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Quantifying Australia's "Three Speed" Boom

CAMA Working Paper 10/2013
February 2013 – revised February 2014

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We examine Australia's terms of trade boom since 2003 with a particular interest in quantifying the links between the terms of trade and sectoral performance, conjecturing that a „secondary services boom“ is primarily responsible for the widespread nature of the associated gains in employment. Elemental general equilibrium modelling is employed as numerical theory, to construct hypotheses for empirical assessment. The theory suggests a services expansion of sufficient scale to tighten the labour market but it indicates associated “de-industrialisation”. The empirical analysis addresses these hypotheses using vector auto-regressions estimated from pre-boom Australian data (1989 through 2002) and out-of-sample simulations over the subsequent boom period. The secondary services boom appears clearly in both income and employment, though the effects on manufacturing are ambiguous, with observed performance better than predicted by the numerical theory or the estimated VARs. This suggests that the recent boom accompanied changes in industrial structure and behaviour that favoured surviving manufacturing firms.

Keywords

resources boom, Dutch disease, general equilibrium, mining, secondary services boom, two-speed boom

JEL Classification

F41, C32, C53, C68, E17, F47

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* The research toward this paper is funded via a Discovery Grants from the Australian Research Council: DP1094835 Commodity Booms and Busts – Implications for Economic Performance. Thanks are due to Ken Clements for his support and valuable discussions and to Juerg Weber for comments on the first draft. Discussions on the topic of the paper with Bob Gregory and Max Corden were influential and much appreciated. Finally, very detailed and constructive comments from Peter Dixon are especially appreciated.

** Views expressed are those of the authors alone and in no way represent those of their respective institutions.

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Abstract

We examine Australia's terms of trade boom since 2003 with a particular interest in quantifying the links between the terms of trade and sectoral performance, conjecturing that a 'secondary services boom' is primarily responsible for the widespread nature of the associated gains in employment. Elemental general equilibrium modelling is employed as numerical theory, to construct hypotheses for empirical assessment. The theory suggests a services expansion of sufficient scale to tighten the labour market but it indicates associated "de-industrialisation". The empirical analysis addresses these hypotheses using vector auto-regressions estimated from pre-boom Australian data (1989 through 2002) and out-of-sample simulations over the subsequent boom period. The secondary services boom appears clearly in both income and employment, though the effects on manufacturing are ambiguous, with observed performance better than predicted by the numerical theory or the estimated VARs. This suggests that the recent boom accompanied changes in industrial structure and behaviour that favoured surviving manufacturing firms.

I Introduction

The remarkable increase in Australia's terms of trade since 2003 led to a significant boom in employment and investment in the resource sector and a rise in the income derived from it.¹ Recently, but also over the past three decades, manufacturing has experienced a declining share of total gross value added (GVA), a decline in total employment and a comparatively slow rate of real wage growth. Over the corresponding three decades the opposite has been true of services and this trend has strengthened in the boom period. During the booms incline (2003 to end-2011), services real gross value added in services (GVA) increased by 43 per cent. As of end-2012, services had created 2.2 million additional jobs since the turn of the century.²

Although there were prominent external shocks to the Australian economy in the boom period since 2003,³ the public discourse was consistent with the spirit of the Dutch Disease literature,⁴ anticipating "de-industrialisation", with the favoured term in the popular press being 'the two-speed economy'. Porter (2011), for example, describes a 'fast' and a 'slow'

¹ Gregory (2012) classifies these developments into three distinct stages, the first surrounding the terms of trade rise, the second covering the resulting investment boom and a third stage in which real returns to the mining sector rise as export volume increases though its domestic factor demands moderate.

² ABS 2012a; ABS 2012d; ABS 2012e.

³ These include the "great recession" and the expanded role of governments in international financial markets since that have caused significant changes in global borrowing rates and real exchange rate realignments.

⁴ Although its emphasis is on resource discovery rather than terms of trade or investment shocks, the core of the Dutch Disease literature comprises Gregory (1976), Corden and Neary (1982), Corden (1984) and Cassing and Warr (1985).

lane, referring to the mining sector on the one hand and manufacturing on the other. Even though Corden's own work on the Dutch Disease did identify the possibility of a secondary services boom (Corden 1984: 361-362; Corden and Neary 1982: 830-831)⁵ it has been rarely recognised in public debate, at least until recently, when Corden (2012) highlighted it and adopted the 'three-speed economy' phrase.

This paper focusses on the links between Dutch disease shocks and sectoral performance. In particular, conjectures that the observed strong performance of the services sector during the boom, in terms of both income and employment, has been a direct consequence of the boom. To approach this question, we first construct testable conjectures from numerical theory, for which we construct a simple economy-wide comparative static model in the Dutch disease tradition. These conjectures apply to the sectoral income and employment as well as overall performance implications of the full set of boom shocks, namely the rises in export commodity prices, investment and newly-accessible resource endowments. The conjectures are then approached empirically, by examining the paths of key variables prior to and since 2003 using vector auto-regression. The boom shocks are thus linked to the coincidental changes in services and manufacturing performance.

Section II offers a brief review of the relevant theory and an analysis of the current Australian resource boom. In Section III, comparative static modelling of boom shocks is undertaken to examine any 'three-speed' effects in output and employment. Section IV then outlines the data and econometric methods used to assess the links between boom shocks and sectoral performance. Section V then concludes.

II Dutch Disease Theory and the Australian Context

Boom signatures are clear from the core theory. They involve the expansion of a resource-intensive sector, the (at least) relative contraction of a lagging sector and a real appreciation. Briefly consider the Corden-Neary (1982) three-sector model. It has a booming sector (B), a lagging sector (L) and a non-tradeable sector (N). Sectors B and L produce traded goods, with prices determined exogenously in world markets. Output is determined by labour and a sector-specific fixed factor, resources or capital. Labour is mobile between the three sectors,

⁵Cassing and Warr (1985: 317) also identified the critical role played by the non-traded sector and the gains that could accrue therefrom.

equalising the wage rate W . Fixed factor rents in the three sectors are R_B , R_L , and R_N . All goods produced are for final consumption. There is an exogenous technological improvement in B , due, say, to a rise in capital investment or the discovery of new resources specific to B . Two effects are given prominence. First, the higher incomes of the resource owners must be disposed of, creating a *spending effect*. Assuming a positive marginal propensity to consume for N , demand for it rises.⁶ Since traded goods prices are constrained by free trade, the relative price of N rises and so there is a *real appreciation*.⁷ Increased demand for B and N causes the second effect, the *resource movement effect*, whereby labour market arbitrage requires redistribution in favour of these sectors and against L .

The term *de-industrialisation* is usually applied to the movement of labour away from L . The movement of labour from L to B is called *direct de-industrialisation*, as it lowers output in L without involving the market for N or the real exchange rate. The indirect counterpart of this movement starts with labour being drawn from N to B but the net flow then depends on the resulting excess demand for N this creates and hence the resulting real appreciation. The result is some moderation of the flow to B and some additional flow from L , which is referred to as *indirect de-industrialisation*. While it is unambiguous that a resource boom leads to a contraction in output in the lagging sector, the overall effect on the non-traded sector is more ambiguous. The spending effect tends to increase output of N , whilst the resource movement effect tends to reduce its output. The relative magnitudes are best examined numerically, due to the many contributing factors.⁸

Australian booms

As a commodity exporter, the Australian economy faces a volatile terms of trade and progresses between commodity booms and busts. It has therefore been forced to cope repeatedly with structural adjustments associated with the resource movement effects and de-industrialisation. Battellino (2010) reviews the five major mining booms in Australia since the 1850's: the gold rush, the late 19th century mineral boom, the 1960's to early 1970's minerals and energy boom, the late 1970's to early 1980's energy boom and the current minerals and energy boom, defining booms as periods involving significant increases in

⁶ See Corden (1984: 361-362) footnotes for explanation of when the spending effect may actually be negative.

⁷ The price of all home production rises relative to that of a corresponding bundle of foreign products.

⁸ Assumptions regarding capital-intensities, the distribution of ownership, marginal propensities to consume, resource mobility, the number of industries within sectors, demand elasticities, immigration, protection and more all influence the overall effects, particularly for the non-traded sector (Corden 1984; Corden & Neary 1982; Gregory 1976).

mining investment or output, or both. The 1850's gold rush involved mainly surface alluvial mining for gold, requiring very little capital. As a result this boom saw very little increase in investment. Labour, however, flowed strongly towards the booming gold sector from other states as well as through immigration. The increased income, as well as demand from immigration, led to significant spending effects on domestic services. These spending and resource movement effects meant that real wage increases across industries were strong. With a fixed nominal exchange rate, the real appreciation had to come from inflation, amounting to 50 per cent by the peak of the boom. Non-mining industries struggled to retain labour and deal with higher costs and real exchange rates, the wool industry being a noted example. However, the overall impact of the boom on economic activity was positive, and GDP growth remained high for a decade after its peak.

The late 19th century boom arose from the discovery of new metal resources in Western Australia, Queensland and western New South Wales. At the time, high unemployment and ample capital ensured that wage pressures were not as severe during this episode, and that the real appreciation was modest. There was strong labour migration towards the booming sectors, however, and tariffs were introduced to protect the lagging sector (manufacturing). In the 20th century, the 1960's to early 1970's minerals and energy boom was characterised mainly by increased coal and iron ore mining activity, and oil and bauxite discoveries. The global and domestic backdrop was one of strong activity with rising relative prices of commodities. The capital intensity of mining activity was much higher than in previous booms, due to technological improvements and capital market development, leading to a significant rise in mining investment. Large scale immigration and increased female labour force participation facilitated the resource movement effect but did not prevent widespread real wage increases.

The late 1970's to early 1980's boom was driven mainly by the energy sector, after the (Iranian) "second oil price shock". A pick-up in mining investment re-invigorated wage demands which, because further expansion was anticipated, were not met with strong resistance from government or employers. This boom was analysed thoroughly by Dixon et al. (1978), using the then state-of-the-art ORANI model. Importantly, they found a dominant secondary services boom, concluding that "the main beneficiaries in the mining boom experiment are the producers of non-traded goods, services and construction".

This boom was short-lived, however, collapsing into a deep recession as the Reagan administration's tax cuts (not accommodated by the US Fed) drove up interest rates and drew savings away from private investment around the world. A key lesson from this experience is that expectations about the duration of the boom matter, and that wage cost increases and productivity slowdowns that have occurred during the most recent boom leave the economy vulnerable should it turn into a bust (Australian Productivity Commission 2008: 6-7, Connolly and Orsmond 2011: 34-35), or even taper off into a period of negative shocks (Gregory and Sheehan 2013). It is particularly important this time because the recent boom is a monster, involving all three boom shocks simultaneously: a large increase in the terms of trade, a surge in investment and an expansion in accessible natural resources. It is primarily the result of rapid economic growth in emerging economies, which accounted for over 50 per cent of global energy consumption in 2010, and particularly spectacular growth in China (Connolly and Orsmond 2011:8).

The China boom

The historically high levels of Australia's terms of trade and real trade-weighted exchange rate associated with the recent boom are illustrated in Figure 1. Departing from previous experience, which has seen little nominal exchange rate adjustment and high domestic inflation, the RBA was this time effective in maintaining a stable home price level and allowing the nominal exchange rate to appreciate.⁹ The investment component of the boom, and the consequent GDP growth it engendered, are illustrated in Figure 2.

There have been significant resource movement effects in response to short run wage disparities. Growth in mining wages has been the strongest, averaging 4.2 per cent per annum. Construction wages have risen almost as strongly as mining wages, averaging 4.1 per cent per annum while wage growth in manufacturing has been slower at around 3.5 per cent annually, below the national average of 3.65 per cent (ABS 2012e).¹⁰ In response, between February 2000 and December 2012, average annual employment in the mining industry grew by 10 per cent per year – an addition of 170,000 workers. Manufacturing employment declined on average by 1 per cent each year. While this suggests a “lagging sector” role, the comparative decline did not depart significantly from the long run trend since the 1980s, as

⁹ See Battelino (2010). This required the inversion of Australia's yield curve as excess global savings saw long interest rates continue to trend down while a tight monetary policy stance was required to prevent inflation and drive up the exchange rate.

¹⁰ All growth rates are geometric averages.

indicated in Figure 3. Services employment grew at just 2.47 per cent per year but it is a much larger sector, adding to its labour force more than 2.2 million workers.

A breakdown of employment numbers in the boom period, commencing mid-2002, is given in Figure 4. This shows most clearly that the pattern of labour distribution in the period was dominated by an expansion in total labour supply by almost a quarter, with virtually all of this increase matched by the expansion of services employment. While Australia's services sector was expanding, collective employment in agriculture, mining and manufacturing stagnated. The natural resource based (*NRB*) sectors, agriculture and mining combined, gained 64,000 workers while manufacturing lost 72,000. The largest swap was within the *NRB* sectors, with agriculture losing 103,000 workers while mining gained 166,000. The significance of the secondary services boom can be seen here. It dominated the structural change occurring in the boom period and, when construction is included, it accounts for 86 per cent of Australian employment (ABS 2012d).

III Numerical Theory in the Dutch Disease Tradition

This section presents comparative static analysis using a numerical general equilibrium model. While the model is designed to represent the Australian economy prior to the boom, like most general equilibrium models it embodies behavioural assumptions and parameter values that are difficult to verify empirically. It is therefore best to regard the analysis of this section as numerical theory, extending the theoretical Dutch Disease literature via the use of a more complete model that is tailored numerically to the focus economy.¹¹ Accordingly, the model is a generalisation of the Corden-Neary model and the Devarajan et al. (1990) "1-2-3" model, including three sectors (*NRB* goods, manufacturing and services) and three primary factors, natural resources including land and reserves of minerals and energy (*A*), labour (*L*) and capital (*K*).¹²

¹¹ This said, as Peter Dixon rightly points out, the model we use is simple by the standards of comprehensive national models like MONASH or USAGE (Dixon and Rimmer 2002 or 2004). For the purpose of constructing testable hypotheses, however, our approach is parsimonious yet a substantial advance on standard Dutch disease analytics.

¹² The model is also similar to that used in the analysis of Australia's protectionist policies of the 1930s by Tyers and Coleman (2008), albeit with an updated database. In an earlier draft we also used a version of the Devarajan et al. (1990) "1-2-3" model, which offers a very clear graphical motivation for the secondary services boom but suffers the abstraction that manufactures are not produced in the home economy and so the issue of "de-industrialisation" cannot be addressed directly. This section is available on request from the authors.

The *NRB* sector is comparatively intensive in natural resources and capital while services and manufacturing are both labour-intensive, with manufacturing slightly less so. The services sector is almost non-traded, whilst consumers can purchase foreign or domestic varieties of manufactured goods and natural resource based products. In the tradition of more modern general equilibrium analysis, home and foreign products are differentiated and there is intra-industry trade in both. The economy is “almost small”,¹³ by which is implied that the foreign economy produces at fixed prices but its household substitutes in consumption between foreign products and home exports. Home exports are specialised varieties that therefore have some market power abroad while importers are price takers.

The Supply Side

Production in each sector is Cobb-Douglas in the three primary factors. Solving the firms’ cost minimisation problems subject to this technology yields unit factor demands that depend on relative factor prices. If these are v_{ij} , indicating the demand for factor j to produce a unit of output in industry i , and price taking behaviour is enforced, then product prices depend on these unit demands and factor prices, w_j .

$$(1) \quad p_i = \sum_{j=1}^3 v_{ij} w_j \quad .$$

Factor endowments are \bar{V}_j , with the capital element being divided between domestic and foreign ownership ($K = K_D + K_F$). If the gross volume of output in sector i is Y_i , the endowment constraints are:

$$(2) \quad \bar{V}_j = \sum_{i=1}^3 v_{ij} Y_i$$

The stock of domestically owned capital is assumed fixed, so that, if the capital stock is made endogenous, its variation depends on changes in foreign owned capital. GDP at factor cost is then simply the vector product of the factor price and endowment vectors.

The Demand Side

¹³ For national models this is in the tradition of Dixon et al. (1982), Harris (1984) and Dixon and Rimmer (2002, 2004).

The collective household is assumed to have a Cobb-Douglas utility function in the volumes of generic consumption, where δ_i is the expenditure share on industry i 's product.¹⁴

$$(3) \quad U = \prod_{i=1}^3 C_i^{\delta_i}$$

Maximisation of (3) within a budget constraint leads to Cobb-Douglas Marshallian demand functions in a composite price of domestic and foreign versions of each generic product, P_i .

$$(4) \quad C_i = \delta_i \frac{GNP}{P_i}$$

Products are differentiated by country, allowing consumers to choose between foreign and domestic varieties. Armington separability is invoked, as between the choice between the three generics and that between imported and home varieties. Generic consumption of good i (C_i) is then a constant elasticity of substitution (CES) composite of domestic and foreign varieties:

$$(5) \quad C_i = (\gamma_i h_i^{-\rho_i} + \gamma_i^* m_i^{-\rho_i})^{-\frac{1}{\rho_i}}$$

The elasticity of substitution between the two varieties is then $\sigma_i = 1/(1+\rho_i)$ and, with initial values for prices set to unity, the database shares of each in demand for the composite product are $s_i = \gamma_i^{\sigma_i}$, $(1-s_i) = (\gamma_i^*)^{\sigma_i}$. The Marshallian demand functions for the domestic and imported varieties of each good are derived by first choosing C_i 's so as to maximise utility, and then choosing h_i and m_i to minimise expenditure.

$$(6) \quad h_i = C_i s_i \left(\frac{p_i}{P_i} \right)^{-\sigma_i} \quad m_i = C_i (1-s_i) \left(\frac{(1+\tau_i) p_i^F}{P_i} \right)^{-\sigma_i},$$

where P_i are the generic prices, which are CES composites of the varietal prices p_i for home goods and p_i^F for foreign (imported) goods, here adjusted by the ad valorem tariff rate, τ_i .

The composite price of generic good i is then:

$$(7) \quad P_i = \left[\gamma_i^{\sigma_i} p_i^{1-\sigma_i} + (\gamma_i^*)^{\sigma_i} \{(1+\tau_i) p_i^F\}^{1-\sigma_i} \right]^{\frac{1}{1-\sigma_i}}$$

¹⁴ These are homothetic preferences, representing equal income elasticity for each good. In reality services and manufactured products are more income elastic than *NRB* products but the effects of this are small in comparative static analysis.

Total tariff revenue, R , needed for real GDP, is:

$$(8) \quad R = \sum_{i=1}^3 \tau_i m_i p_i^F$$

and the consumer price index (CPI), necessary for calculating real factor rewards, is

$$(9) \quad CPI = \prod_{i=1}^3 P_i^{\delta_i} .$$

GDP at factor cost is

$$(10) \quad GDP_{FC} = \sum_j w_j \bar{V}_j ,$$

and so gross national product is then $GNP = GDP_{FC} + R - rK_F + KA$, where rK_F captures repatriated capital returns and KA reflects usually exogenous capital account inflows.¹⁵

Foreign consumption of all three generic goods, i , is assumed constant at Q_i , which is a CES composite of foreign-produced goods and domestic exports:

$$(11) \quad Q_i = \left(\lambda_i X_i^{-\rho^*} + \lambda_i^* C_{iF}^{-\rho^*} \right)^{-\rho_i^*}$$

For each sector, i , the shares of domestic exports in foreign consumption (s_i^F) are $\lambda_i^{\sigma_i^*}$, where $\sigma_i^* = 1/(1 + \rho_i^*)$ is the foreign elasticity of substitution in demand between foreign and domestic products. Foreigners choose domestic exports (X) and consumption of local products (C_F) in order to minimise expenditure on Q , leading to the export demand function:

$$(12) \quad X_i = s_i^F Q_i \left(\frac{P_i}{P_i^F} \right)^{-\sigma_i^*} ,$$

and the foreign composite price index for the generic good, P^F is:

$$(13) \quad P_i^F = \left[\lambda_i^{\sigma_i^*} p_i^{1-\sigma_i^*} + (\lambda_i^*)^{\sigma_i^*} (p_i^F)^{1-\sigma_i^*} \right]^{\frac{1}{1-\sigma_i^*}} .$$

Data, parameters, shocks and closures

¹⁵ KA could, alternatively, be thought of as net unrequited transfers on the current account. In Australia's case, however, a surplus is run on the capital account to match its current account deficit.

The model comprises 73 variables and 59 equations, requiring a closure with 14 variables declared exogenous.¹⁶ Most importantly, the initial (standard) closure has fixed factor endowments (and therefore endogenous factor prices) and fixed net inflow on the capital account, *KA*. The key parameter values are in Table 1.¹⁷ The model database is designed to reflect the pre-boom structure of the Australian economy.¹⁸ Common to conventional general equilibrium studies is the sensitivity of results to the elasticities of substitution between home and foreign varieties. The values shown in Table 1 reflect convention for medium term studies and differ across sectors to reflect the fact that natural resource based goods are comparatively homogeneous internationally while manufactures offer a diverse mix of products the content of which tends to be idiosyncratic to individual countries. The near non-tradability of services justifies the very small substitution elasticity shown for it.

We construct stylised shocks to represent a generic resource boom with all three types of boom shocks: a terms of trade shock that comprises a rise in the foreign price of *NRB* goods by 50 per cent, an investment boom that causes a 25 per cent increase in capital account net inflow and, to reflect the associated expansion in accessible natural resources, their domestic endowment is raised by 10 per cent. Finally, to represent boom-linked changes in Australia's total labour supply (due primarily to immigration), the labour endowment is also expanded by 10 per cent.¹⁹ Three closures are considered. The first is conventional - consistent with the early Dutch Disease literature. It has capital immobile internationally, and so the stock of physical capital is unaltered by the boom. This closure might be thought of as characterising the first two phases of the boom as identified by Gregory (2012), in which there is a terms of trade boom and an investment inflow but not yet any expansion of the working capital stock.

The second closure relaxes the assumption of internationally immobile capital and, instead, fixes the rental rate measured in terms of the numeraire: imported manufactures (whose external price is always constant). This assumes foreigners will invest in Australia so long as the rents are at least constant relative to the price of foreign manufactured goods. The foreign owned component of Australia's physical capital stock is therefore endogenous. The third closure accounts for the fact that the boom causes a real appreciation and so costs in Australia

¹⁶The software used is Gempack. See Harrison et al. (2013), Pearson (1988)..

¹⁷ A full list of variables and their initial values is available for reviewers in Appendix Table A1.

¹⁸The flow data are from GTAP data release, identifier R7.0_21Nov08.

¹⁹ From Figure 4 it is clear that Australia's actual labour supply expanded by almost a quarter after 2002. Our purpose here is to offer a stylized characterization of the shocks associated with the boom. It is not to subject the model to all the shocks affecting the Australian economy during the period.

rise relative to the international price of manufactures. In this case, foreigners demand rents that keep pace with Australia's costs, holding exogenous the rental rate deflated by Australia's domestic CPI. Since, in this closure, foreigners demand necessarily higher rents, less new foreign capital becomes available. The latter two closures might be thought of as representing the (Gregory 2012) third phase of the boom in which capital expansion facilitates substantial increases in mining output but also increases in the share of foreign ownership of Australian capital.

Results

A summary of the results is offered in Table 2. In their interpretation it is useful to recall that the analysis is comparative static and the alternative closures offer only crude insight into lengths of run.²⁰ The first, or traditional, closure considers a period over which, while there is an inflow of financial capital, there is not yet any rise in the stock of useful physical capital. Given the long gestation lags associated with mining investment this could be seen as representing a substantial part of the boom period. In this case, Table 2 indicates six clear patterns:

- 1) There is a large real appreciation. This is predicted by the Dutch Disease literature and has been observed in the Australian case as indicated in Figure 1.
- 2) There is only a modest rise in real GDP, which is due mostly to the expansion of total labour supply. The modest volume expansions from the Australian boom have also been noteworthy.²¹
- 3) There is a substantial rise in real (CPI deflated) GNP, indicating that the boom has expanded real national income beyond that associated with the labour supply jump, due primarily to the terms of trade change.
- 4) There is a net positive effect on the real consumption wage, indicating a net tightening of the labour market. This is a strong statement considering that we include the labour supply increase as an indirect consequence of the boom. The domestic CPI rises by a third relative to the numeraire, which is the import price of manufactures.

The real production wage compares the wage with producer product prices, which rise

²⁰ Very useful discussions on lengths of run in comparative static analysis are available in Cooper et al. (1985) and Cooper and McLaren (1983). For a recent application of dynamics to related problems, see Steinmetz (2010) and Berg et al. (2012).

²¹The slow expansion in output during the boom spawned the new literature on the distinction between gross national income, GNI, and GNP (Coleman 2008). Here, however, the terms of trade effect on prices is captured in the change in the CPI and hence in CPI deflated GNP.

with the real appreciation by more than the CPI. For producers, therefore, labour is rendered comparatively cheap notwithstanding that workers are better off.

- 5) “Three speeds” are observed. There is expansion in output in the NRB sector, contraction in manufacturing, and slower expansion in services output. The latter is most significant, however, since it occurs in a sector with more than 80 per cent of Australia’s GDP. It suggests that the “spending effect” outweighs the “resource movement effect” for services, allowing this net expansion.
- 6) While the scale of the expansion in services output is slower, the services employment effects are dominant. This is consistent with the general pattern shown in Figure 4.

These results do deviate from the observed pattern to the extent that the general equilibrium solution implies that agents view the shocks as permanent and full adjustment is allowed in factor markets. Because, in reality, at least some agents recognise that the boom need not be permanent, and the resource movements require adjustments that take time, the net “resource movement effects” emerge as larger than observed thus far and hence the predicted extent of deindustrialisation is substantial.

The other closures examine a much greater length of run in which capital inflows have been translated into effective new physical capital. Once again, because embodied agents regard the boom shocks as permanent, the adjustments in these cases are much larger than in the first and they might be expected to go well beyond observation. In this sense they can be thought of as projections for the case where the boom shocks are very long lasting and confidence in them is sustained. The second and third closures differ in their assumptions about the rental rates to be extracted from foreign investment in the Australian economy. The second assumes that the rental rate on capital can remain constant relative to the foreign price of manufactures. Since the boom causes a considerable real appreciation foreign manufactures become comparatively cheap at home, as therefore does physical capital. A very large volume of physical capital is therefore absorbed, amounting to an expansion of the total capital stock by more than half. This causes a correspondingly large expansion in real GDP and, this time, a much smaller net increase in real (CPI deflated) GNP, due to the necessary expansion in financial capital service (repatriated profit) flows abroad. The additional capital reduces its domestic real return, especially for producers. Notwithstanding that half of the capital is now foreign owned, the marginal product of labour in all sectors is raised and so the principal domestic beneficiaries are workers, whose real consumption wage rises by a fifth.

The “three speeds” are again observed in sectoral output changes, though now the services sector becomes more capital intensive and sheds labour to mining.

The results from the second closure are unrealistic as to scale not only because of the implied length of run and the shock permanency assumption. The scale of the capital inflow is overly optimistic on the assumption that foreign investors are happy not to take the additional rents accruing to capital that are due to the boom. In reality, it is these boom rents that attract foreign investment and so, to incorporate this, the third closure assumes foreign investors demand that rents rise with the Australian CPI (they remain constant in real terms within Australia). This time the foreign investment raises the home capital stock by only a fifth. The rises in real GDP and real (CPI deflated) GNP are now smaller but more comparable. The gain to Australian workers is also smaller, though it remains substantial, and the “three speeds” are again evident, this time both in terms of gross sectoral output and sectoral employment.

General points associated with these results

At first glance a trade economist would view the primary shock, a rise in the export price of the capital-intensive good, as foreshadowing real gains to capital and real losses to labour, via the Stolper-Samuelson (1941) Theorem. This more complete model shows that labour can enjoy real net gains when there is a secondary boom in the (largely non-traded and comparatively labour-intensive) services sector.

Second, the services boom observed in the results depends, in theory, on the properties of final demand, particularly as between manufactures and services. Bias in income effects away from services and the elasticity of substitution between manufactures and services are central. Here we have assumed homothetic preferences. We believe this assumption is conservative. Given that services are traditionally income elastic compared with raw materials and manufactures in general, the expenditure effect would yield a larger secondary services boom than modelled here.

Third, while the model’s predictions as to manufacturing employment are similar to the changes observed in the boom period (a contraction of seven per cent was observed), those for gross manufacturing production suggest unrealistic declines. This is because of the assumed mobility of physical capital between sectors, which allows an expanding capital-intensive mining sector to steal capital from manufacturing at a greater rate than it steals

labour. In reality, physical capital is less mobile between sectors than labour in the short run. And fourth, because the model maintains the traditional three-sector structure it aggregates agriculture and mining, thus missing the contractionary effect of the boom on agriculture shown in Figure 4.

Sensitivity to manufacturing demand elasticity

Both de-industrialisation and the services rise are sensitive to the elasticity of demand for home manufactures. We explore this by varying the elasticity of substitution between home and foreign manufactures in home consumption. We did this for the case of the first closure, allowing the elasticity of substitution to vary from 0.5 to 6.0, obtaining the results shown in Figure 5. These reveal that the positive effect on services output is surprisingly robust, principally because it depends principally on the extra income from the terms of trade change and the extra employment, which are unaffected by the elasticity of substitution. The extent of de-industrialisation, however, is very sensitive to this elasticity since it determines the level of replacement of home manufacturing by imports following the real appreciation.²² A case for a smaller elasticity, and therefore less de-industrialisation, can be made on the grounds that, after several decades of Australian manufacturing decline the surviving firms are much more closely interlinked than previously with either mining or services. This suggests that strong performance in these industries has tended to buffer the Dutch disease “de-industrialisation” effect to a greater extent than indicated in our original results in Table 2.²³

Hypotheses for empirical testing

The central hypothesis of Dutch disease theory is an appreciated real exchange rate and this is clearly observed and in no need of testing. The key areas where the pure theory leaves ambiguity relate to sectoral performance – whether there is a secondary services boom and the scale of any deindustrialisation. Our numerical theory suggests two testable hypotheses. First, it predicts a substantial secondary services boom that is sufficient to tighten the labour market even with generous immigration. Second, it predicts substantial de-industrialisation,

²² We thank Peter Dixon for helping to elucidate this point.

²³ The short to medium run analysis of the previous boom by Dixon et al. (1978) is supportive of this view. It was based on the ORANI model, which contained 109 sectors. The choice of comparatively small elasticities of substitution resulted in the conclusion that the majority of Australia’s manufacturing industries gained slightly from that mining boom because the favourable effect of increased incomes outweighed the adverse effect of real appreciation.

albeit at a level that depends on poorly estimated elasticities of substitution, most particularly as between home and foreign manufactures. We now turn to an examination of the data to see if these predictions are accurate.

IV Empirical Analysis

Here we examine the boom period for performance at the sectoral level. This is done using vector auto-regressions (VARs) that focus on the links between sectoral incomes and employment on the one hand and the terms of trade on the other.

The data

Nominal *GVA* and employment data for the mining, manufacturing and services sectors are sourced from the Australian Bureau of Statistics (ABS 2012b; ABS 2012d).²⁴ These yield the income variables Y_{min} , Y_{man} and Y_s , and the employment variables L_{min} , L_{man} and L_s . ‘Services’ industries are classified as all industries excluding agriculture (including forestry and fishing), mining and manufacturing.

Terms of trade (T) data are sourced from the Reserve Bank of Australia (RBA 2012), where it is available quarterly for the period September 1985 to December 2011. The ABS compiles quarterly employment figures on a different cycle, sourced from August 1985 to November 2011 (one month prior to the terms of trade data). Nominal *GVA* figures are only available annually (millions A\$). Quarterly variants of these series are constructed so that Y_{min} , Y_{man} and Y_s run from September of 1989 to June of 2011.²⁵ *Nominal GVA* figures (current prices) are only available annually from June of 1990 to June 2011, whilst *real* (“chain volume”) *GVA* figures are available quarterly over the same period as the terms of trade.²⁶ The nominal figures exhibit the large resource boom post-2003 whilst the real figures do not, reflecting the rapid export price increases over the period and the long gestation periods in mining investment that caused the real response of the economy to lag substantially. The

²⁴ Catalogue numbers 5204.5 (*GVA*) and 6291.4 (employment).

²⁵ A full summary of all data sources is available in Appendix Table A2.

²⁶ September 1985 to December 2011. Real figures were obtained from ABS Catalogue 5206.6 (ABS 2012a).

quarterly real figures are used as a proxy to transform the annual nominal series from annual to quarterly.²⁷

The quarterly data were then tested for seasonality and “de-seasonalised” where appropriate (Enders 2010: 97-103). To do this, each series was fitted to a time trend with seasonal dummies.²⁸ Manufacturing *GVA* exhibited significant seasonality in both levels and log-levels at 5 per cent significance. The log-level of services *GVA* also exhibits strong seasonality at the one per cent level.²⁹ Variables without at least one seasonal dummy significant at the 5 per cent level were left unchanged. The relevant industry output series were then seasonally adjusted following the procedure outlined in Gujarati and Porter (2009: 290). To indicate this in the algebra below, a “*ds*” is superscripted to the affected variables.

The seasonally adjusted quarterly series were then assessed for stationarity. Elemental economic intuition suggests that the employment and *GVA* variables, *L* and *Y*, are stationary around their *long-term* log-trends, whilst the terms of trade is a trend-stationary process in its level. So we began by linearly de-trending each variable in both level and log-level form, over the respective full data periods.³⁰ A superscript ‘*l*’ is added to the variable if it is a log-level and a ‘*dt*’ is superscripted to indicate it has been linearly de-trended. Augmented Dickey-Fuller (ADF) tests were performed for the levels, log-levels and de-trended series of each variable to test for stationarity.³¹ As expected, these tests fail to reject non-stationarity at the 5 per cent level.

As a first response, we considered the approach taken in an expanding literature that sacrifices the strict stationarity criterion for VARs on economic grounds. Recent papers by Mountford and Uhlig (2009), Romer and Romer (2010) and Ramey (2011) all perform VAR analyses using the log-levels of their chosen variables without strict stationarity, occasionally incorporating time trends directly. In the end, we rejected this approach because the simple de-trending was strongly affected by the current incomplete boom cycle.

²⁷ It is assumed that the quarterly movements of the real figures around the trend between annual means are proportionally the same as for the corresponding nominal figures. Details of the quarterly conversion are provided in the Appendix (A1).

²⁸ The method used and results are detailed in the Appendix (A2).

²⁹ This excludes the June quarter which is insignificant at the 10% level.

³⁰ Each variable is regressed against a linear time trend and a constant. The time trend is significant for all variables in both levels and log-levels. The residuals of this trend regression are the de-trended series.

³¹ The results of these tests for the full sample are summarised in the Appendix (A3).

Virtually all the series show long periods of “normal” stochastic behaviour around stable trends, followed by an upswing after the end of 2002, due to the boom. There is therefore the appearance of non-stationarity (upward turning trends during the boom period), yet economic intuition would suggest that the current boom will eventually end and the series will resettle toward their pre-boom trends. In other words, the boom is a partially observed stochastic perturbation around a long term deterministic trend. Considering the extraordinary scale of this perturbation, it would seem to be inappropriate to use conventional de-trending methods across the entire series. One alternative would be to use a difference form model, which might allow the accommodation of the boom period data. The scale of the boom is so significant, however, that a similar problem arises in this case also.

The boom is commonly regarded as having commenced in the interval from late 2002 to early 2003 (Gregory and Sheehan 2013). We take the view that reliable and useful estimates of responses to terms of trade shocks cannot be estimated from the full series, including from 2003, which includes the partially unfolded boom. We have therefore restricted our estimations to the pre-boom period: 1989:3 to 2002:4 (54 observations). Rather than waste the information available from the boom period, however, we chose to estimate on the pre-boom interval and simulate through the boom period, both to provide out-of-sample testing of the estimated VARs and to suggest where underlying structure and behaviour might have changed during the boom period.

Seasonality tests were again run for the shorter sample period, yielding the significant findings provided in the Appendix. From the income and employment variables a log-linear trend was extracted. Augmented Dickey-Fuller Tests for stationarity were then performed, with the results shown in Table 3. For the shorter period non-stationarity for all sectoral employment variables and manufacturing *GVA* is rejected at the 10 per cent level. Given the very short interval, it is unsurprising that stationarity is rejected for the terms of trade and the remaining income and employment series. Plots show that minor perturbations explain the test results. In the case of the terms of trade, a cyclical pattern is clear while stationarity is evident in the long-run. Mining *GVA* exhibits a jump around 2000, appearing otherwise stationary. Services *GVA* experiences a drop in 1991 and a correcting rise in 2001, following a stable log-linear trend in between.

ADF tests have very low power to reject the null of a unit-root process (Enders 2010: 234), because they struggle to distinguish between trend-stationary and drifting random walk processes.³² We therefore follow economic intuition and employ the sample period 1989:3 to 2002:4 to estimate the VARs. The variables included are the log terms of trade, T^{ldt} , the log de-trended sectoral incomes Y_{\min}^{ldsdt} , Y_{man}^{ldsdt} , Y_s^{ldsdt} , and the log de-trended sectoral employment levels L_{\min}^{ldt} , L_{man}^{ldt} , and L_s^{ldt} .

Vector Auto-Regressions

Two structural VARs are estimated: the first examines the effects of terms of trade shocks on sectoral *GVA*, and the second on sectoral employment.³³ To estimate each VAR's complete structure, restrictions on the parameters are required. For this a 'standard' *Choleski decomposition* is used. Variables are therefore ordered from least to most endogenous using prior theory.

The first includes the de-trended log-levels of the terms of trade and the *GVA*s of mining, manufacturing and services. They are ordered from least to most endogenous as T^{ldt} , Y_{\min}^{ldsdt} , Y_{man}^{ldsdt} , Y_s^{ldsdt} . The theory in section's II and III has most shocks originating from the terms of trade, making it the least endogenous variable. Mining *GVA* is likely to be affected by terms of trade shocks and mining-specific shocks only and so it is placed second. Manufacturing *GVA* is affected by terms of trade shocks and changes in mining output as described by the *direct de-industrialisation* effect of Dutch disease theory. Services *GVA* is considered the most endogenous variable, influenced by both the *spending* and *indirect de-industrialisation* effects.

The *structural* or *primitive* VAR of order p [VAR(p)] takes the matrix form

$$(14) \quad Bx_t = \Gamma_0 + \sum_{i=1}^p \Gamma_i x_{t-i} + \varepsilon_t ,$$

³² Differencing all variables leads to ADF tests rejecting non-stationarity for all variables but is avoided as theory suggests these variables are trend-stationary processes. "Sims (1980) and Sims, Stock and Watson (1990) recommend against differencing *even if the variables contain a unit root*[emphasis added]" (Sims 1980 and Sims, Stock & Watson 1990, quoted in Enders 2010, p. 303).

³³ We recognise that our analysis to date suggests that the levels of income and employment are jointly affected by the terms of trade and that their separation in this way suggests mis-specification. Our concern is the "curse of dimensionality", given the available data. We choose to regard the two VARs as alternative specifications of a necessarily simpler econometric model, for stand-alone consideration.

where the $\{\varepsilon_t\}$ are serially uncorrelated white noise shocks. To transform the *primitive* equation to its *reduced* or *standard* form for estimation, equation (13) is pre-multiplied by B^{-1} to obtain:

$$(15) \quad x_t = A_0 + \sum_{j=1}^p A_j x_{t-j} + e_t$$

Here the error terms e_{it} are now composites of the shocks ε_{it} , and are individually serially uncorrelated with zero-mean.³⁴

The first VAR has the following elements in its *structural* form:

$$(16) \quad B = \begin{bmatrix} 1 & 0 & 0 & 0 \\ b_{21} & 1 & 0 & 0 \\ b_{31} & b_{32} & 1 & 0 \\ b_{41} & b_{42} & b_{43} & 1 \end{bmatrix}, \quad x_t = \begin{bmatrix} T^{l_{dt}} \\ Y_{\min}^{l_{dsdt}} \\ Y_{\text{man}}^{l_{dsdt}} \\ Y_s^{l_{dsdt}} \end{bmatrix}, \quad \Gamma_0 = \begin{bmatrix} v_{10} \\ v_{20} \\ v_{30} \\ v_{40} \end{bmatrix}, \quad \varepsilon_t = \begin{bmatrix} \varepsilon_T \\ \varepsilon_{Y_{\min}} \\ \varepsilon_{Y_{\text{man}}} \\ \varepsilon_{Y_s} \end{bmatrix}$$

The second replaces the income variables with employment, in the corresponding order. All that remains is to select appropriate lag structures. The Akaike Information Criteria (AIC) and Schwartz Bayesian Criteria (SBC) are both used.³⁵ Table 4 displays both statistics with the indicated lag length shown. For the income VAR, both the AIC and SBC tests indicate one lag is appropriate. For the employment VAR both the AIC and SBC suggest a lag of two quarters. In this case the impulse responses are erratic, despite converging very quickly. As a result, the more parsimonious model with a *lag of one quarter* is used.³⁶

Estimation results

Impulse responses are presented in preference to parameter estimates. These allow us to trace the response of each variable's time path following a shock in one of the variables. Each function includes a confidence interval band of two standard deviations around the predicted change in the variable. An increase or decrease in a variable is deemed significant at a point in time if both bands are above or below the zero line. The impulse response

³⁴ Despite non-zero correlation between these errors across equations, the OLS estimates of the *reduced* form VAR(p) are consistent and efficient (Enders 2010: 303).

³⁵ AIC tends to work better in small samples, whilst SBC is asymptotically consistent and will always choose a more parsimonious model (Enders 2010: 70-72).

³⁶ Recall that due to data collection frequencies, the change in employment variables occurs over a period one month prior to the stated duration. For example, a rise in mining employment one quarter after the terms of trade shock is actually 2 months following the shock.

functions for the income VAR illustrate changes over time in the de-trended log-levels of industry *GVA* and employment in response to a *one standard deviation* increase in the de-trended log-level of the terms of trade. The standard deviation is equivalent to a shock of approximately 4.2 per cent.

The effects of a one standard deviation increase in the de-trended log-level of the terms of trade on sectoral *GVA* are illustrated via the impulse response functions shown in Figure 6. A strong rise in mining *GVA* is observed for five years, with a peak growth rate of around 1 per cent occurring around 1.5 years after the terms of trade shock. The increase is significant after one year for around 5 quarters. Manufacturing appears to suffer a contraction in output after a lag of three quarters following the shock, before which its *GVA* is predicted to rise. The peak decline in output of around 0.4 per cent occurs nearly 2 years after the shock but is not significant. Services *GVA* enjoys an immediate boom following the terms of trade innovation, reaching a peak growth of almost 0.25 per cent five quarters later, which is almost but not quite significant. In June of 2011 services *GVA* was at least 8 times larger than that of manufacturing, implying that the peak rate of absolute change in services *GVA* significantly outweighs the peak rate of decline in manufacturing. All effects are completed by 6 years following the shock at latest.

In the case of the employment VAR (Figure 7), the impulse response functions appear to support a secondary boom in services employment, but they contradict the hypothesised contraction in manufacturing, or deindustrialisation. As expected, mining employment rises following the terms of trade innovation, with the peak growth rate of 0.7 per cent one quarter after the change showing as statistically significant. In these results, manufacturing employment exhibits a strong and significant *increase* following the terms of trade innovation, with a peak growth rate of almost 0.5 per cent occurring one year on. This rise is significant with a lag of between two quarters and two years. Services employment grows for around twelve quarters following the shock, but is not significantly positive at any stage.³⁷ The estimated peak growth rate is smaller than the other two sectors at around 0.23 per cent,

³⁷ Significance is almost obtained 7 quarters after the terms of trade jump when employment enjoys its peak growth rate.

but in levels the changes in services employment are substantially larger, confirming the importance of the secondary services boom.³⁸

Out of sample testing:

The choice to use data ending in quarter four of 2002 in the VARs allows out of sample testing across the boom period. The reduced form parameter estimates obtained from the income VAR yield the following forecasting model:

$$(17) \begin{aligned} (Y_{min}^{ldsdt})_t &= 0.001238 + 0.3718T_{t-1}^{ldt} + 0.6038(Y_{min}^{ldsdt})_{t-1} - 0.1781(Y_{man}^{ldsdt})_{t-1} + 0.3563(Y_s^{ldsdt})_{t-1} \\ (Y_{man}^{ldsdt})_t &= -0.001294 - 0.08550T_{t-1}^{ldt} - 0.06879(Y_{min}^{ldsdt})_{t-1} + 0.7686(Y_{man}^{ldsdt})_{t-1} + 0.08139(Y_s^{ldsdt})_{t-1} \\ (Y_s^{ldsdt})_t &= -0.00007 + 0.07705T_{t-1}^{ldt} - 0.01313(Y_{min}^{ldsdt})_{t-1} + 0.01673(Y_{man}^{ldsdt})_{t-1} + 0.8126(Y_s^{ldsdt})_{t-1} \end{aligned}$$

The simulated behaviour of mining and services *GVA* mirrored the actual movements quite well, with the secondary services boom in output coinciding with that of mining.

Manufacturing *GVA* actually declined less than simulated, however, only falling below trend after 2008. This indicates that, if the manufacturing industry experienced any

“deindustrialisation”, it was milder than implied by the pattern of behaviour observed prior to 2003, and only occurred during the ‘great recession’ period of the last four years.³⁹ Our hypothesis that the secondary services boom in income is an indirect product of the resources boom, rather than the consequence of other shocks, is supported strongly as Figure 8 shows.⁴⁰

The fitted model from the employment VAR, which links the terms of trade to the variables L_{min}^{ldt} , L_{man}^{ldt} , and L_s^{ldt} , and which is used to project sectoral employment responses, is:

$$(18) \begin{aligned} (L_{min}^{ldt})_t &= -0.000397 + 0.3799T_{t-1}^{ldt} + 0.2743(L_{min}^{ldt})_{t-1} + 0.1712(L_{man}^{ldt})_{t-1} - 0.1147(L_s^{ldt})_{t-1} \\ (L_{man}^{ldt})_t &= -0.000451 + 0.1291T_{t-1}^{ldt} + 0.1138(L_{min}^{ldt})_{t-1} + 0.6419(L_{man}^{ldt})_{t-1} - 0.1530(L_s^{ldt})_{t-1} \\ (L_s^{ldt})_t &= -0.000165 + 0.009774T_{t-1}^{ldt} + 0.01064(L_{min}^{ldt})_{t-1} + 0.1624(L_{man}^{ldt})_{t-1} + 0.6581(L_s^{ldt})_{t-1} \end{aligned}$$

³⁸ Services employment was 40 times and 10 times larger than mining and manufacturing employment respectively in November 2011 (ABS 2012d).

³⁹ This result accords with that of Dixon et al. (1978) for the previous boom. Their analysis, however, was more highly disaggregated and it concluded that there were a wide range of outcomes *within* the manufacturing sector. We would anticipate this here as well, though the composition of manufacturing during the most recent boom is more specialised than it was previously.

⁴⁰ For all the variables, the actual data series were obtained by removing the 1989:3 - 2002:4 trend from the original series through to 2011:2. When simulating the time paths for each LHS variable, actual data was used for every variable except that of interest (which requires only the 1989:3 actual value to begin each simulation).

The actual increase in mining employment post-2002 proves greater than simulated while the simulations project a rise in manufacturing employment relative to trend which is not observed. Importantly, however, as shown in Figure 9, the secondary services boom is clearly evident in employment, though actual services employment rose above trend by significantly more than simulated. While these results support our services boom hypothesis, they are less precise than those from the income VAR. Possible explanations for this include, first, that the employment effects are more sensitive to the omitted boom shocks (investment and resource discovery) than the income effects. Second, structural changes since the inception of the boom (possibly relating to the composition of manufacturing output and employment) have altered the links between manufacturing and mining, on the one hand, and manufacturing and services on the other. And third, it is possible that non-boom shocks have contributed to Australia's services employment boom. In the period after the "great recession", for example, poor-performing European government debt led to increased global demand for Australian government debt, creating financial inflows that would have further appreciated the real exchange rate and raised the services expansion beyond the level associated purely with the terms of trade change.

These results, combined with the stylised facts presented in Section II confirm that the 'three speed' characterisation of the Australian economy following terms of trade shocks is appropriate, and that the resources boom has precipitated a secondary services boom that has dominated employment changes, keeping labour markets tight and unemployment low. This said, the analysis conducted here is not very enlightening about manufacturing performance during the current boom. The general equilibrium analysis supports the Dutch disease convention, anticipating at least some "de-industrialisation". This hypothesis is supported by one of the estimated VARs but not observed during the out-of-sample projections into the boom period. Indeed, the empirical analysis is comparatively weak on manufacturing, yielding inconsistent projections as to income and employment following terms of trade shocks. This suggests the possibility that the underlying parameters, particularly as they affect manufacturing, changed between the estimation and the boom periods. During the boom the Australian economy grew more interdependent with China than it had been early in the 1990's. It is not difficult to imagine that the manufacturing firms that still lingered at the beginning of the boom were more closely interlinked with either mining or services. Hence, strong performance in these tended to buffer the Dutch disease "de-industrialisation" effect.

V Conclusion

The extensive public discourse over the effects of Australia's boom emphasised a "two speed" economy that comprised an expanding mining sector and lagging manufacturing. This implied different levels of performance across Australia's states and regions. That this is a misleading oversimplification was recognised by Corden (2012). Australia's economy is dominated by services and this sector enjoyed a very important secondary boom, spreading the gains from mining expansion across virtually all the states and regions and tightening labour markets throughout.

While the secondary services boom is evident from the data on sectoral incomes and employment levels, its dependence on the particular Dutch disease shocks experienced by Australia is less clear. This paper addresses this, first by adding numbers to the conventional Dutch disease general equilibrium analysis, albeit via the use of a model that is better suited to the analysis than those used in the classic articles but, for reasons of parsimony, one that is simpler than the most detailed available. This provides numerical theory that is more sophisticated and more directed to the Australian economy than is available from the classic works of Gregory, Corden and Neary, which leave ambiguity as to the direction of effects on the services sector. From it, the twin hypotheses emerge that indeed there ought to have been a secondary services boom and that, in concert with it, there ought to have been significant deindustrialisation. These results then form testable hypotheses that form the basis of an examination of the available data on sectoral performance.

Second, an empirical analysis of the links between the terms of trade and sectoral economic performance is presented to test these hypotheses. The occurrence of a significant secondary services boom is supported by this analysis. As to the second hypothesis, however, significant deindustrialisation is not present in the data. Even though the contribution of manufacturing to Australian income and employment has been declining continuously since the 1980s, there does not appear to have been any acceleration in this pattern during the boom. The data indicate a more resilient manufacturing sector in the boom period than is predicted by Dutch disease theory even as extended in the numerical model applied. Related to this, our general equilibrium sensitivity analysis shows that a low level of de-industrialisation can be a consequence of inelastic manufactures demand. We hypothesise

that this is a likely consequence of several decades of Australian manufacturing decline, leaving behind a manufacturing sector much more closely interlinked than previously with either mining or services.

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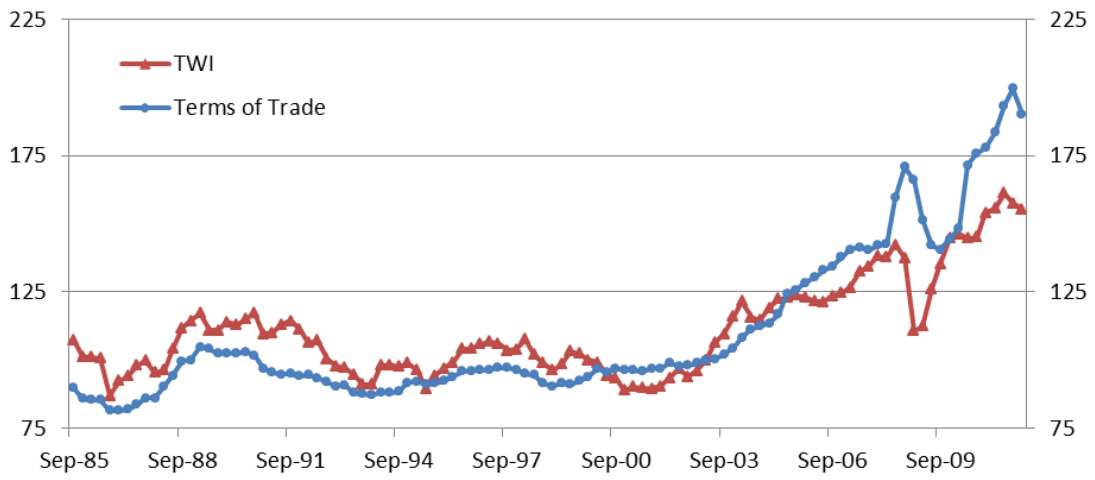
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FIGURE 1

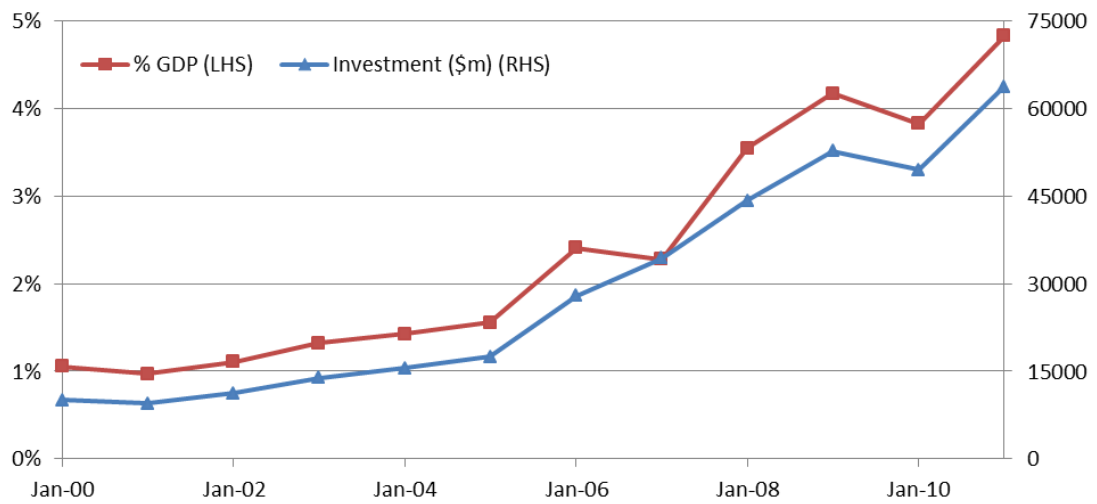
Australia's Terms of Trade and Real Effective Exchange Rate (TWI)
 Mar 2003 = 100



Sources: www.abs.gov.au, www.rba.gov.au

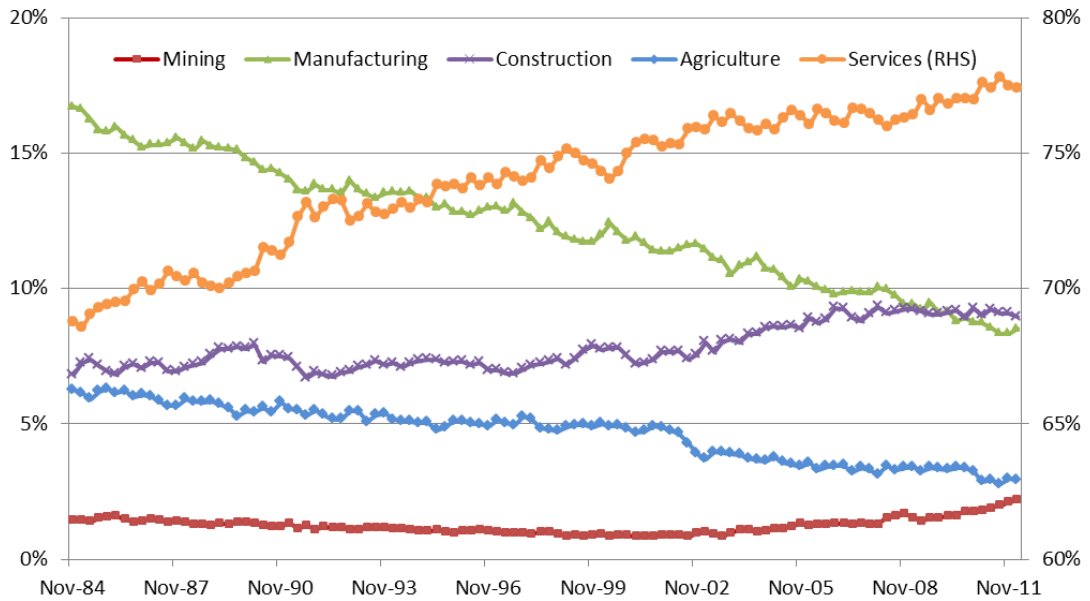
FIGURE 2

Australian Mining Investment, Total Value and Share of GDP



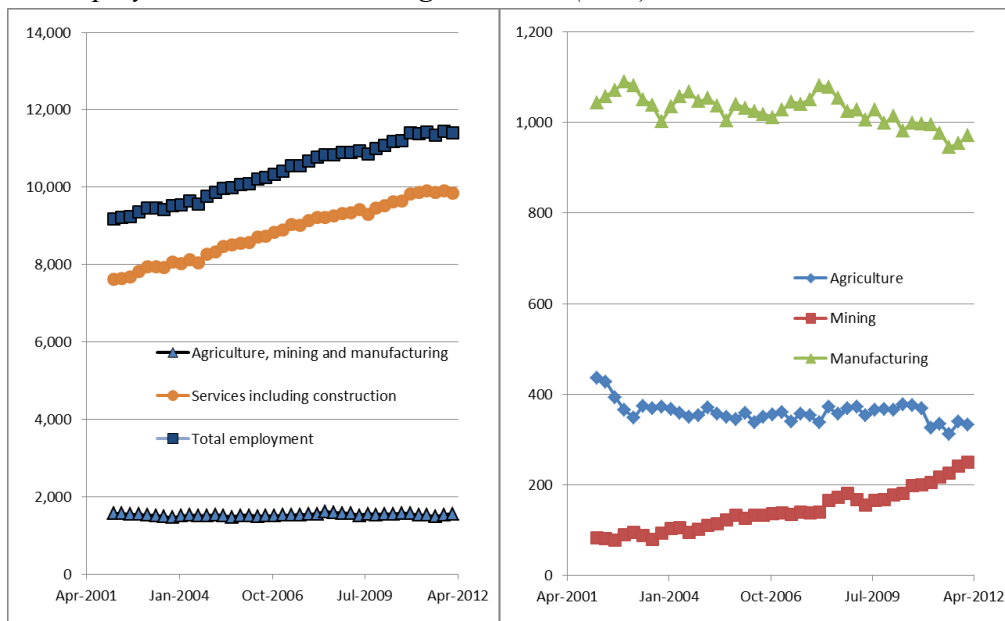
Sources: ABS Cat. 5206.6, 5204.52

FIGURE 3
Australian Industry Shares of Total Employment



Source: ABS Cat. 6291.4

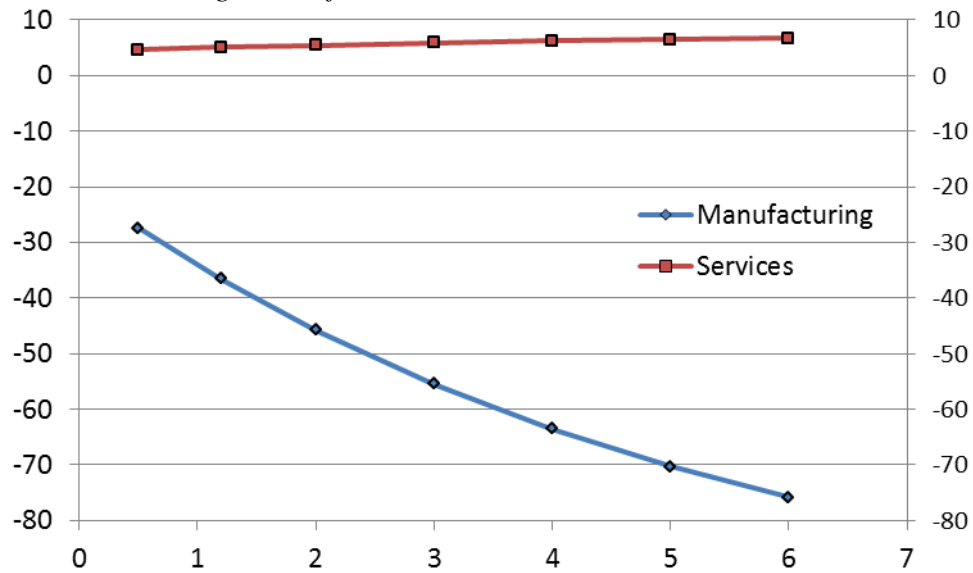
FIGURE 4
Australian Employment Numbers During the Boom ('000)



Source: ABS Cat. 6291.4

FIGURE 5

Sensitivity of Simulated Manufacturing and Services Output to the Elasticity of Substitution Between Home and Foreign Manufactures^a



^a Here the closure 1 (price rise and investment phases) general equilibrium simulation is repeated for different values of the elasticity of substitution between home and foreign manufactures.

Source: Simulations of the general equilibrium model described in the text.

FIGURE 6

GVA responses to a one standard deviation innovation in the TOT (VAR01)

Response to Cholesky One S.D. Innovations ± 2 S.E.

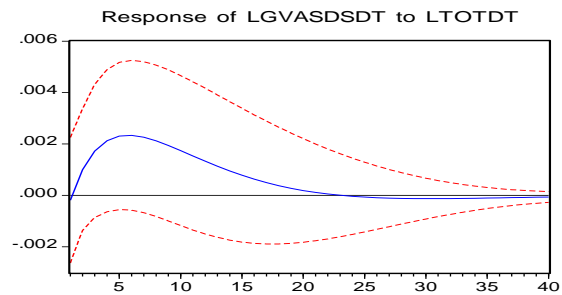
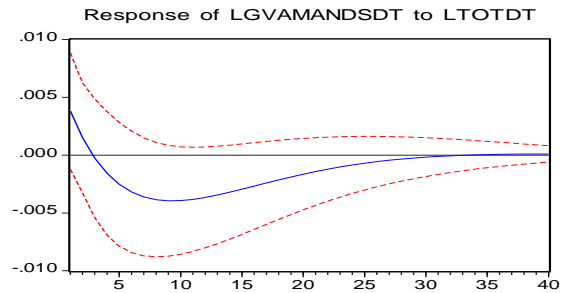
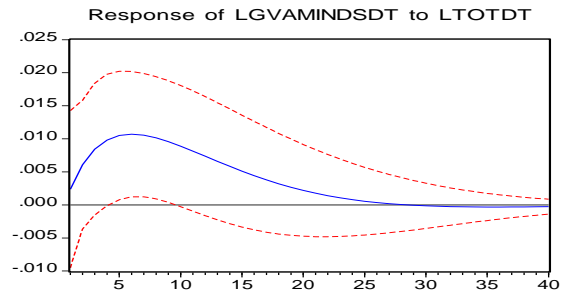


FIGURE 7

Employment responses to a one standard deviation innovation in the TOT (VAR02)

Response to Cholesky One S.D. Innovations ± 2 S.E.

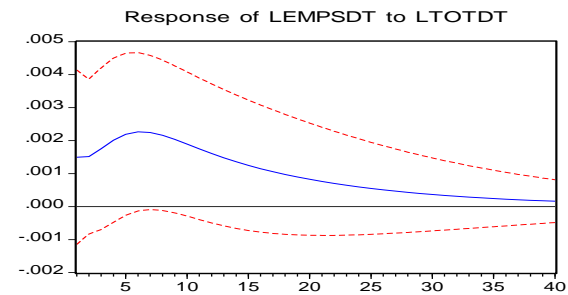
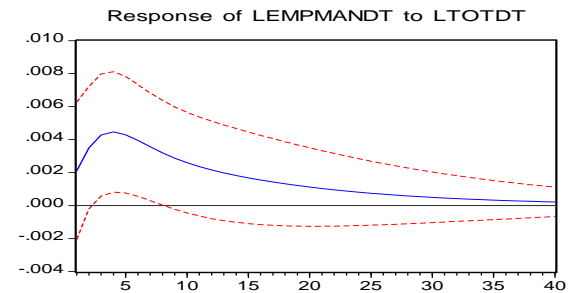
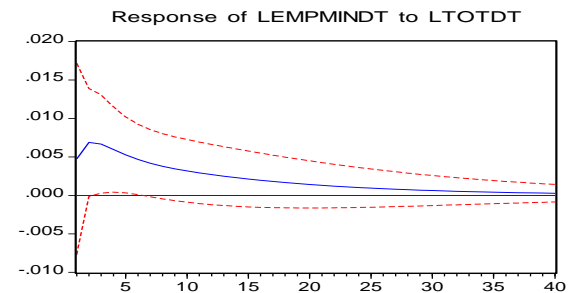
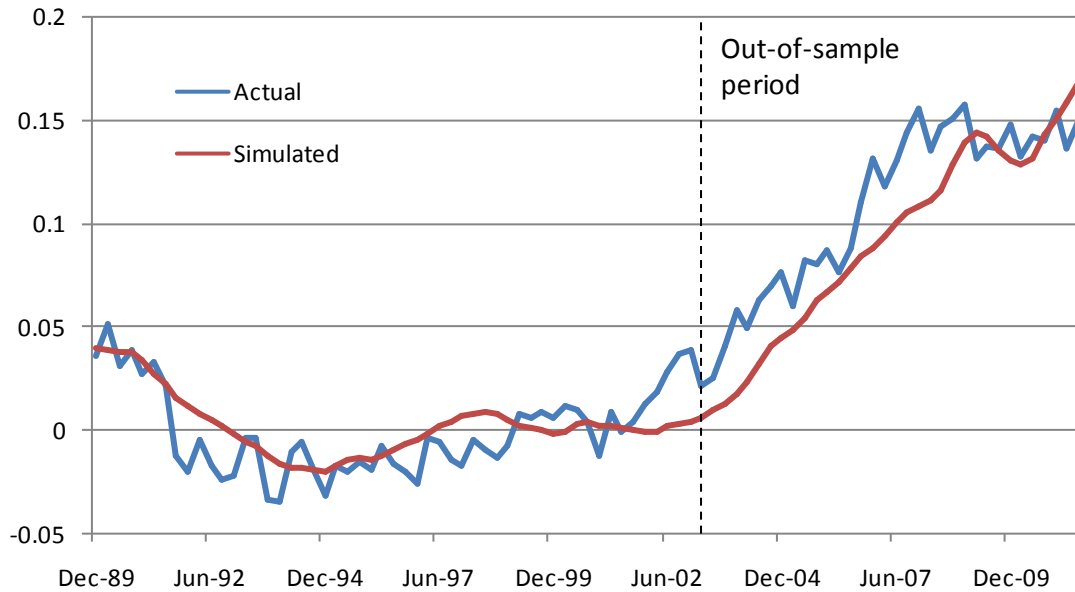


FIGURE 8

Services GVA (Y_s^{ldsdt}), Actual vs Simulated Values

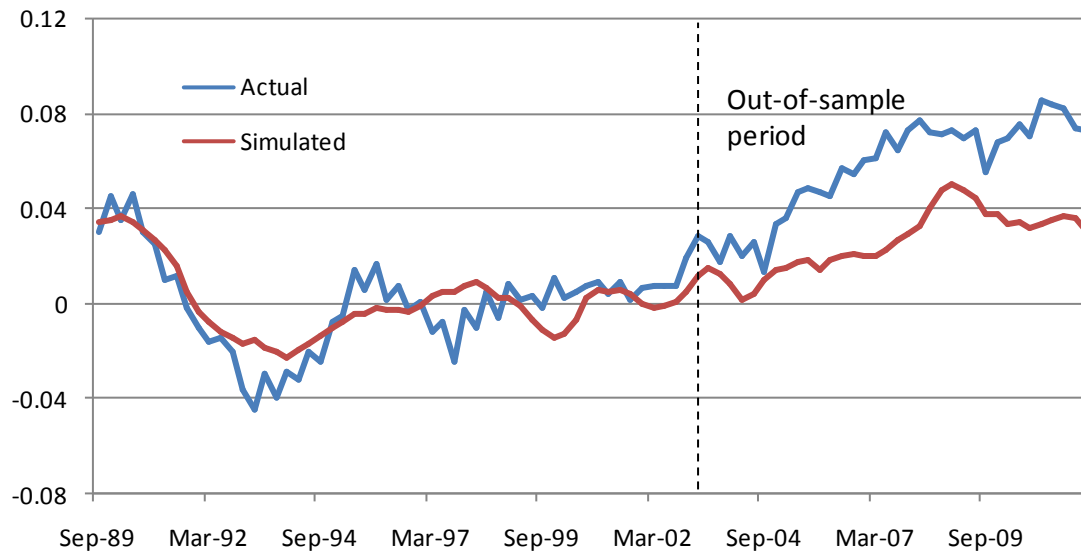


Sources: www.abs.gov.au, and simulations of the model discussed in the text.

Log-levels; Eviews used to transform data and obtain parameter estimates for simulated path.

FIGURE 9

Services Employment (L_s^{ldt}), Actual vs Simulated Values



Sources: www.abs.gov.au, and simulations of the model discussed in the text.

Log-levels; Eviews used to transform data and obtain parameter estimates for simulated path.

TABLE 1
The General Equilibrium Model – Key Parameters

Parameter	Value	Parameter	Value
Shares:		Elasticities of substitution:	
Labour shares ^b (β_L), <i>NRB goods</i>	0.406	Home (σ), <i>NRB goods</i>	6.000
<i>Manufactures</i>	0.557	<i>Manufactures</i>	3.000
<i>Services</i>	0.632	<i>Services</i>	0.500
Capital shares ^b (β_K), <i>NRB goods</i>	0.465	Foreign (σ^*), <i>NRB goods</i>	50.00
<i>Manufactures</i>	0.443	<i>Manufactures</i>	50.00
<i>Services</i>	0.368	<i>Services</i>	0.500
Expenditure shares (δ), <i>NRB goods</i>	0.027	Home import tariff rates (τ):	
<i>Manufactures</i>	0.252	<i>NRB goods</i>	0.050
<i>Services</i>	0.721	<i>Manufactures</i>	0.100
		<i>Services</i>	0.001
Domestic shares of home consumption (s), <i>NRB goods</i>	0.680		
<i>Manufactures</i>	0.354		
<i>Services</i>	0.956		
Home shares in global supply, Q (s^F), <i>NRB goods</i>	0.050		
<i>Manufactures</i>	0.010		
<i>Services</i>	0.005		
<p>a The database values of the share parameters (excluding s^F) reflect the structure of the Australian economy for the year ending June 1997.</p> <p>b The natural resource factor share in the production of <i>NRB goods</i> is the complement of the sum of the corresponding labour and capital shares.</p>			

Source: GTAP 7 data release, identifier R7.0_21Nov08.

TABLE 2
General Equilibrium Simulation Results^a

Variable	Closure 1 Capital immobile internationally ^b	Closure 2 Mobile capital at fixed <i>foreign</i> real rental rate ^c	Closure 3 Mobile capital at fixed <i>domestic</i> real rental rate ^d
Real exchange rate ^e	26.0	20.9	23.2
Real GDP ^f	6.7	34.4	17.4
Real GNP ^g	11.7	18.3	13.6
Stock of foreign owned capital ^h	0.0	309	107
Real unit factor rewards, on CPI			
Natural resource rent	124	363	219
“Consumption” wage	0.4	19.8	7.7
Capital rental rate	14.4	-17.2	0.0
Real unit factor rewards, on GDP price			
Natural resource rent	110	338	201
“Production” wage	-5.8	13.6	1.6
Capital rental rate	7.1	-21.5	-5.6
Sectoral output volume			
<i>NRB</i>	120	354	212
Manufacturing	-55.4	-44.7	-50.8
Services	5.9	12.7	8.2
Change in employment, per cent of original total labour force ⁱ ,			
<i>NRB</i>	8.0	17.8	12.4
Manufacturing	-6.3	-6.4	-6.3
Services	9.3	-1.2	4.5
<p>a Identical shocks are used under all closures: 50 per cent increase in the world price of <i>NRB</i> goods relative to manufactures, 25 per cent increase in capital account net inflow, 10 per cent increase in domestic natural resource endowment and 10 per cent increase in total employed labour. All figures are percentage changes.</p> <p>b The capital stock, including foreign and domestically owned components, is exogenous while unit factor rewards are endogenous.</p> <p>c Capital is internationally mobile so that foreign-owned domestic capital is endogenous while the rental rate is fixed. In this case it is held constant relative to the international (import) price of manufactures. The base share of foreign in total physical capital is about a fifth.</p> <p>d Capital is internationally mobile here but the rental rate demanded by foreign investors rises in the boom – it is held constant relative to the home CPI, which rises relative to the foreign manufactures price.</p> <p>e The real exchange rate is the ratio of the home and foreign GDP prices in a common currency (in this case the model numeraire) which are weighted averages of firm supply prices. The foreign GDP price has fixed components for manufacturing and services.</p> <p>f Real GDP is deflated by the domestic GDP price.</p> <p>g Real GNP is total collective household income deflated by the domestic CPI, which is a complete index of consumer prices stemming from the expenditure function and including imports. Because imports become relatively cheap, this index rises by less than the GDP price.</p> <p>h Foreign owned domestic capital comprises about a fifth of the total stock in the initial equilibrium.</p> <p>i Note that the employed labour force rises by 10 per cent. These per cent changes indicate the relative sizes of the changes in the <i>levels</i> of sectoral employment.</p>			

Source: Simulations of the general equilibrium model described in the text.

TABLE 3
Augmented Dickey-Fuller Tests 1989:3 – 2002:4

Variables	p-values			
	Levels ^a	Log-Levels ^a	De-trended Levels ^b	De-trended Log-Levels ^b
TOT	0.570	0.663	0.362	0.381
Mining GVA [#]	0.710	0.426	0.349	0.165
Manufacturing GVA [#]	0.269	0.272	0.083*	0.093*
Services GVA [#]	0.999	0.829	0.960	0.490
Mining Employment	0.051*	0.023**	0.004***	0.003***
Manufacturing Employment	0.312	0.238	0.071*	0.074*
Services Employment	0.105	0.004***	0.020**	0.006***

a Denotes the test includes a constant and a linear time trend.

b Denotes the test includes a constant.

Denotes the series is de-seasonalised.

*, ** and *** denote rejection of the null hypothesis at the 10, 5 and 1 per cent levels of significance.

TABLE 4

Lag Length Criteria

Lag	VAR01		VAR02	
	AIC	SBC	AIC	SBC
0	-16.37	-16.21	-18.06	-17.90
1	-20.40*	-19.63*	-20.64	-19.88
2	-20.37	-19.00	-21.27*	-19.89*
3	-20.26	-18.27	-21.22	-19.23
4	-19.98	-17.38	-20.99	-18.39

* Indicates the lag length selected by the criterion.

APPENDIX

A1 Conversion of annual nominal GVA series to quarterly:

Using the mining industry as an example, the annual nominal figures are transformed to quarterly as follows. The share of real mining GVA ($RGVA^M$) each quarter for the financial year ending in year t is calculated, where i is the quarter (1,4). The quarterly GVA for year t and quarter i is then:

$$(A1) \quad Y_{i,t}^{min} = \left(\frac{RGVA_{i,t}^M}{\sum_{i=1}^4 RGVA_{i,t}^M} \right) Y_t^{min} .$$

The same procedure is used to transform the annual manufacturing and services nominal GVA series. For these series the annual share accounted for by each quarter is obtained from the quarterly real GVA figures for the manufacturing and services sectors respectively.

A2 Seasonality

Each data series was estimated using an intercept term (c) plus three dummy variables (taking a value of 1 for the quarter they represent and zero otherwise⁴¹). A time trend variable (t) was also included so that the model is:

$$(A2) \quad \text{Series}_t = c + \beta_1 t + \beta_2 D_{2,t} + \beta_3 D_{3,t} + \beta_4 D_{4,t} + \varepsilon_t .$$

These tests are run for each series in both level and log-level forms, over the full interval for each variable. Significant findings are available in Table A3.

The residuals from running equation (A2) are added to the estimated mean of the original series (intercept plus trend term) to obtain the seasonally-adjusted series.⁴² A 'ds' is added to the variable designation once de-seasonalised.⁴³

$$(A3) \quad \text{Seasadj}_t = \text{resid}_t + \bar{c} + \bar{\beta}_1 t$$

⁴¹ D_2 takes a value of 1 for the June quarter, D_3 for the September quarter, D_4 the December quarter.

⁴² Added to significant intercept and trend terms only.

⁴³ For example, the de-seasonalised manufacturing GVA is Y_{man}^{ds} .

Shorter series repetition of de-seasonalisation:

The mining GVA series were again de-seasonalised with respect to D3. Manufacturing and services GVA levels and log-levels were de-seasonalised with respect to all three dummies. The results are shown in Table A4.

A3 Stationarity

A time-series is covariance-stationary (stationary) if it has a constant mean, variance and covariance over time. A series that involves a stationary component plus a *deterministic trend* is labelled a trend-stationary process (TSP), as it becomes stationary when the trend is removed. A series with a stationary component plus a *stochastic trend* is called a difference-stationary process (DSP). A process whose n^{th} difference is stationary is called *integrated* of order n or $I(n)$. It is important to apply the correct technique to a TSP or DSP. Differencing a TSP introduces a unit root (non-stationary) into the moving-average component of the model and causes an unnecessary loss of information. De-trending a DSP fails to remove the stochastic portion of the trend.

There can nonetheless be conflict over stationarity between economic intuition and econometric rigor. If a series is stationary, it implies all shocks are temporary in nature. A non-stationary series also runs the risk of *spurious regression*, where statistical significance is imparted upon a variable which is economically meaningless. However, the Augmented-Dickey-Fuller test for the presence of a unit root (non-stationarity) has very low power to reject the null hypothesis (Enders 2010: 234). Even if the series is indeed non-stationary, sometimes the differencing or de-trending required to obtain stationarity involves the loss of vital information, leading to insignificant results.

The de-trending adopted for each variable is indicated in the text. ADF tests are conducted across the full estimation interval and for the foreshortened interval through 2002. The results for the full interval are in Table A5 while those for the foreshortened interval are in the text.

Table A1: Numerical Model Variables and Base Values

Variable	Base Value ^a	Variable	Base Value ^a
Volumes:		Quantities:	
Output, <i>NRB goods</i>	17869.6	L Supply	370628
<i>Manufactures</i>	46771.8	K stock	238201
<i>Services</i>	243710.0	Foreign-owned K	60000
Exports, <i>NRB goods</i>	13312.5	Land	6748
<i>Manufactures</i>	17113.7		
<i>Services</i>	7898.8	Values:	
Imports, <i>NRB goods</i>	2144.5	GDP	625720.2
<i>Manufactures</i>	54121.8	GDP _{FC}	615577.0
<i>Services</i>	10853.2	GNP ^b	665458.2
		Net Capital Inflows (KA) ^b	99738.0
Prices:		Net Income Repatriation ^d	60000.0
Wage, capital and land rent	1.00	Export Value	85311.0
Price, <i>NRB goods</i>	2.68	Import Value	125048.7
<i>Manufactures</i>	2.00	Tariff Revenue	10143.2
<i>Services</i>	1.95		
Border Price, <i>NRB goods</i>	2.55	Real Factor Rewards:^e	
<i>Manufactures</i>	1.82	<i>Land</i>	0.51
<i>Services</i>	1.94	<i>Labour</i>	0.51
Consumer Price Index (CPI)	1.98	<i>Capital</i>	0.51
GDP price ^c	1.00	Foreign GDP price ^c	1.00
<p>a The database values of the original endowments and GDP_{FC} reflect the structure of the Australian economy for the year ending June 1997.</p> <p>b Net inflows on the capital account are larger than net income repatriation on the current account, raising GNP above GDP.</p> <p>c The GDP price is initially defined as unity, and subsequently adjusted as a weighted average of producer prices. The foreign one is a correspondingly weighted average of import prices and a fixed foreign services price with fixed weights. When the price of NRB goods is raised exogenously, both GDP prices adjust but the weights embodied in the domestic GDP price are endogenous along with all the producer prices of domestic varieties. The real exchange rate is defined as the home GDP price over the foreign GDP price.</p> <p>d Net income repatriation is the sum repaid to foreigners as return on the physical capital they own.</p> <p>e Real Factor Rewards refer to real <i>consumption</i> factor rewards, which are the nominal prices w_j divided by the CPI.</p>			

Table A2: Data Sources Summary

Data	Variables	Citation	Website
Nominal Gross Value Added by industry (annual)	Y_{min}, Y_{man}, Y_s	Australian Bureau of Statistics 2012b.	www.abs.gov.au
Real Gross Value Added by industry (quarterly proxy)		Australian Bureau of Statistics 2012a.	
Employment (by industry)	L_{min}, L_{man}, L_s	Australian Bureau of Statistics 2012d.	www.abs.gov.au
Terms of Trade	T	Reserve Bank of Australia 2012.	www.rba.gov.au

Table A3: Selected Seasonality Tests (p-values^a) – Full Data Period (1989:3 - 2011:4^b)

Series _t	c	β_1	β_2	β_3	β_4
Y_{min}	0.000***	0.000***	0.640	0.256	0.431
Y_{min}^l	0.000***	0.000***	0.496	0.067*	0.280
Y_{man}	0.000***	0.000***	0.031**	0.000***	0.000***
Y_{man}^l	0.000***	0.000***	0.028**	0.000***	0.000***
Y_s	0.689	0.000***	0.520	0.119	0.060*
Y_s^l	0.000***	0.000***	0.119	0.000***	0.000***

a p-values are given for the estimated coefficients in equation (A2).

b The mining investment series runs from 1985:3 to 2011:4.

*, ** and *** denote rejection of the null hypothesis (coefficient value = zero) at the 10, 5 and 1 per cent levels of significance.

Table A4: Selected Seasonality Tests (p-Values^a) – Sample Period (1989:3 - 2002:4)

Series_t	c	β₁	β₂	β₃	β₄
Y_{min}	0.000***	0.000***	0.359	0.020**	0.263
Y_{min}^l	0.000***	0.000***	0.176	0.004***	0.154
Y_{man}	0.000***	0.000***	0.039**	0.000***	0.000***
Y_{man}^l	0.000***	0.000***	0.052*	0.000***	0.000***
Y_s	0.000***	0.000***	0.464	0.011**	0.006***
Y_s^l	0.000***	0.000***	0.163	0.000***	0.000***

a p-values given for the estimated coefficients in equation (A2).

*, ** and *** denote rejection of the null hypothesis (coefficient value = zero) at the 10, 5 and 1 per cent levels of significance.

Table A5: Augmented Dickey-Fuller Tests (p-Values, 1985:3 - 2011:4)^{a,b}

Variables	Levels^b	Log-Levels^b	De-trended Levels^c	De-trended Log-Levels^c
Terms of trade	0.857	0.874	0.513	0.571
Mining GVA	0.772	0.866	0.344	0.589
Manufacturing GVA ^d	0.221	0.492	0.069*	0.208
Services GVA ^d	0.970	0.085*	0.790	0.097*
Mining employment	0.999	0.989	0.995	0.904
Manufacturing Employment	0.093*	0.093*	0.022**	0.022**
Services employment	0.622	0.079*	0.272	0.019**

a Mining investment ends at 2011:2. Mining, manufacturing and services GVA are tested over the period 1989:3 to 2011:2.

bDenotes the test includes a constant and a linear time trend.

c Denotes the test includes a constant.

d Manufacturing (level and log-level) and services GVA (log-level) are de-seasonalised series.

*, ** and *** denote rejection of the null hypothesis at the 10, 5 and 1 per cent levels of significance.