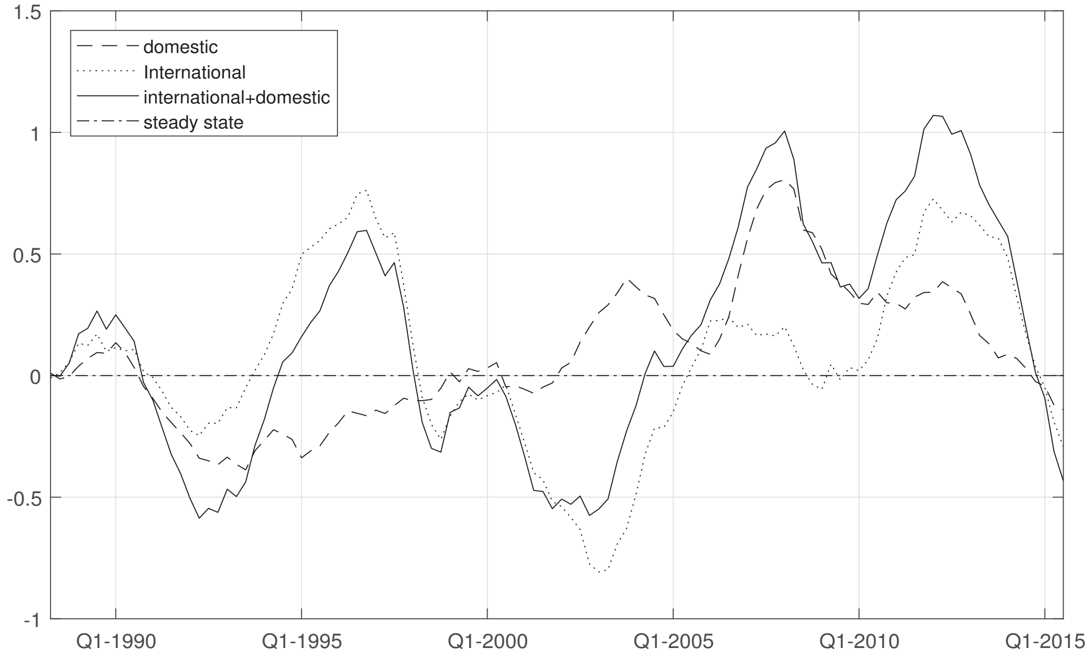

Figure 4: Empirical steady-state gap for the Australian economy, 1998Q1 to 2016Q1. Contribution of domestic and international spillover shocks.

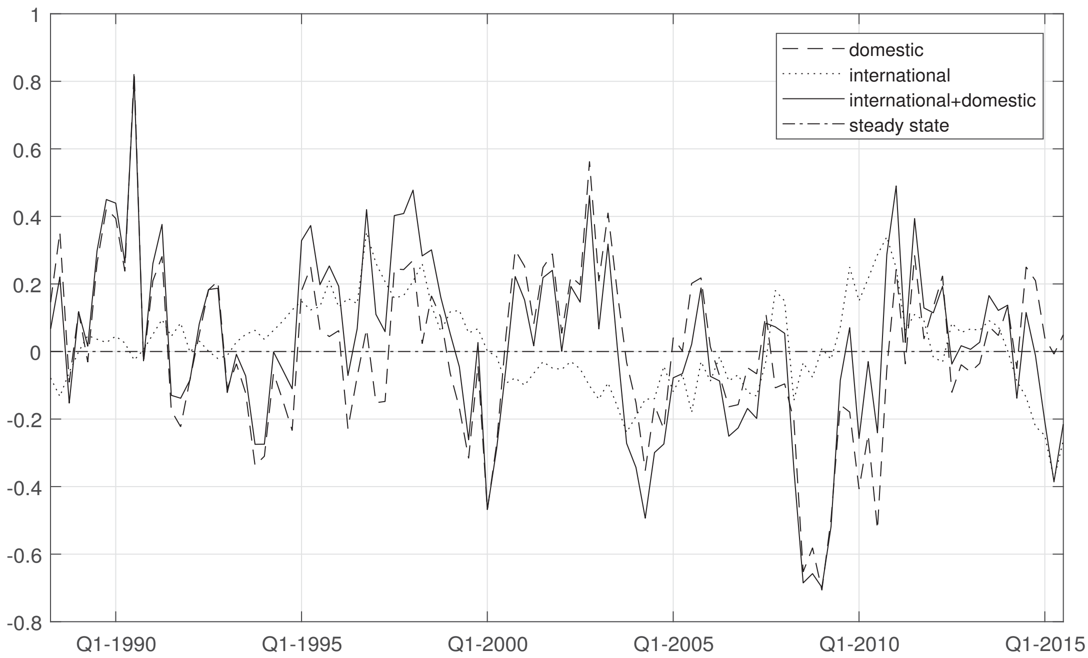

Figure 5: Empirical steady-state gap for the Australian economy, 1998Q1 to 2016Q1. Contribution of own shocks.

At the end of the sample, there is a remarkable convergence of the total, international and domestic empirical steady-state spillover gaps to the empirical steady-state pathway, indicating that the economy has returned to that which could be expected, given historical data.[9] The figure illustrates that the empirical steady-state spillover gaps for both international and domestic sources were zero in mid-2015. (A period of zero empirical spillover gaps is also evident in the early 1990s. However, we do not pay too much attention to the early part of the sample due to the likely larger effects of initial conditions as shown in equation (4).

Figure 4 shows that in addition to 2015, other periods in the sample are also at the empirical steady-state, most notably in mid-2004. However, in these earlier episode, the contributions of empirical steady-state spillovers from domestic and international shocks are offsetting. The change to an overall negative empirical steady-state gap after mid-1997 corresponds to the change in contribution of international sourced shocks from generally positive to negative - reflecting the impact of the East Asian crisis of 1997-98 on the trade relationships of the Australian economy. During this period both the international and domestic empirical steady-state gap were negative. The Australian economy officially experienced a recession in the early 1990s, with recovery dating from around 1994. Despite improvements in labour productivity there was considerable concern that the productivity improvements may be a once-off result of the structural reforms in the 1980s, Bean (2000), and a reliance on 'old economy' production. The "new economy" involved information technology based industry, burgeoning in the US at the time; Gruen and Stevens (2000) present the arguments of the time. The burst of the dot-com bubble in 2000 effectively resolved the arguments in favour of a less tech-led growth strategy.

In the later part of the sample the international and domestic spillover gaps are generally both positive compared with earlier periods where there was often considerable offset of the two sources. This means that the shocks spilling over to the domestic economy from both sources are acting to widen the gap between the steady-state and the observed outcomes. Post-2012, the empirical steady-state spillover gap from both sources declines, indicating that the system is reverting towards its projected empirical steady-state.

Figure 5 illustrates the own-shock contributions SSG_t^{own} described by equation (8) for international, $i = 1, ..., 4$, and domestic variables, $i = 5, ..., 9$, to the Australian economy empirical steady-state gap. Again, the large dashed line represents the domestic sector own shock contributions to the empirical steady-state spillover gap over the sample period. The dotted line represents the international sector (csp, pc, yw, and $resx$) own shock contributions to the empirical steady-state spillover gap from the international shocks. The solid line gives the combination of these two gaps. The empirical steady-state gaps from own shocks are clearly more volatile than from spillovers as shown in Figure 4, although the magnitudes are similar to those from spillovers.

The GHD decomposition allows us to have a clearer understanding of how the Dutch Disease evident for Australia in Dungey et al. (2014) and Bjørnland and Thorsrud (2016) is being cured

[9]Note that this is not a conditional statement, we fully recognize that this is a retrospective analysis of the development of past economic events and depends on an unconditional estimate of the empirical steady-state.

by the normal interactions of the economic forces driving the Australian economy.

4 Conclusion

The existing literature documents the existence and prevention of Dutch Disease for resource intensive exporting economies. Less attention has been paid to the evidence for recovery from Dutch Disease conditions. This paper examines the path of the Australian economy in the aftermath of the commodity price boom of 2003-2012, which manifested in a booming Australian mining sector. We show that consistent with theory, Dutch Disease can be overcome when the main contributor to the booming sector is sourced from external demand (here Chinese steel production), and the booming sector is a relatively high value but low employment part of the economy.

Our empirical modeling shows how the responses of economic variables in the Australian economy to economic shocks have returned to what we would usually expect, consistent with the rhetoric of the Central Bank (see Kent (2017) for example). Impulse responses and forecast error variance decompositions illustrate how the evidence for Dutch Disease present at the height of the boom is mitigated in the subsequent periods. In particular, the results show that shocks during a commodities boom appear to be long lived in comparison to the recovery periods.

To support these arguments we introduce a new tool for VAR modeling, the Generalized Historical Decomposition, which allows us to assess the extent to which the observed outcomes in the system have deviated from the empirical representation of steady-state. We dubbed these deviations as empirical steady-state gaps and were able to determine the contribution of domestic and international sourced shocks to driving the economy away from its empirical steady-state. This representation showed that positive empirical steady-state gaps from both the domestic and international sources existed during the period of the mining boom, but were both resolved during 2015.

One contention about the relatively benign recovery of the Australian economy from Dutch Disease is that it may be at least partly due to increased wage flexibility in the economy compared with previous periods, allowing both the boom conditions to be relatively isolated into the booming sector (and aligning wage growth with sector specific productivity), and for faster adjustment of wages to falling profitability in mining post-boom. This hypothesis cannot be directly addressed using the framework of this model but is left for future examination.

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Appendix A: Data descriptions and sources

Variable	Code	Description and source
Chinese steel production	*csp*	seasonally adjusted Datastream, code CHVALSTLH
Commodity prices	*pc*	index of commodity prices in US dollars Reserve Bank of Australia, Statistical Table G5 deflated by the US CPI for all urban consumers: all items Bureau of Labor Statistics
Foreign output	*yw*	export-weighted real GDP of Australia's major trading partners seasonally adjusted Reserve Bank of Australia provided
Aust resource exports	*resx*	sum of the value of exports of metal ores and minerals, coal, coke and briquettes, other mineral fuels, metals (excluding non-monetary gold) and non-monetary gold, chain volume measure, 2009-10 prices seasonally adjusted Australian Bureau of Statistics, Cat. No. 5302.0
Mining investment	*mininv*	mining private new capital expenditure, chain volume measure, 2009-10 prices seasonally adjusted Australian Bureau of Statistics Cat. No. 5625.0
Domestic output	*yd*	chain volume measure of non-farm gross domestic product seasonally adjusted Australian Bureau of Statistics Cat. No 5206.0
Inflation	*pd*	trimmed-mean consumer price index, 1989/90 = 100, excluding interest charges, adjusted for the tax changes of 1999–2000 Reserve Bank of Australia provided
Cash rate	*rd*	quarterly average of the target cash rate Reserve Bank of Australia Statistical Table F1
Exchange rate	*q*	real trade-weighted index Reserve Bank of Australia Statistical Table F15