Research Discussion Paper

The Effect of the Mining Boom on the Australian Economy

Peter Downes, Kevin Hanslow and Peter Tulip

The Effect of the Mining Boom on the Australian Economy

Peter Downes*, Kevin Hanslow** and Peter Tulip***

Authors: peter.downes at domain OutlookEconomics.com
and tulipp at domain rba.gov.au

Media Office: rbainfo@rba.gov.au

Abstract

This paper estimates the effects of the mining boom in Australia, using a large-scale structural macroeconometric model, AUS-M. We estimate that the mining boom boosted real per capita household disposable income by 13 per cent by 2013. The boom has contributed to a large appreciation of the Australian dollar that has weighed on other industries exposed to trade, such as manufacturing and agriculture. However, because manufacturing benefits from higher demand for inputs to mining, the deindustrialisation that sometimes accompanies resource booms – the so-called 'Dutch disease' – has not been strong.

Table of Contents

The Effect of the Mining Boom on the Australian Economy

Peter Downes, Kevin Hanslow and Peter Tulip

1.   Introduction

The world price of Australia's mining exports has more than tripled over the past decade, while investment spending by the mining sector increased from 2 per cent of GDP to 8 per cent. This 'mining boom' represents one of the largest shocks to hit the Australian economy in generations. This paper attempts to quantify some of its effects, using a large-scale structural model of the Australian economy, AUS-M.

We find that the mining boom has substantially increased Australian living standards. By 2013, we estimate that it had raised real per capita household disposable income by 13 per cent, raised real wages by 6 per cent and lowered the unemployment rate by about 1¼ percentage points. There have also been costs. The boom has led to a large appreciation of the Australian dollar that has weighed on other industries exposed to trade, such as manufacturing and agriculture. However, because manufacturing benefits from higher demand for inputs to mining, the deindustrialisation that sometimes accompanies resource booms – the so-called 'Dutch disease' – has not been strong. We estimate that manufacturing output in 2013 was about 5 per cent below what it would have been without the boom.

2.   Previous Research

Our analysis builds on a large body of research, much of which is by Australian academics, on the 'Dutch disease'. Prominent papers include Gregory (1976), Corden and Neary (1982), Corden (1984) and Cook and Seiper (1984). This work emphasises that a boom in commodity exports often affects the broader economy by inducing an appreciation of the real exchange rate. This tends to raise general living standards by reducing the relative cost of imports. However, the appreciation also weakens the competitiveness of other exporters and of import-competing industries such as manufacturing.

Later studies have explored how the effects of a resource boom depend on its cause. Bean (1987) notes that the discovery of oil in the 1970s and the consequent increase in investment had different effects on the UK economy than the increase in oil prices following the second oil price shock in 1979–1980. In Bean's modelling both booms lead to an exchange rate appreciation. However, in the first boom, driven by new discoveries, the expansion of demand for manufactured goods due to higher investment more than offsets the effects of the exchange rate on manufacturing. In contrast, in the second boom, which was driven by higher prices, the negative impact on the exchange rate is larger than the positive impact on investment and manufacturers are worse off.

Cagliarini and McKibbin (2009) look at the impact on Australia of a rise in energy and mining commodity prices relative to manufacturing prices driven by: (1) rising productivity in China; (2) a reduction in risk; and (3) monetary easing in the United States. One surprising result is that an increase in commodity prices driven by an increase in manufacturing productivity in China *reduces* income and GDP in Australia by drawing capital away from OECD countries and increasing global real interest rates. Jääskelä and Smith (2011) examine effects on the Australian economy of changes in the terms of trade arising from: (1) an increase in world demand; (2) developments in individual commodity markets; and (3) globalisation and the rise of Asia, where rising commodity demand and prices are accompanied by lower manufacturing prices. The estimated impacts are markedly different for output, inflation and the exchange rate.

There have been numerous applications of these general principles to recent Australian developments, including Connolly and Orsmond (2011), Sheehan and Gregory (2012), Minifie *et al* (2013), Plumb, Kent and Bishop (2013), Edwards (2014) and other references we cite below. Although we use a similar analytical framework to most of these papers, our work differs in that we quantify the timing and magnitude of economic responses. Specifically, we construct a counterfactual for how the economy would have evolved without the boom; comparisons with this scenario distinguish the effects of the mining boom from developments that would have occurred anyway. Our empirically grounded counterfactual lets us discuss effects in greater detail.

Like us, Rayner and Bishop (2013) use input-output tables to estimate how the mining boom has affected different sectors of the economy. Our approach extends this work by including effects working through the greater purchasing power of national income, the exchange rate and other effects working through relative prices. Our estimates suggest that such 'indirect' effects have been larger than the direct effects of demand on upstream industries.

A set of papers with close parallels to ours has analysed the mining boom with the Monash Multi-Regional Forecasting (MMRF) model. This includes McKissack *et al* (2008), the Productivity Commission (2009) and Thompson, Murray and Jomini (2012). We discuss these papers in Appendix B, where we also compare the two models.

3.   Modelling the Mining Boom

To gauge the impact of the mining boom requires a comparison to what would have happened otherwise. We use the AUS-M model of the Australian economy to construct a counterfactual simulation of history assuming the boom did not occur. In the following subsections we first explain the model and then the counterfactual.

3.1   The AUS-M Model

The Australian Macroeconomic (AUS-M) model is a large quarterly time series structural model of the Australian economy. It is based on the TRYM model, originally developed by the Australian Treasury. AUS-M builds on TRYM by incorporating input-output based demand systems and more industry and commodity detail. In terms of common labels, AUS-M is a modern Keynes-Klein-style model, to which CGE features have been added.

AUS-M retains many of the overarching features of TRYM, including an intent to fit the data closely and to reflect mainstream thinking in economic policymaking circles. Key macroeconomic properties are similar. Output in both models is essentially demand determined in the short run (with some important exceptions, discussed below), with major components of real GDP(E) estimated by separate time series regressions.

The model has three sectors (the household sector, the business sector and the public sector) and three markets (the product market, the labour market and the financial market). Systems of equations link each sector and each market. Each equation also has a long-run representation, and these are combined to form a steady-state version of the model that is simulated to provide forward values for expectation variables. A more detailed description of the model is in Appendix A.

The macroeconomic responses of the model to the mining boom are largely in line with the academic literature on the Dutch disease, as applied to recent developments by Sheehan and Gregory (2012) and Plumb *et al* (2013). Our results can be seen as broadly confirming that earlier work. Our main contribution is quantifying the magnitude and timing of the responses and supplying further detail.

Unlike models such as ORANI, GTAP and G-Cubed where parameters are largely imposed, the parameters in AUS-M are mainly estimated on the basis of the historical time series data. Doing so limits the size of the model, so it is not as detailed as a traditional CGE model. The advantage is that the model has a stronger empirical grounding, especially with regard to dynamic adjustments.

The model is updated quarterly and used for detailed forecasting and sensitivity analysis. It is constantly tested against the data, which promotes a close fit to empirical time series relationships. This helps to provide a realistic description of the dynamics in the economy and a coherent explanation of historical developments.

3.2   The Baseline and Counterfactual Simulations

To quantify the effects of the mining boom, we first simulate the model to recreate history up to mid 2013. That involves the construction of time series of residuals for each of the endogenous stochastic variables of the model.

Many of the effects of the mining boom are still unfolding; in particular, many mining projects are transitioning from their construction phase to production. To capture these developments, we extend the baseline to 2030, using the model's standard forecasting routines. Of course, any such extension is debatable and almost immediately out of date. However, our interest is in deviations from the baseline, which are relatively insensitive to the precise level of the baseline.

Extending our baseline to 2030 also facilitates comparisons with other research and models, discussed in Appendix B. Despite the inclusion of future values, we refer to this as the 'historical baseline' – an unfortunate but standard terminology.

To construct a counterfactual, we then assume different paths for certain exogenous variables and residuals to construct an alternative 'history' in which the mining boom did not occur. Almost all our results compare this counterfactual with our historical baseline. In our view, the mining boom is best viewed as the confluence of several large distinct shocks hitting the Australian economy. This is reflected in the construction of our counterfactual, which proceeds in three major stages, listed below. A few minor adjustments, which are of a more technical nature, are discussed in Appendix C.

A large part of the run-up in mining prices and investment can be explained as a response to faster economic growth among our trading partners. Accordingly, the first step in constructing our counterfactual is to lower recent world growth and industrial production. We hold the trend growth of world industrial production and other global variables constant after 2002 at their 2002 rates. This results in the level of world industrial production being 13 per cent below baseline by 2013 (Figure 1). In doing so, only the trend growth rate is changed, not the variation around the trend – so for example, the global financial crisis still occurs. The slower growth impacts on agricultural, manufacturing and service exports as well as mining exports.

Figure 1: World Industrial Production – with and without the Mining Boom

November 2010 = 1
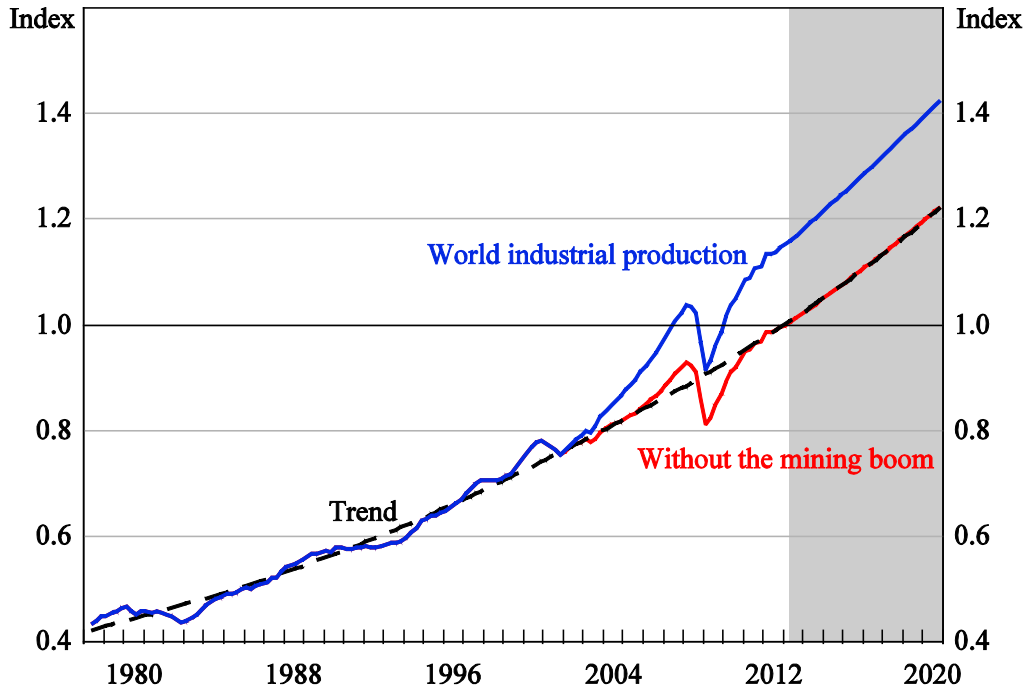
Notes: Trends in world GDP, industrial production and trade are an HP filter (lambda = 20 000) of the natural log of the variable from 1978 to 2002 and then extrapolated; shocked series adjusted from 2002 onwards

Sources: Authors' calculations; CPB Netherlands Bureau for Economic Policy Analysis; Emerging Markets Economic Data Ltd.; OECD; World Bank

Removing the above-trend growth in global demand is estimated to reduce commodity prices by about 40 per cent, but still leaves them well above previous levels (Figure 2). Implicitly, there appears to have been supply-side as well as demand-side elements to the surge in prices, perhaps reflecting depletion of resources. The second step in constructing our counterfactual is to adjust equation residuals so as to lower world mineral prices (including oil and gas) a further 25 per cent, to bring them into line with average levels from 1985 to 2000.

Figure 2: Mineral Commodity Prices – Actual and Counterfactual
November 2010 = 1
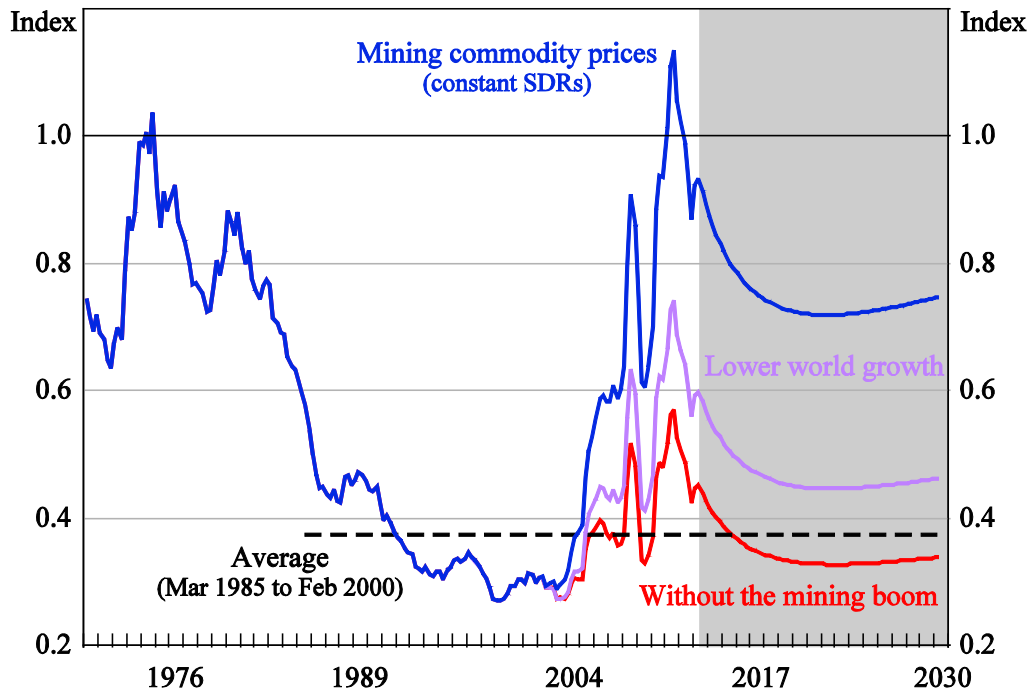
Note: RBA non-rural commodity price index in SDRs divided by G7 consumer prices

Sources: Authors' calculations and AUS-M model database and simulations; Barber *et al* (2013); IMF; OECD; RBA

Even with lower world growth and lower minerals prices, investment in Australian mining surges (Figure 3). That is because AUS-M interprets much of the recent strength of mining investment as a response to the discovery of new resources and technology, over and above the usual response to high prices. For example, the development of horizontal drilling and seam fracturing or fracking technology has allowed the exploitation of coal seam and shale gas reserves that previously were difficult if not impossible to tap. At the same time, a combination of factors in Asian energy markets, particularly concerns over energy security, pollution and greenhouse gas emissions, has led to a demand for the sort of long-term contracts that have allowed commitments to be made to build the projects. And some mining discoveries have reflected simple good luck. Some narratives of these developments describe them as a larger-than-normal effect of demand. However, how these unusual effects are labelled is not a substantive issue.

Accordingly, the third major component of our counterfactual is to lower mining investment beyond the response to lower commodity prices, as shown in Figure 3. We implement this by setting residuals in the mining investment equations to zero.

This means that mining investment in the counterfactual can be interpreted as the standard response to economic conditions, without unusual surprises.

Figure 3: Mining Investment – Actual and Counterfactual
Per cent of trend GDP
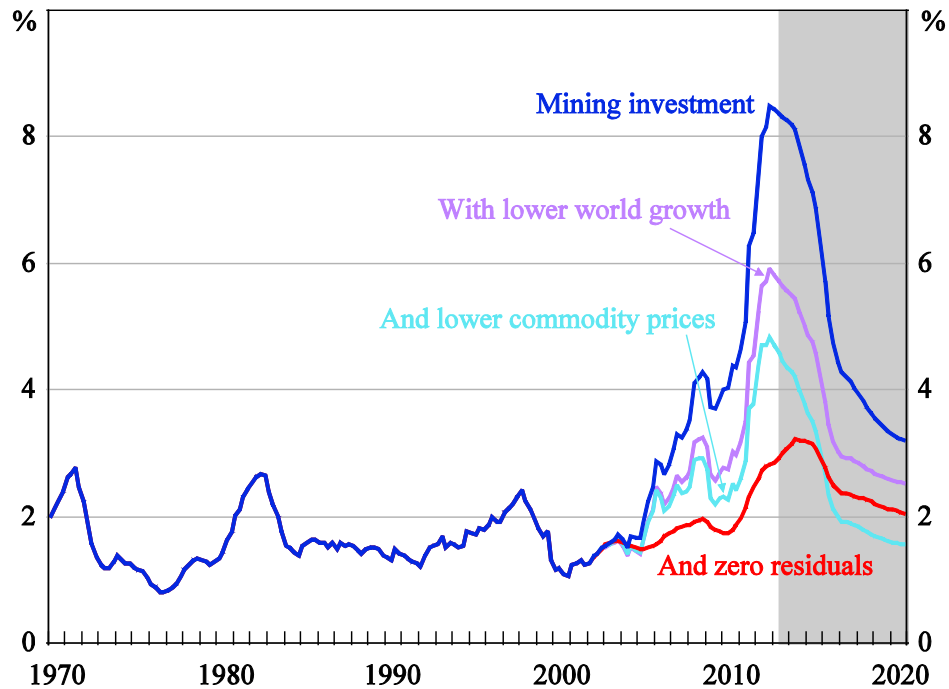
Sources: ABS; Authors' calculations and AUS-M model database and simulations

Our interpretation of the mining boom reflects one possible set of choices and tools. The experiment could easily be designed in other ways. A simple alternative would be to assume that the changes in prices, investment and output were entirely exogenous. For example, we model the effects of an exogenous change in prices in Appendix B. However, given the predictability of the response of the mining industry to growing world demand, a central scenario that did not model these relationships seemed unrealistic and difficult to interpret.

In the other direction, the boom could be explained at deeper levels, for example by tracing its links back to the growth in Chinese steel demand. In a larger, more complicated model, more dimensions of the mining boom could be explained. However, the level of detail in AUS-M provides a constraint on that. And more fundamentally, our focus is on the consequences of the mining boom, not its causes. In the rest of this paper, we take the above developments as given, and explore their effects.

3.3   Caveats

AUS-M provides a simple description of key economic relationships at a relatively aggregated level, estimated with macroeconomic time series. By design, it ignores differences between detailed industry and commodity classifications. For example, our central experiment concerns a change in 'mining prices' and we do not distinguish whether this is a change in iron ore, coal, aluminium or liquefied natural gas (LNG) prices, though in practice these prices have moved differently, with different effects. Nor do we distinguish between where or how the mining is done or by whom. Those differences matter for some purposes, but are beyond the scope of this study. The MMRF model is better suited to address some of these questions. We compare our results with MMRF in Appendix B.

Like all models, AUS-M is a simplification. It relies on data of uneven reliability and applicability. We make many specification choices that others would not necessarily agree with. Human behaviour is not constant and economic structures evolve over time. Economic analysis that involves feedback is complex. Consequently, the model is not meant to be used just in a mechanical way, and results should be interpreted with care.

4.   Aggregate Responses

The following sections discuss how our baseline differs from the counterfactual described above.

4.1   National Income

The effect of the mining boom on living standards can be gauged by the change in real household disposable income per capita. As shown by the green line in Figure 4, this measure is estimated to be about 13 per cent higher in 2013 than it would have been without the boom. In subsequent sections, we discuss in detail how this estimate arises and some of its implications. The effect can largely be decomposed into increases in the relative price (or purchasing power) and volume of output, which are also shown in Figure 4.

Figure 4: Effects of the Mining Boom on Income
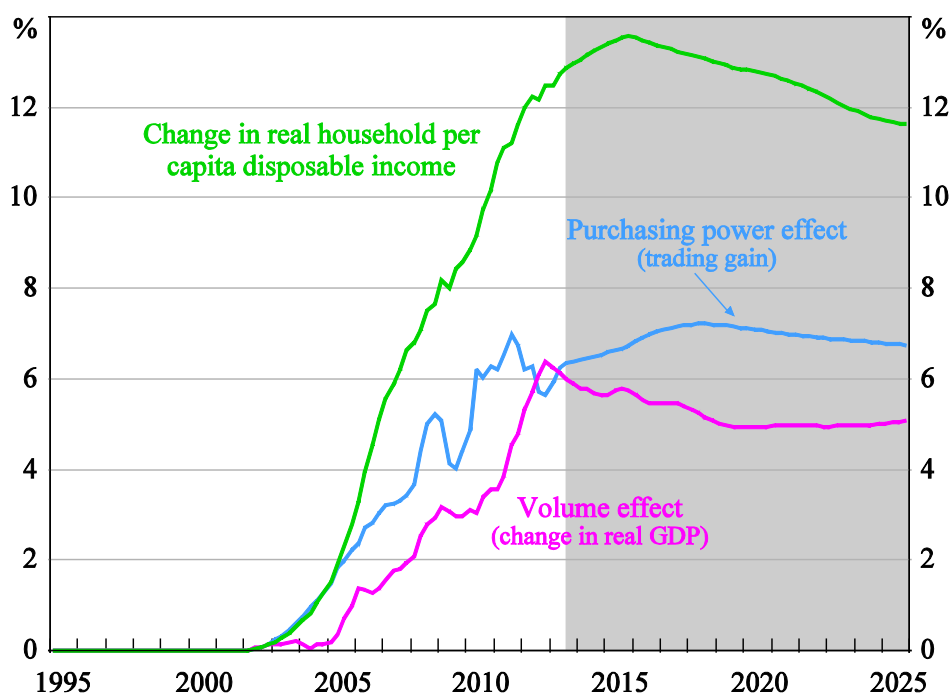
Note: Percentage deviation of baseline estimates from the no-mining-boom counterfactual

Sources: ABS; Authors' calculations and AUS-M model database and simulations

An estimate of the direct relative price effect or trading gain is shown by the blue line in Figure 4. Higher commodity prices translate into higher terms of trade, which directly boost the purchasing power of domestic income. This effect is commonly measured by the change in 'real gross domestic income', where nominal exports are deflated by import prices, rather than export prices. This trading gain boosts real gross domestic income (GDI) by about 6 per cent in 2013.[1] Sheehan and Gregory (2012, Figure 3) discuss the construction of estimates such as these. Their baseline estimate of the trading gain is 11 per cent of GDP, larger than ours because their estimate refers to the doubling of the terms of trade from 2002 to 2011, whereas ours refers to the terms of trade being 39 per cent higher in 2013 than in our counterfactual. As we discuss in Section 5.2, the change in real GDI overstates the increase in the purchasing power of national income, because some of the benefit accrues to foreign investors.

The pink line in Figure 4 represents an estimate of the increase in the volume of goods and services produced arising from the boom. Higher mining investment directly contributes to higher aggregate demand. Furthermore, higher national

---

1 We weight the trading gain using volume weights from the historical baseline. The estimate is not sensitive to this choice of weights.

purchasing power boosts consumption and other spending components. Higher mining investment also increases the national capital stock and hence aggregate supply. There are many further compounding and offsetting effects which are discussed below. However, the estimated net effect is to increase real GDP by 6 per cent (Figure 4).

The increase in the volume and value of domestic production, noted above, account for most of the increase in household disposable income shown in Figure 4. There are also minor contributions from changes in taxes, in foreign income, in population, and so on. We discuss the more important of these issues below.[2]

4.2   The Exchange Rate

Many of the effects of the mining boom estimated by AUS-M reflect changes in the exchange rate. However, estimating exchange rate responses is difficult. Much of the variation in the data seems to be noise. And systematic responses to macroeconomic variables largely reflect changes in expectations, which are not observable. This makes estimated time series correlations difficult to interpret. In AUS-M the exchange rate is assumed to gradually move to a level that reconciles the trade balance with the savings and investment decisions of households, business and government. This means it increases with the terms of trade, and expected rates of appreciation match interest differentials. These effects are calibrated to be consistent with common views, available research and the long-run equilibrium implicit in the model. They are discussed further in Douglas, Thompson and Downes (1997).

Because of its central importance, we decompose the exchange rate change into responses to the different elements of our counterfactual in Figure 5. As can be seen, the exchange rate responds in somewhat similar amounts to the slowing in world growth, the further reduction in minerals prices and the zeroing out of investment residuals. The latter effect reflects the need to offset the long-run effect

---

2 Our estimate of the increase in income arising from the mining boom is greater than that of Edwards (2014). One important reason for the difference is that we consider the trading gain arising from the higher terms of trade to be an increase in real domestic income. Our estimates of the growth in the volume of GDP encompass the effects of this increased income being spent in line with historical correlations, after allowing for the effects of taxes, net income transfers and so on.

on exports and the trade balance. The sum of these effects is that the real exchange rate is estimated to be 44 per cent higher in 2013 than it would have been in the absence of the boom. That is, the exchange rate would not have appreciated but would have remained on average around the same levels as the previous 20 years.

Although precise estimates depend on the details of the experiment, the long-run elasticity of the exchange rate with respect to the terms of trade (as implemented in Appendix B) is 0.8 in AUS-M. The response in Figure 5 is somewhat larger than this, mainly because there is an extra response to mining investment. The AUS-M elasticity compares with an elasticity of 0.9 in the MMRF model (see Table B1) and 0.6 in Stone, Wheatley and Wilkinson (2005, Table 2).

Figure 5: Real Exchange Rate – Actual and Counterfactual
November 2010 = 1
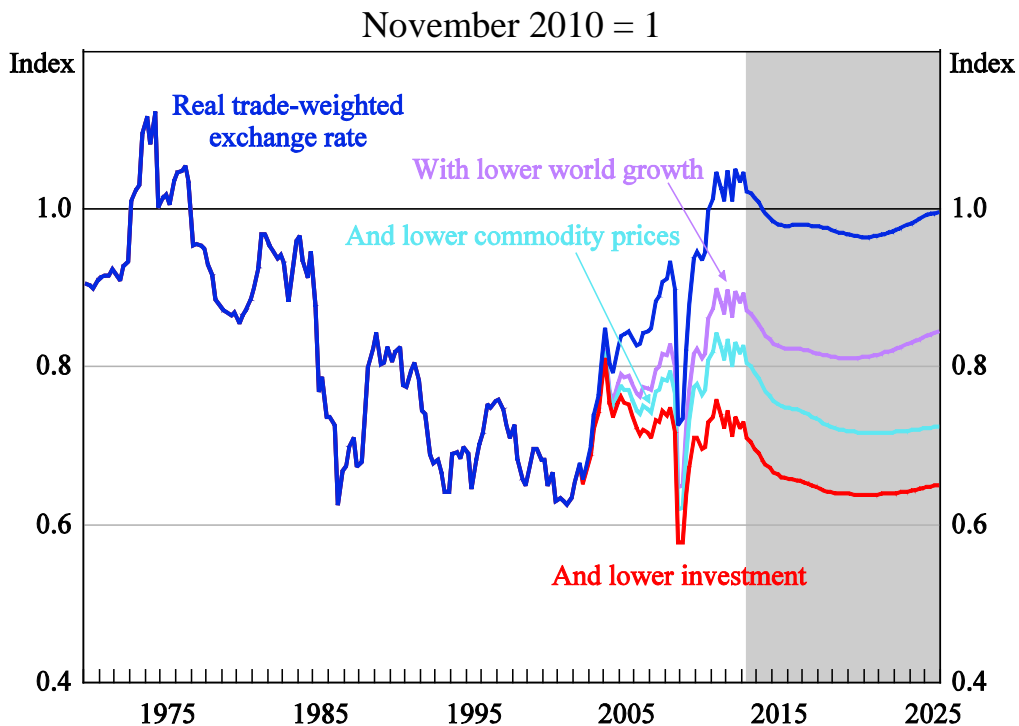
Note: Real trade-weighted exchange rate is the trade-weighted exchange rate adjusted for movements in relative consumer prices

Sources: ABS; Authors' calculations and AUS-M model database and simulations; OECD; RBA

4.3   Unemployment

The stronger activity arising from the mining boom, shown in Figure 4, results in lower unemployment. As shown in Figure 6, the mining boom is estimated to have lowered the unemployment rate by 1¼ percentage points in 2013. Some of this

change represents a reduction in long-term unemployment, which in AUS-M is an important determinant of the non-accelerating inflation rate of unemployment (NAIRU). However, most of the fall in the unemployment rate represents a reduction in economic slack.[3]

Figure 6: Effects of the Mining Boom on Unemployment
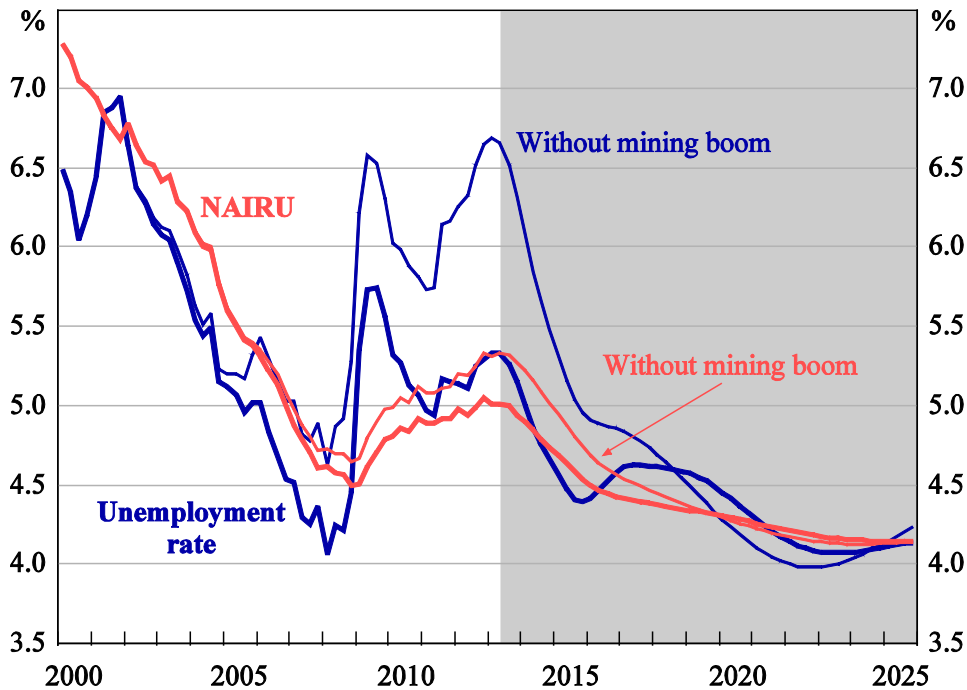
Notes: As with other figures, estimates are based on published data up to 2013 then model simulations thereafter. A divergence between the simulations and subsequently published data is noticeable for the unemployment rate. NAIRU strictly speaking is a NAWRU as it represents the equilibrium from the wage equation.

Sources: ABS; Authors' calculations and AUS-M model database and simulations

4.4   Inflation

The lower unemployment gap (Figure 6) and higher oil prices that accompany the mining boom place upward pressure on inflation. However, these effects are initially more than offset by the appreciation of the exchange rate (Figure 5), which lowers import prices. As shown in Figure 7, the net effect in the first few years of the mining boom is to lower the inflation rate by an average of about half a percentage point. However, in AUS-M, the effect of a change in the exchange rate

---

3   In the absence of the mining boom, AUS-M suggests that the unemployment rate may have remained well above the NAIRU for an extended period of time. This persistence partly reflects asymmetries and non-linearities in the model's Phillips curve, which make inflation relatively insensitive to weak activity.

on inflation is temporary, whereas the effect of a change in the unemployment gap is highly persistent. So, by 2008, the unemployment effect begins to dominate and inflation is higher.

Figure 7: Effects of the Mining Boom on Inflation
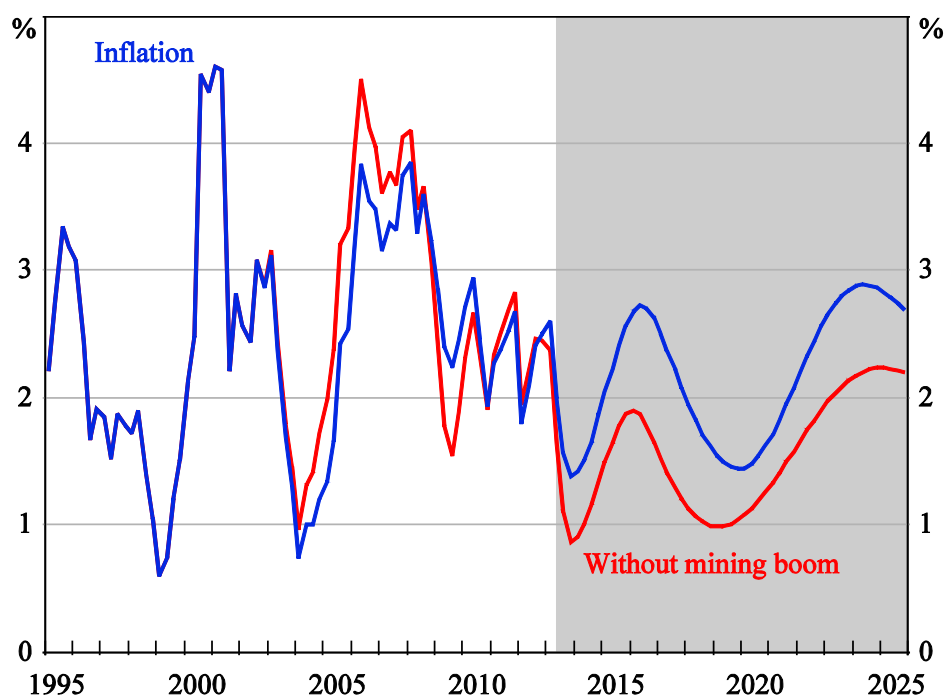
Note: Inflation is measured as the four-quarter percentage change in the household consumption deflator; this national accounts measure differs slightly from the consumer price index

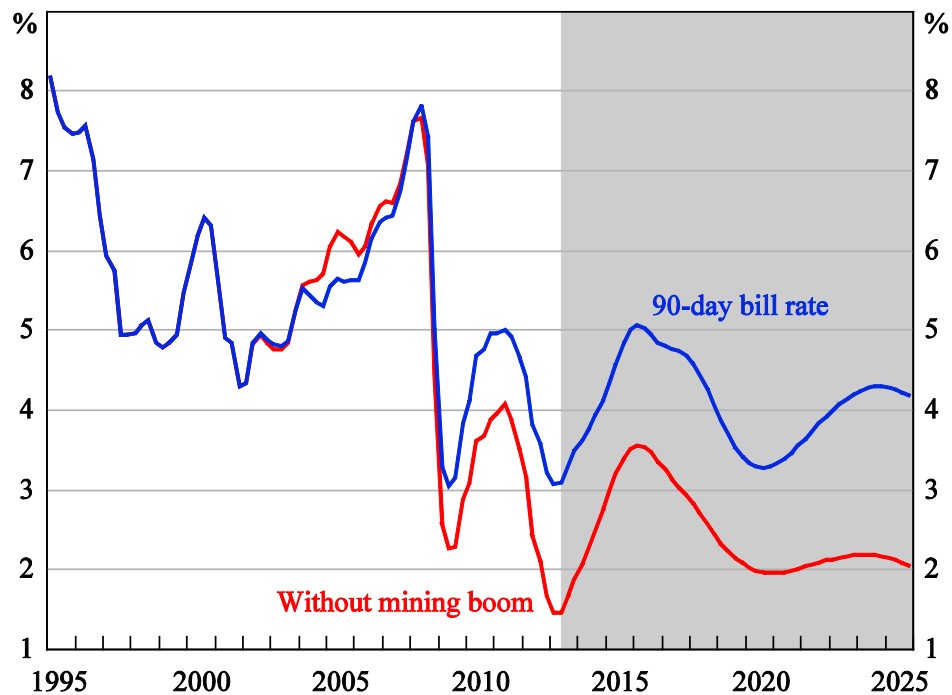Sources: ABS; Authors' calculations and AUS-M model database and simulations

4.5   Interest Rates

Short-term interest rates, represented by the 90-day bank bill rate, are determined by a modified Taylor rule. In the first few years of the boom lower inflation offsets stronger activity and interest rates are slightly lower than they otherwise might have been (Figure 8). However, as the deviation in inflation diminishes, interest rates increase in reaction to the tight labour market. By 2013, interest rates are almost 2 percentage points above their estimated levels without the boom. Interestingly, interest rates are estimated to remain positive in the counterfactual. That is, even without the strong growth in Asia and its effects on minerals prices, and without the surge in mining investment, Australia would still have escaped the zero lower bound on interest rates that has constrained monetary policy in many other countries. The strong fiscal stimulus at that time may be one reason for that.

Figure 8: Effects of the Mining Boom on Interest Rates

Our estimated response of interest rates differs from Plumb *et al* (2013, Figure 3), who suggest that, in theory, interest rates might initially rise in response to an increase in world mining prices. One possible explanation for the difference is that we estimate a larger weight on the response of interest rates to lower inflation arising from the exchange rate appreciation.

5.   Sectoral Responses

5.1   Household Income and its Components

The mining boom is estimated to raise household income through several different channels, shown in Figure 9. As of 2013, the population is about 1 per cent larger than in the counterfactual, reflecting the response of net migration flows to relative job opportunities and higher real wages. Employment is 3 per cent higher, largely due to the boost to aggregate demand. Real consumer wages are about 6 per cent higher, reflecting the effect of the higher exchange rate on import prices. A larger tax base leads to lower average tax rates, which help raise household disposable income by about 13 per cent. Household income is also supported by higher property income, reflecting higher wealth, in turn attributable to higher equity

prices and higher saving (discussed below). Capital gains would boost broader measures of income, though not the national accounts definition.

Figure 9: Effects of the Mining Boom on Household Income
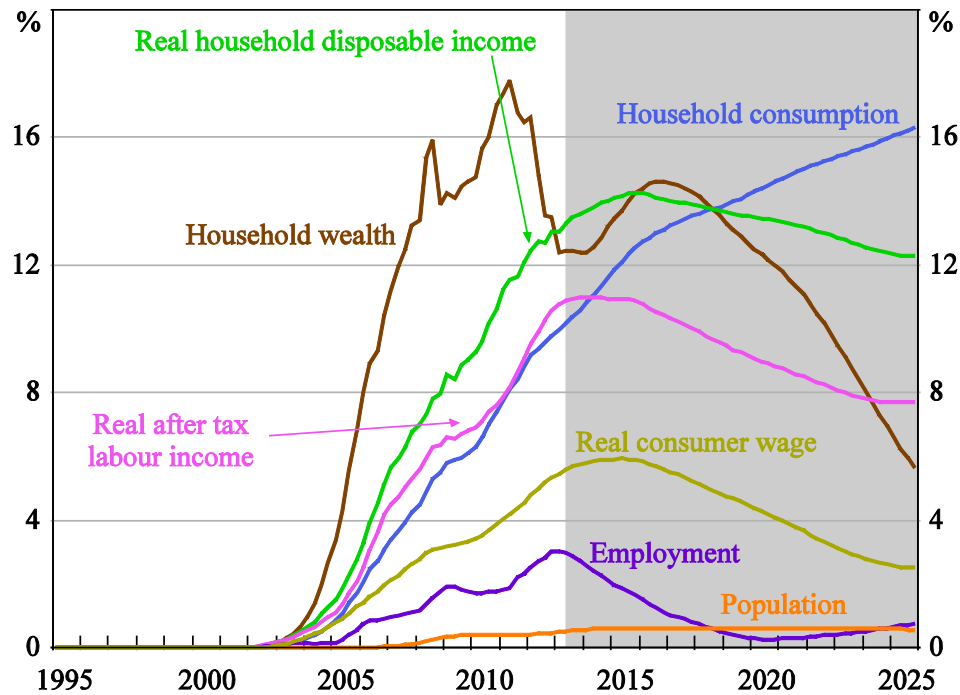
Notes: Percentage deviation of baseline estimates from the no-mining-boom counterfactual; real incomes are deflated by the national accounts consumption deflator; real household disposable income is as defined in the ABS quarterly national accounts' household income and outlay accounts

Sources: ABS; Authors' calculations and AUS-M model database and simulations

5.2 Foreign Income Outflows

An important issue in assessing the contribution of the mining boom to national income is the extent to which the profits of mining companies accrue to foreigners. Sheehan and Gregory (2012) and Edwards (2014) emphasise that some foreign-owned projects will have little impact on the domestic economy apart from the tax paid. This is especially the case for some large LNG projects, where the platforms and processing plants are manufactured overseas and towed to sites off the coast of Western Australia, with little domestic input in either the investment stage or in production. A large part of the return from such projects flows overseas in higher profits. More broadly, many projects have a large domestic input in the investment phase but not in production. Reflecting these concerns, Sheehan and Gregory worry that the domestic benefits from the mining boom may have largely passed.

Estimating the effect of the mining boom on net investment flows is difficult, for several reasons. First, the ABS balance of payments estimate flows of retained earnings where there is an investment stake of 10 per cent or more (foreign direct investment), but not for portfolio investments that fall below this ownership threshold. This means that income accruing to foreigners is understated and national income is overstated. These omissions do not affect data on household disposable income, but will affect the model's projections.

Second, the share of foreign ownership by industry, specifically mining, is even harder to gauge. On the basis of a sample of company publications, Connolly and Orsmond (2011, p 38) calculate that the foreign ownership share might have been around 80 per cent a few years ago, with the share for iron ore producers being a little lower and that for coal and LNG producers a little higher. Given the rise, fall and mergers of many key players in the industry over the past decade or two, the share is unlikely to have been constant.

Third, even if we knew the foreign ownership share of Australian mining, this would only tell us how much of the benefit of a change in *Australian* export prices remains in Australia. For our purposes, the more realistic experiment is a change in *world* mining prices. This also requires an estimate of the benefit Australians gain from their ownership of mines overseas. Balance of payments estimates suggest that Australian foreign mining assets are worth 11 per cent of GDP and foreign mining liabilities are worth 21 per cent of GDP. These estimates can be difficult to interpret as many financial claims are allocated to the finance industry. But it is clear that Australian ownership of overseas mining assets is substantial. For example, it includes a large share of BHP-Billiton's overseas assets following their merger in 2001. And Australian superannuation funds are likely to own significant equity in foreign mining companies.

In the absence of a clear or easy solution to these difficulties, AUS-M's treatment of net foreign investment income is fairly simple. Changes in the industry composition of profits do not explicitly affect net income flows. Higher mining prices lead to moderately larger net dividend payments abroad, though much less than a simple application of Connolly and Osmond's (2011) estimates might suggest. A more subdued response seems appropriate given offsetting dividends from overseas and the financing of investment from retained earnings. This is an issue on which more research and better data are needed.

5.3   Consumption and its Components

As can be seen in Figure 9, household consumption (the blue line) is estimated to initially rise more slowly than real household disposable income (the green line). That is, the saving rate increases. This reflects inertia in consumption, coupled with a default assumption that households initially view the boom as temporary. In the medium to long run, as it becomes apparent that the change in incomes is permanent, savings return toward normal and consumption rises further. In the long run, consumption will adjust to be consistent with the rise in household disposable income, which is around 11 per cent higher per capita.

Changes in the composition of consumption are an important determinant of how the mining boom affects different industries. These compositional changes, in turn, reflect how households react to relative price movements and changing income. Figure 10 shows estimated changes in prices. The higher exchange rate drives the prices of imported goods like motor vehicles and durables lower but has relatively little effect on the prices of most goods and services produced domestically.

Figure 10: Effects of the Mining Boom on Consumer Prices – Selected Components
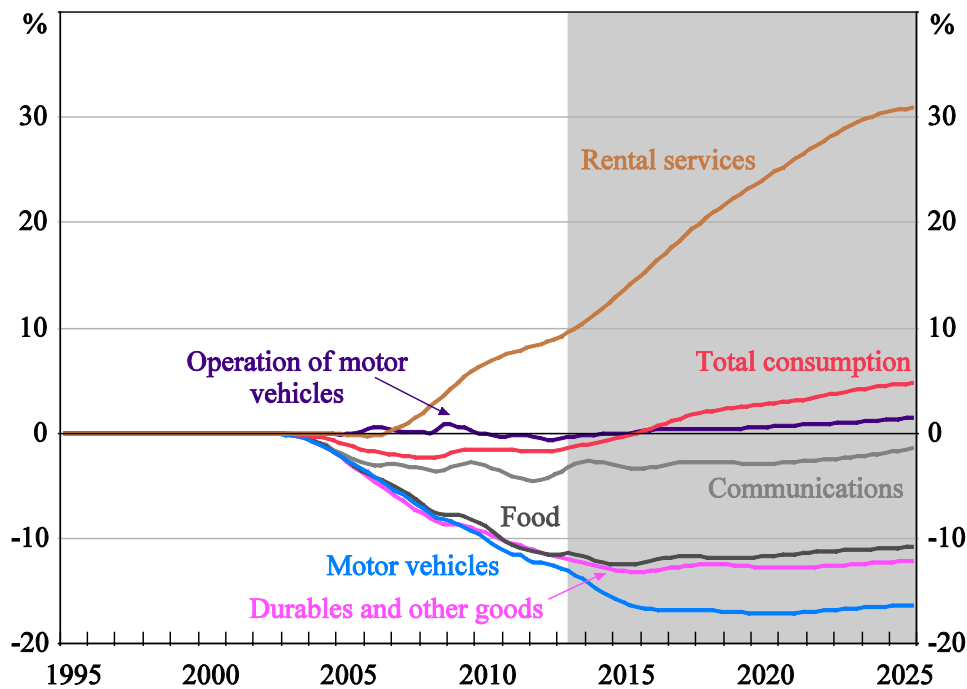
Note: Percentage deviation of baseline estimates from the no-mining-boom counterfactual

Sources: ABS; Authors' calculations and AUS-M model database and simulations

Consumption of durables and motor vehicles also respond strongly to the increase in real household disposable income. The combination of the substitution and income effects mean that motor vehicle purchases may have been 30 per cent higher as a result of the mining boom, and durables 25 per cent higher (Figure 11).

Figure 11: Effects of the Mining Boom on Household Consumption – Selected Components
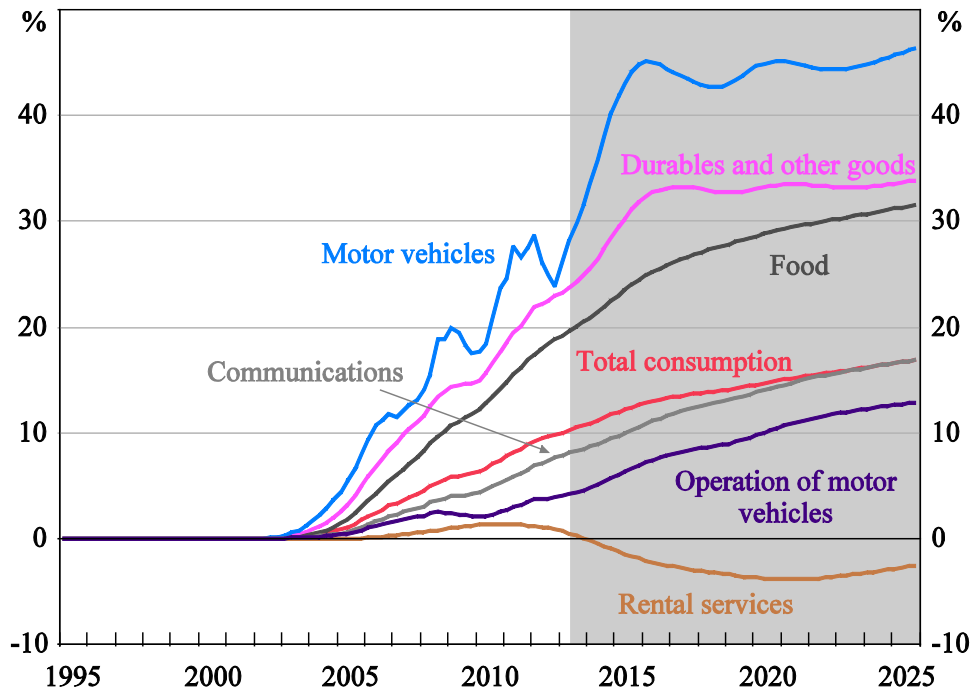

Note: Percentage deviation of baseline estimates from the no-mining-boom counterfactual

Sources: ABS; Authors' calculations and AUS-M model database and simulations

The increase in household disposable income has involved a surge in demand for housing. However, whereas most other elements of consumption are supplied elastically, the supply of housing is relatively fixed in the short run. Thus the mining boom results in a substantial reduction in vacancy rates and rapidly rising rents, as shown in Figures 10 and 12. Although high rents and house prices encourage housing construction, these effects are more than offset by higher interest rates after 2009 (relative to the counterfactual), shown in Figure 8, which depress dwelling investment. So despite strong demand, the supply of housing contracts, compounding the downward pressure on vacancies and upward pressure on rents. We estimate that, without the mining boom, the vacancy rate would barely have fallen below 2 per cent during 2006/07 and rents would have roughly kept pace with inflation.

Figure 12: Housing Vacancies and Rents
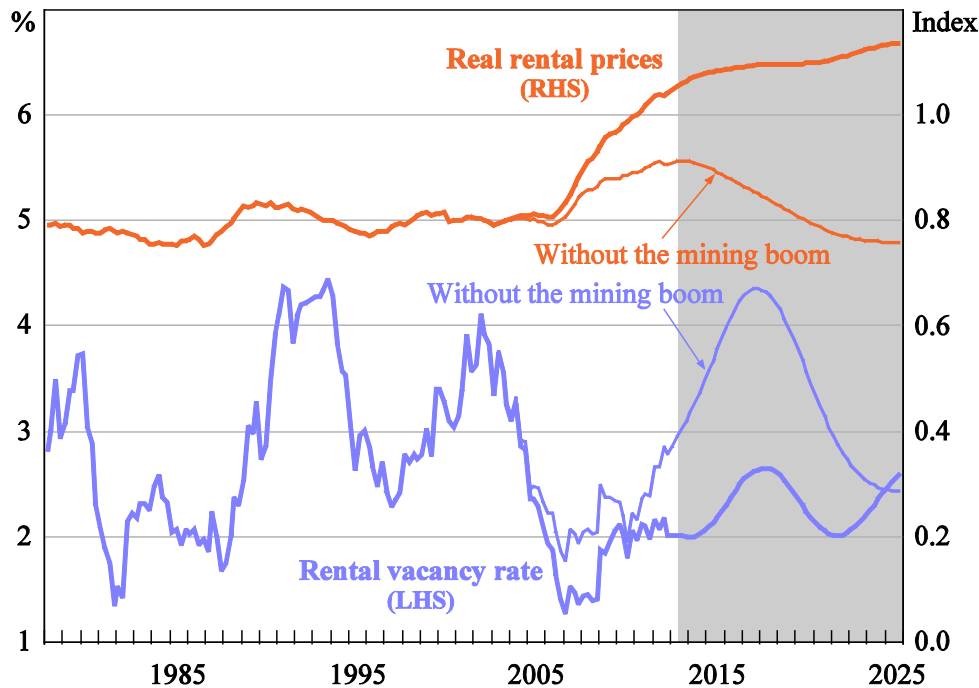
Notes: Real rental prices measured as the deflator for the consumption of rents divided by the deflator for non-rental household consumption, November 2010 = 1; rental vacancies are a population-weighted average of REIA capital city rental vacancies, seasonally adjusted

Sources: ABS; Authors' calculations and AUS-M model database and simulations; Real Estate Institute of Australia (REIA)

5.4 Export Volumes

Exports are modelled in different ways in AUS-M. For commodity exports (agriculture and mining), we assume that goods are reasonably homogenous and that producers are price takers on the world market. Supply is price-inelastic in the short run but responds with a lag to 'internal competitiveness' (the world price expressed in A$ relative to local costs), and hence profitability, which induces investment. For agricultural exports (Figure 13), prices are reduced by the exchange rate appreciation, an effect that is partially offset by the assumed increase in world demand, the latter effect being relatively small. With lower profitability and investment, supply decreases and exports are about 20 per cent lower after a decade.

Figure 13: Mining and Agricultural Export Volumes
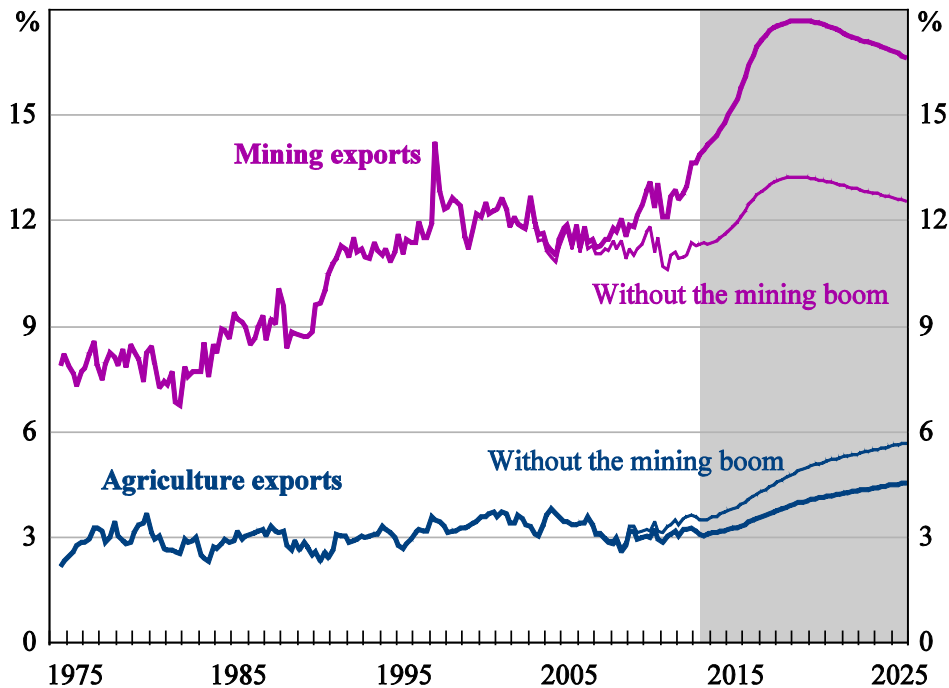
Note: Constant 2010/11 prices expressed as a per cent of GDP

Sources: ABS; Authors' calculations and AUS-M model database and simulations

In contrast, manufacturing and service exporters are assumed to face a downward sloping demand curve, and only supply part of their output to the export market. They are consequently driven by 'external competiveness' (the price of exports in foreign currency on the world market relative to world prices) and are directly affected by fluctuations in world activity (shifts in the demand curve). Strong foreign demand raises the demand for manufacturing and service exports, shown in Figure 14. The effect of strong demand is offset, to varying degrees, by the exchange rate appreciation. For manufacturing exports, the two effects are broadly offsetting and hence there is not a great deal of change. Service export demand is more price sensitive and declines substantially. Although AUS-M does not explicitly include this level of detail, exports of tourism and air transport services seem to have been particularly affected.

Figure 14: Manufacturing and Service Export Volumes
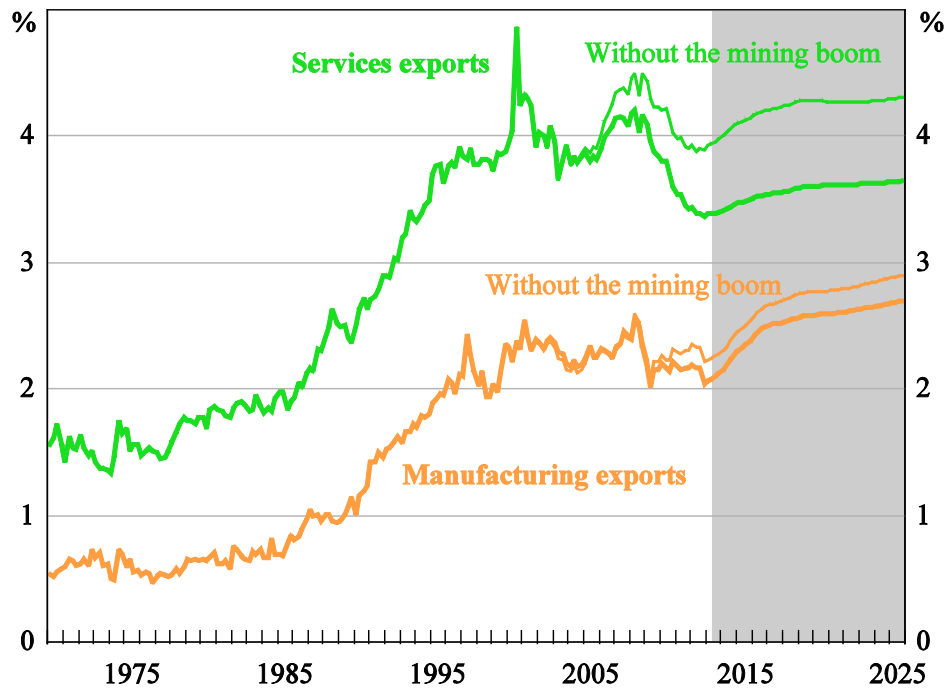
Note: Constant 2010/11 prices expressed as a per cent of GDP

Sources: ABS; Authors' estimates and AUS-M model database and simulations

In short, the major effect of the mining boom on the volume of exports occurs in services and agriculture rather than manufacturing. Although manufacturing exports increased through the 1990s, Australian manufacturing still mainly services the domestic market. The main impact of the mining boom on manufacturing is therefore felt via import substitution from the higher exchange rate, particularly after the investment boom phase, which we discuss further below.

5.5   Output and Price by Industry

AUS-M's treatment of industry responses can be broken down into several stages. First, changes in components of demand, such as disaggregated consumption, investment and exports are estimated, typically on the basis of time-series regressions. Many of these estimates are shown above. These expenditure changes are then mapped to individual supply categories (that is, industry outputs and imports) via input-output coefficients. This approach is very similar to that outlined by Rayner and Bishop (2013) for example. As we illustrate below, this can be presented as an 'input-output weighted demand' for each industry. Then, substitution between different industry outputs and imports is driven by relative prices, in particular the higher exchange rate. Appendix A has further details.

Effects of the mining boom on industry output are shown as deviations from the counterfactual in Figure 15 and as shares of constant price GDP in Figure 16. Consistent with previous studies such as Stoeckel (1979), the largest impact of the boom, outside mining, is on agriculture. It is an industry heavily dependent on the export market and gains little benefit from the surge in domestic incomes and demand associated with the mining boom. However, the result is dependent on the assumption that world agricultural prices are little affected by higher global activity and industrial production.

Figure 15: Effects of the Mining Boom on Industry Output
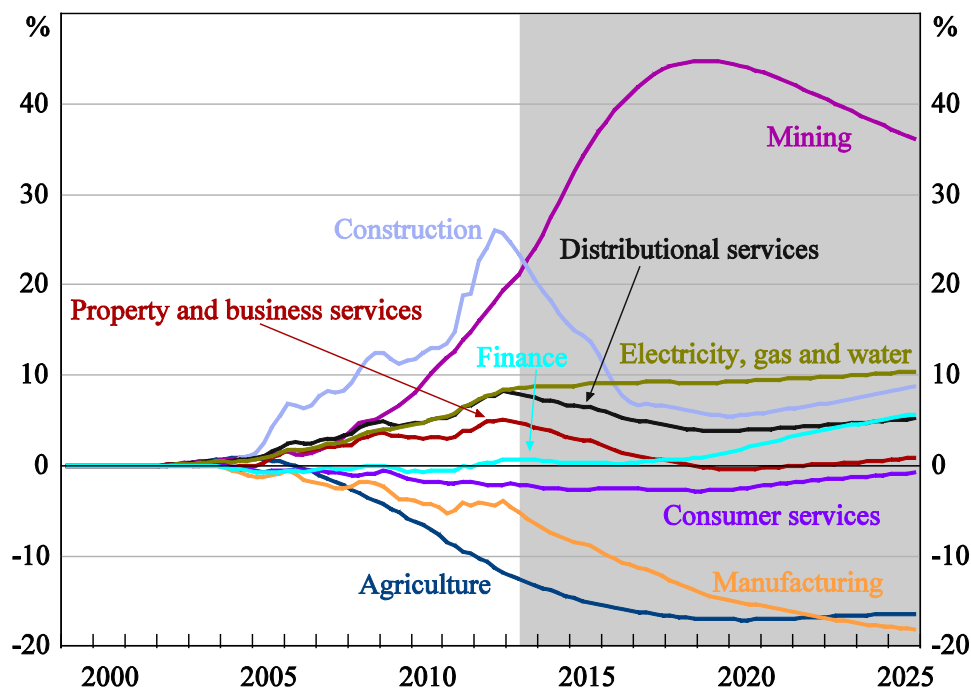
Notes: Percentage deviation of baseline estimates from the no-mining-boom counterfactual; industry output is the chain volume measure of value added

Sources: ABS; Authors' estimates and AUS-M model database and simulations; RBA

Figure 16: Output Shares in GDP – Selected Industries
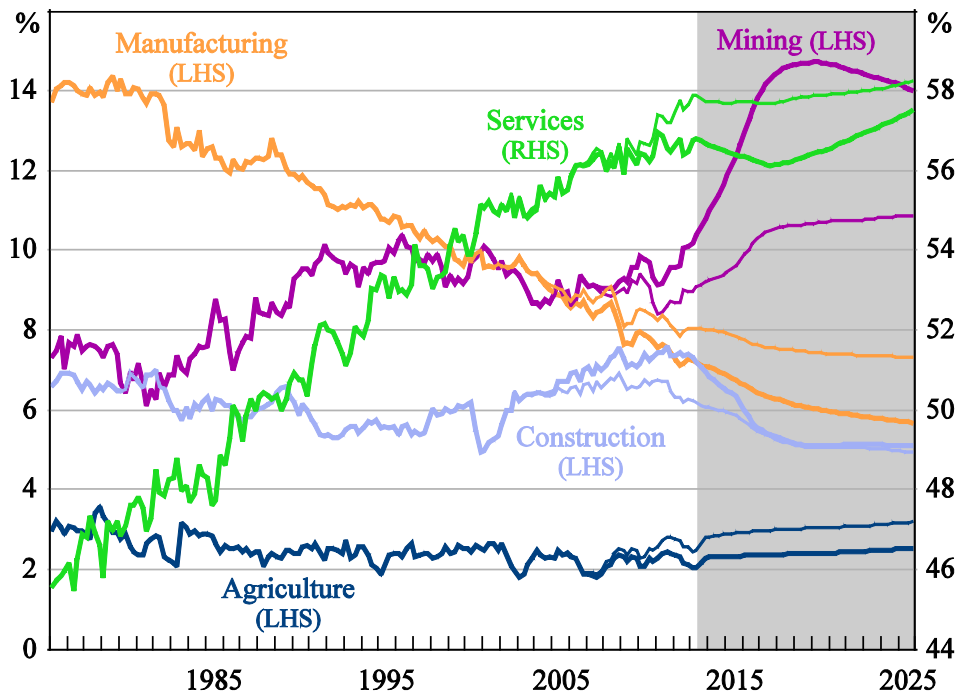
The industries that are estimated to benefit most from the boom, outside mining itself, are construction; electricity, gas and water; and distributional services. These industries sell a disproportionate share of their output to the mining industry. The effect on electricity, gas and water reflects in part the heavy use of electricity in the production of aluminium. AUS-M classifies aluminium exports within the mining category, though elsewhere it is often considered as part of manufacturing. The aluminium industry has not grown as quickly as some other resource industries, so a more disaggregated analysis would presumably show weaker demand for electricity.

Figure 17 shows the effect of the mining boom on industry output (value-added) prices. The main changes in prices are for industries selling tradeable goods, such as mining, agriculture and manufacturing. For domestic non-commodity industries, price changes are relatively small.

Figure 17: Effects of the Mining Boom on Industry Output (Value-added) Prices
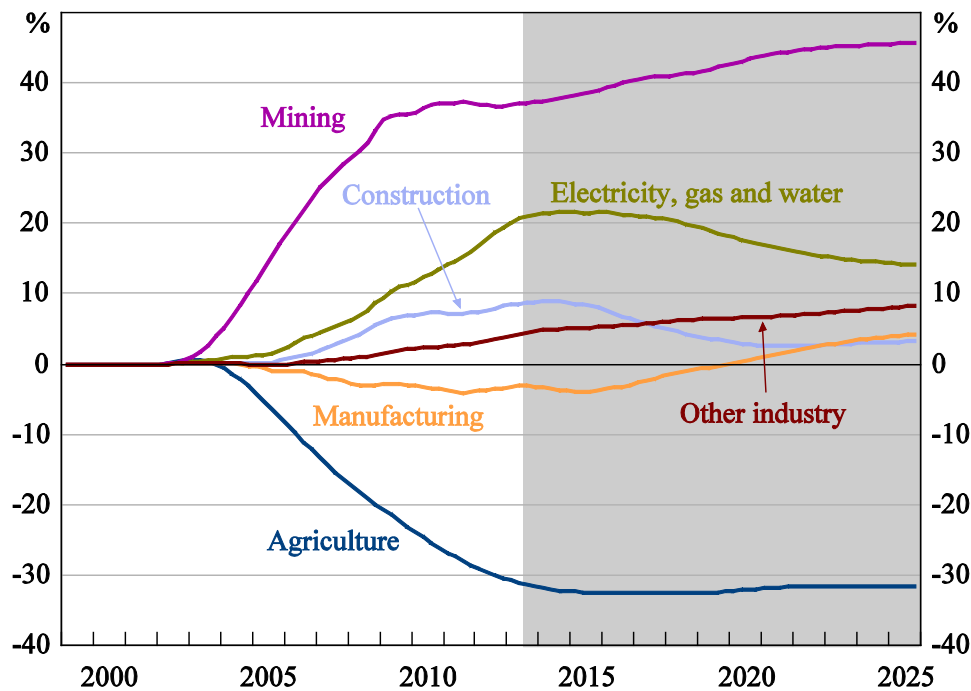
Note: Percentage deviation of baseline estimates from the no-mining-boom counterfactual

Sources: ABS; Authors' calculations and AUS-M model database and simulations

The manufacturing sector has been the focus of concern about the 'Dutch disease' and 'deindustrialisation'. In the short term, manufacturing output is supported by the higher incomes and expenditure associated with the mining boom. In particular, manufacturing benefits from strong demand for equipment and material used in construction. This can be seen in the line labelled 'input-output weighted demand' in Figure 18, which is somewhat stronger than GDP. As a result, investment by manufacturing (not shown) is higher in the first few years of the boom, a result that Bean (1987) found in his study of the effects of North Sea oil in the United Kingdom. However, this effect is more than offset by the 40 per cent appreciation of the exchange rate, which makes manufacturing less competitive. In the first decade of the boom the net effect is moderate, with manufacturing output estimated to be about 5 per cent lower in 2013 than it would have been in the absence of the boom. Then, as the investment boom fades, and with it the demand for manufacturing inputs, the relative price effects increasingly dominate. By 2016, manufacturing output is about 13 per cent lower, an effect that continues to increase over time.
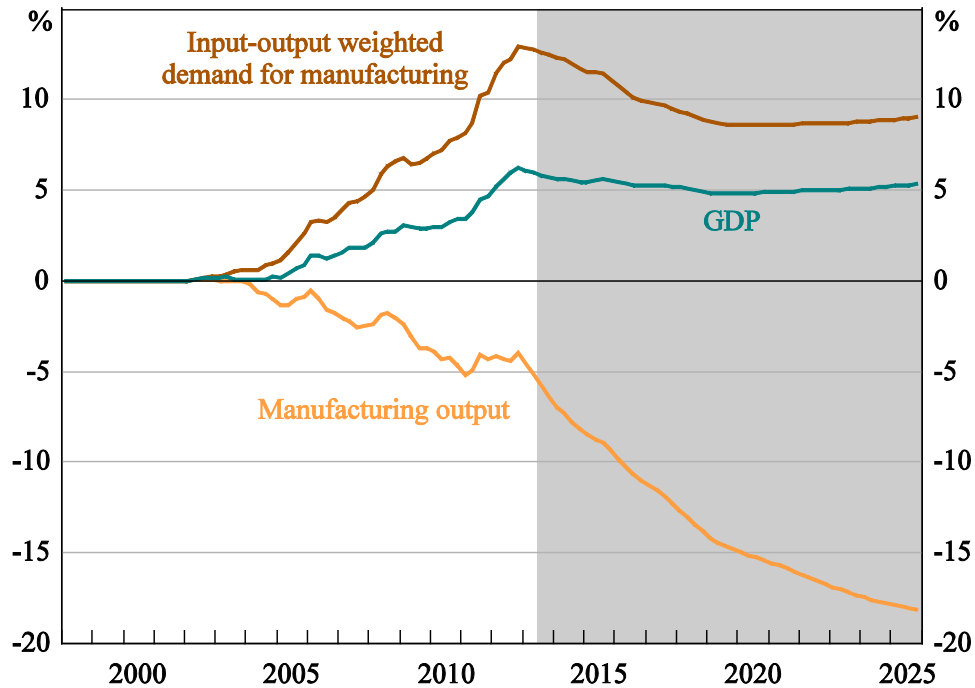
Figure 18: Effects of the Mining Boom on Manufacturing Output

Note: Percentage deviation of baseline estimates from the no-mining-boom counterfactual

Sources: ABS; Authors' calculations and AUS-M model database and simulations

However, as Giesecke (2004), Downes and Stoeckel (2006) and Minifie *et al* (2013) argue, it would be wrong to conclude that the mining boom is the main source of the manufacturing sector's troubles. As shown in Figures 16 and 19, manufacturing has been declining as a share of the Australian economy for decades. The mining boom accentuates this trend, but its contribution is small compared to the changes that have come before.

Figure 19: Effects of the Mining Boom on Manufacturing Employment Share
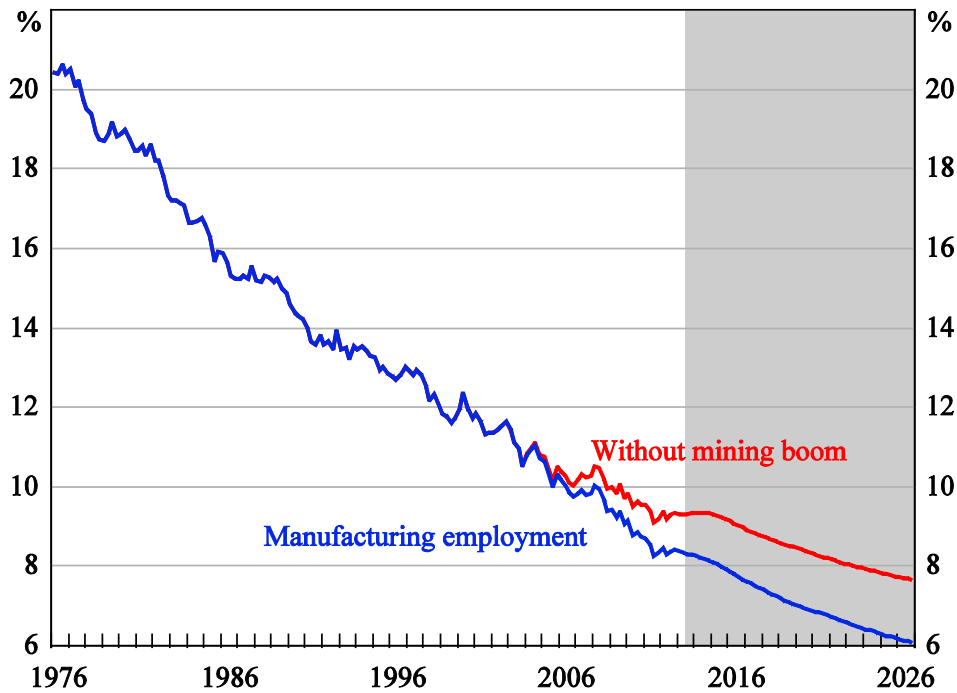
Sources: ABS; Authors' calculations and AUS-M model database and simulations

5.6   Employment by Industry

The estimated pattern of deviations of employment by industry (Figure 20) is largely driven by the pattern of output by industry (Figure 15). The boom induces large increases in employment in mining and construction and reduces employment in agriculture and manufacturing.

Differences in the responses of output and employment by industry (that is, changes in industry productivity) largely reflect changes in real producer wages. These in turn are mainly the result of large deviations in output prices (Figure 17) that are slightly offset by fairly small changes in wages.[4] For example, mining employment rises noticeably before the increase in mining output, because mining output prices are higher (by 37 per cent in 2013), partially offset by a 4 per cent increase in hourly earnings in mining. Similarly manufacturing employment is 9 per cent lower by 2013, compared to an output deviation of 5 per cent. This is because manufacturing output prices are lower, producer real wages are higher and hence there is substitution away from labour for a given level of output.

---

4 In contrast, Plumb *et al* (2013, Section 3.2.4) describe the variations in wages by industry as 'substantial'. That characterisation reflects different data sources and a perspective of reallocation of labour across industries.

Figure 20: Effects of the Mining Boom on Industry Employment
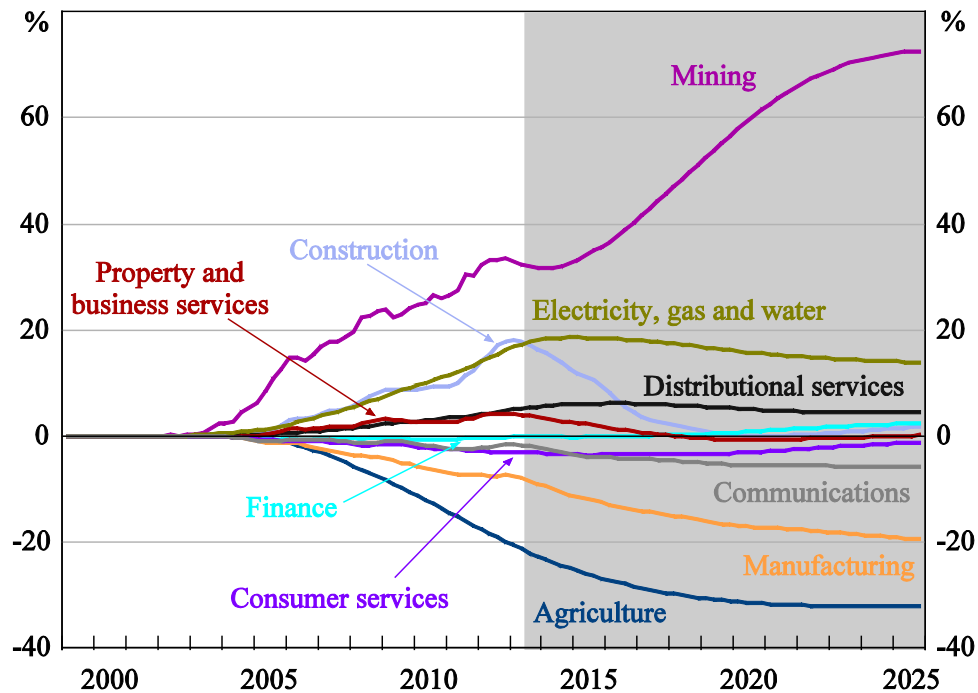
Notes: Percentage deviation of baseline estimates from the no-mining-boom counterfactual; industry employment is measured on a heads basis, similar deviations are seen on an hours worked basis

Sources: ABS; Authors' calculations and AUS-M model database and simulations

These substitution effects have an impact on measured labour productivity. For example, labour productivity fell in the mining sector when commodity prices rose in the mid 2000s, something the model attributes to a substitution effect rather than a decline in underlying labour efficiency. Similarly, if or when commodity prices decline measured labour productivity in mining should rise. The same applies to other industries where there are large movements in output prices relative to labour costs.

6.   Conclusion

We consider the mining boom as a confluence of events that have boosted world minerals prices and mining investment. This combination of shocks has boosted the purchasing power and volume of Australian output. It has also led to large changes in relative prices, most noticeably an appreciation of the exchange rate. The combination of changes in income, production and relative prices has meant large changes in the composition of economic activity. While mining, construction and importing industries have boomed, agriculture, manufacturing and other trade-exposed services have declined relative to their expected paths in the absence of

the boom. Households that own mining shares (including through superannuation) or real estate have done well, while renters and those who work in import-competing industries have done less well.

All of these results are estimates that depend on linkages and assumptions which are open to debate. Some confidence can be placed in the broad pattern of responses we estimate, which is in line with previous research. There is less certainty about magnitudes and the timing of responses. Even if the model accurately captured the response of the Australian economy in the past, current and future relationships can be expected to evolve. Indeed, an important reason models like AUS-M exist is to allow users to explore alternative assumptions. But hopefully our analysis has provided a framework for thinking through some of the problems, and guidance about the relative importance of some of the main effects.

Appendix A: Description of AUS-M

Full documentation of AUS-M has not yet been published, but details on individual equations and sectors underlying the results in this paper are available on request to Outlook Economics. The macroeconomic properties of AUS-M are very similar to those of the <u>T</u>reasury <u>M</u>acroeconomic (TRYM) model, from which AUS-M was developed. Documentation of the TRYM model is available in Taplin *et al* (1993) and at http://archive.treasury.gov.au/contentitem.asp?NavId=016&ContentID=238. TRYM was shown to have macroeconomic responses that were similar to the Pagan-Dungey 10-equation VAR model of the Australian economy and the small RBA model (Stone *et al* 2005). Given that the properties of TRYM have been well documented and scrutinised, it is probably useful to focus on the key points of difference between the two models.

A major focus in the development of AUS-M has been closer integration of GDP(E) and GDP(P), or what input-output analysis refers to as demand and supply. The components of GDP(E) are mapped into industry output and imports using input-output tables.[5] A framework similar to the Almost Ideal Demand System (Deaton and Muellbauer 1980) is used to model industry and import volumes, where each individual supply component depends on: (1) the input-output weighted demand term; (2) relative prices; (3) the change in total demand; and (4) a stochastic time trend to capture effects from changing technology and tastes. Cross price elasticities are jointly estimated. Following Deaton and Muelbauer, the dependent variables are the weights in total supply, cross price elasticities are symmetric, and income and substitution effects on weights sum to zero.

---

5 This table is known as the Primary Input Content of Final Demand. If $\mathbf{I}$ is the identity matrix; $\mathbf{A}$ the matrix of industry to industry interactions; and $\mathbf{D}$ the matrix of industry to final demand coefficients, then the table is given by $[\mathbf{I} - \mathbf{A}]^{-1}\mathbf{D}$ (i.e. the Leontief inverse times the final demand component of the supply-use tables). As the ABS national accounts produce chain-linked, constant price, time series estimates of industry value added we are mainly interested in the allocation of value added to final demands (and vice versa), thus avoiding much of the detail of a standard CGE model. To build an econometric time series model consistent with the historical data we need to focus on the available time series data. There are no available time series data for the thousands of industry to industry interactions. Hence, we solve out for the industry to industry interactions and model them as a reduced form by forming a demand system for individual industry output, which depends on relative prices and components of demand. That is, rather than impose a set of industry to industry substitution effects by calibrating a detailed set of equations based on imputed data series, we let those effects be determined by the responses to relative prices evident in the historical time series data.

Other key elements of AUS-M in addition to those in TRYM include:

- Household consumption is disaggregated. Like the demand system for imports and industry outputs, this is based on an Almost Ideal Demand System style framework where each component is estimated on the basis of relative prices, the change in total consumption (to pick up cyclical and income effects), and stochastic trends (to capture changing tastes and technology over time).

- Expenditure deflators are estimated in a system which maps production deflators to the demand-side expenditure items. Each demand-side deflator has an input-output weighted production equivalent. Indirect taxes are also allocated using the input-output coefficients leading to implicit tax variables for each demand component. Expenditure deflators respond directly to supply prices, indirect taxes and the GST.

- Production functions for each industry are estimated indirectly by jointly estimating equations for employment, investment and output prices. (The long run of each equation depends on similar first-order conditions and hence the equations contain common parameters.) Stochastic trends capture changes in underlying labour and capital productivity. Each industry has a derived measure of potential output and its capacity utilisation can be compared with measures from the business surveys.

- Trade equations – for import and export prices and export volumes – are disaggregated.

- Equations for inventories are disaggregated.

- The labour market framework includes unfilled job vacancies and a detailed cohort model that forecasts the duration structure of unemployment. Employment equations are estimated on an industry basis, and employment demand for each industry is adjusted for unfilled vacancies and average hours worked in each industry.

- The dwelling sector includes an equation for rental vacancies, reflecting imbalance between demand and short-term supply. Lower vacancies lead to

higher rents, a higher dwelling Q ratio, and a higher level of investment. Higher rents also lead to a substitution away from the consumption of dwelling services.

- Explicit equations have been developed for non-dwelling construction investment in finance and insurance, property and business services, and consumer services to capture some of the movement in commercial property investment.

- Government budget identities are more detailed, reflecting the greater detail available in the model to establish various tax bases and that the model has a complete representation on the income side adding up to GDP(I).

- Extensive use is made of systems estimation. In one sense the model can be viewed as a kind of Sudoku, utilising constraints across a number of dimensions to reconcile estimates and fill in a complete picture of how the economy works. Any information on expenditure components has implications for production and income components, and vice versa, both in volumes and in values. The model forecasts converge on a steady state growth path that essentially stems from a small scale CGE growth model.

Appendix B: Comparisons to the Monash Model

The responses in the model depend on estimated parameters and specification choices, all of which are subject to uncertainty. So it is useful to compare the AUS-M results to results from other models and previous studies. In this appendix, we compare AUS-M results with those from the Monash Multi-Regional Forecasting (MMRF) model, which other researchers have used to examine related issues. The MMRF model is described in Centre of Policy Studies (2008). Downes and Hanslow (2009) present and discuss a comparison of MMRF and AUS-M for long-run responses to a change in wages.

The Monash model has a simpler treatment of short-term dynamics and macroeconomic relationships than AUS-M. However, these differences do not necessarily affect the long-run results, which we report below. Whereas MMRF is largely calibrated, in AUS-M the elasticities of substitution are estimated directly from the time series data, either as part of demand systems or the joint estimation of production functions. With respect to specification of industry responses, both models use constant elasticity of substitution (CES) production technology for industry value added and are based on ABS input-output data. The AUS-M production functions model constant price industry value added whereas MMRF models industry gross output using a nested CES structure at a much higher level of detail. (Some inputs are combined in fixed proportions at the top level of the nested production functions for some industries but substitution is allowed elsewhere.) The treatment of trade is broadly similar. Reflecting these differences, the two models are useful for addressing slightly different questions.

B.1   Comparison of Terms of Trade Simulations

To facilitate comparisons across models, we focus on a simple experiment of an exogenous change in the terms of trade. To be precise, in both models we shock mining export prices so as to increase the terms of trade by 10 per cent. The shock to AUS-M is around a forecast baseline run out to 2030 while that on MMRF uses the standard long-run closure. We focus on the long-run results – on the

assumption that the capital stocks in the model will fully adjust to the shock by 2030.[6]

In contrast to the AUS-M scenario discussed in Section 3.2, we do not adjust world growth or investment residuals. In contrast to the further AUS-M adjustments discussed in Appendix C, we do not adjust the import composition of construction equipment or net migration flows. These features seemed to complicate the model comparison and several of them are difficult to implement in MMRF in a consistent manner. This simpler experiment design also facilitates comparisons with some previous studies of terms of trade shocks, which we discuss below.

We make two adjustments to MMRF to make the shocks more similar. First, we increase capital productivity in line with adjustments made in AUS-M, discussed in Appendix C.1. The rationale is that the mining boom seems to have led to substantial reductions in capital productivity, as increasingly marginal reserves are brought into production and as the composition of mining has been increasingly capital intensive. The adjustments are implemented by changing the rental value of capital stocks.

Second, we broaden the definition of mining exports in MMRF to include metals such as zinc, lead and aluminium. These are ordinarily classified as manufacturing exports in MMRF but as mining exports in AUS-M. This involves shifting the export demand curves for steel, alumina, aluminium and other metals inwards, so as to give similar changes as other minerals prices.

Table B1 shows the long-run effect of a 10 per cent increase in the terms of trade on other variables in both models.

---

6 As there is still some cyclical movement in the data, the average deviations over the period 2025:Q3 to 2030:Q2 are reported in Table B1.

Table B1: Long-run Effect of Increase in Mining Prices
Percentage change from baseline

	MMRF	AUS-M
Terms of trade	10	10
Real GDP	2	2
Real private consumption	4	5
Real government consumption	2	0
Real investment	5	4
Real imports	5	8
Real exchange rate	9	8
Real exports	–6	3
Agriculture	–10	–8
Mining	24	10
Manufacturing	–14	–7
Services	–26	–12
Real output		
Agriculture	–3	–4
Mining	13	8
Coal	15	na
Gas	7	na
Iron ore	26	na
Other metallic ore	20	na
Manufacturing	–2	–5
Steel	–2	na
Alumina	22	na
Aluminium	14	na
Other metals	5	na
Metal products	–1	na
Services	2	1
Real gross state product		
NSW	1	na
Vic	–1	na
Qld	4	na
SA	–3	na
WA	11	na
Tas	0	na
NT	8	na
ACT	3	na

Notes: Per cent deviations of long-run solution from alternative simulations in which mining export prices are lower; alternative simulations are calibrated so that terms of trade in the baseline are 10 per cent higher; simulations are described in text

Given the different approaches to specification and estimation, the similarity of the broad results may be surprising. Both models suggest a moderate increase (of about 2 per cent) in real GDP with consumption and investment rising somewhat more, offset by large increases in import volumes. Both models have appreciations in the real exchange rate that are similar to, but slightly smaller than, the increase in the terms of trade. With respect to industry output, mining production rises substantially, accompanied by smaller increases in services. These increases are partially offset by decreases in agriculture and manufacturing.

There are also differences in the results. For example, export volumes increase slightly in AUS-M, but decline substantially in MMRF. The reduction in MMRF includes a large response by manufacturing and services exports to the higher exchange rate, which more than offsets a rise in mining export volumes.

One of the more important differences is that MMRF provides more finely disaggregated responses. The model provides estimates of output disaggregated by state and detailed industrial categories. The full output of the simulation runs to hundreds of thousands of estimates. In Table B1 we provide a very brief illustration, with estimates of output by state and a few select industries.

B.2   Comparison with Previous MMRF Studies

Three previous studies have examined the effect of terms of trade changes using MMRF. McKissack *et al* (2008) examines the impact of a 20 per cent increase in the terms of trade generated by a shift in world demand for iron ore and coal. The study is mainly concerned with the distribution of employment effects across states and industries. It uses a short-run closure for the model simulation where capital stocks are fixed. Total employment is also fixed (although labour freely flows between industries and regions). Impacts on macroeconomic aggregates like consumption, the exchange rate and national income are not reported. Presumably national income is around 5 per cent higher, and much of this would be redistributed to the household sector via a higher exchange rate. (Real wages are 2 per cent higher.) GDP rises by 0.3 per cent reflecting the movement of employment from low-productivity industries to the mining industry. Employment in mining and construction are higher while manufacturing employment falls by 7 per cent. Other industries are relatively unaffected.

The fall in manufacturing employment in this short-run simulation is likely to be a result of the impact of the exchange rate movement. There is no short-run boost to manufacturing from higher investment – the authors note this as a limitation of the analysis.

The Productivity Commission (2009) looks at the impact of increased labour mobility on the economy's response to an increase in the terms of trade. The study, using a modified version of MMRF, finds that a uniform 10 per cent increase in mining export prices (which would represent roughly a 6 per cent improvement in the terms of trade) leads to a 2.4 per cent increase in GDP and a 4 to 7 per cent increase in the real wages of blue-collar workers. The results are from the standard long-run closure of the model where there is full adjustment of capital stocks. Hence the much larger impacts on GDP than the Treasury study using the short-run closure where output only responds as a result of the reallocation of labour. (The simulation with reduced labour mobility reduces the GDP impact by 0.3 of a percentage point.)

Thompson *et al* (2012) extend the Productivity Commission study and look at the impact of the increase in the terms of trade and the potential impact of labour mobility in more detail, using both long-run and short-run closures. The short-run results are similar to the Treasury results, the main differences arising from the different pattern of export price shocks imposed. In the long run the study finds a 30 per cent improvement in the terms of trade leads to a 3 per cent increase in GDP, and an 8 per cent increase in household consumption. Manufacturing employment falls by 11 per cent while employment in mining and services is up by 13 per cent and 4 per cent respectively. Limiting labour mobility reduces the long-run GDP increase by 1 percentage point.

Appendix C: Modifications to the Model

Although AUS-M is designed to be able to simulate a wide range of scenarios, the mining shock we consider pushes the model into unfamiliar territory. Some simplifications that ordinarily work well are less obviously applicable in the construction of our counterfactual. Accordingly, there are some places where we have brought extra judgement to bear. Were these changes to be a routine feature of AUS-M simulations, we would modify the model so that these responses were automatic. But for this one-off exercise, that complication is not worthwhile. Instead, we make some ad hoc adjustments. This appendix describes the more important of these.

### C.1   The Decline in Mining Capital Productivity

One large adjustment, which we also apply to the MMRF simulations discussed in Appendix B, is to underlying capital productivity in the mining sector. Whereas this is usually modelled as an exogenous stochastic trend, we assume that its recent decline is attributable to the mining boom. Accordingly, we remove this decline from the counterfactual.

Capital productivity in the mining sector is measured as chain linked value added divided by the net capital stock at replacement cost. This has two important components, shown in Figure C1. First, longer-term changes in technology are modelled by a stochastic trend and shown as the pink lines. In the projections the trend declines, so as to reconcile the model's mining output and export forecasts with those from the Bureau of Resources and Energy Economics. Actual capital productivity, shown by the blue lines, fluctuates around this trend reflecting endogenous substitution effects and lags between investment and production.

For this particular shock, modelling underlying capital productivity as a stochastic trend seems to be an over-simplification. The decline is arguably not random, but reflects essential features of the mining boom. In particular, the average quality of resources being exploited has declined as prices rise; and the sector has become more capital intensive due to compositional changes, specifically the rise of LNG and iron ore production. Arguably, this should be a permanent feature of the model. Pending such a re-specification, we assume underlying capital productivity in the counterfactual remains flat, as the surge in iron ore and LNG investment

does not occur. Measured capital productivity still declines because of endogenous responses to relative prices and activity.

Figure C1: Capital Productivity in Mining
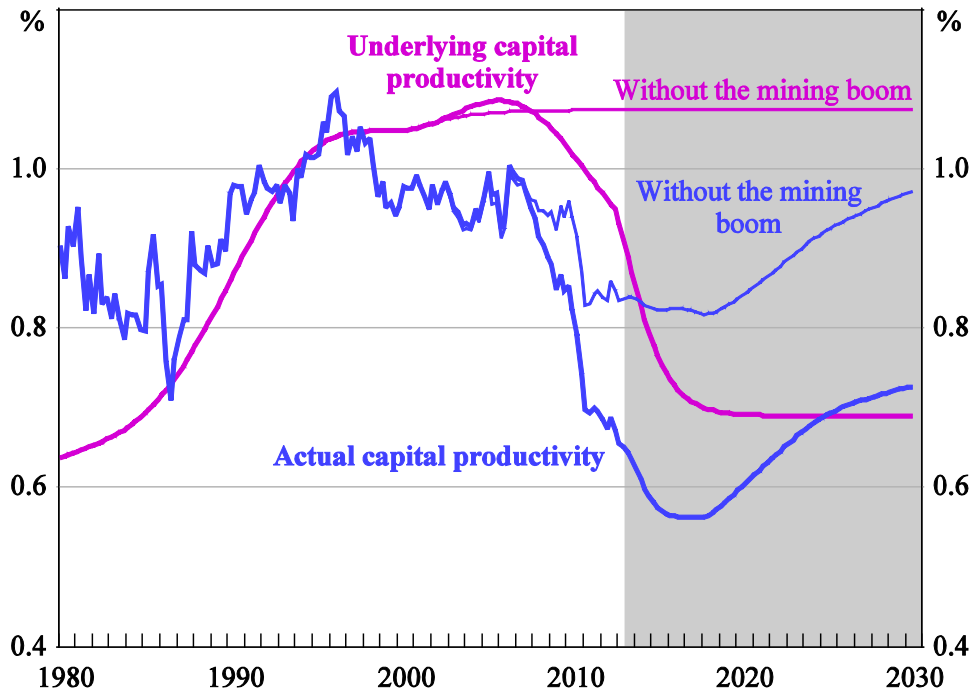
Notes: Capital productivity is measured as constant price value added (GMIN) over the net capital stock (KMIN) lagged eight quarters. Underlying capital productivity is a stochastic trend derived in the joint estimation of the employment and investment equations, with the joint estimation involving common parameters derived from the production function in the long-run component of each equation; the variable controls for substitution effects and lags between investment and production.
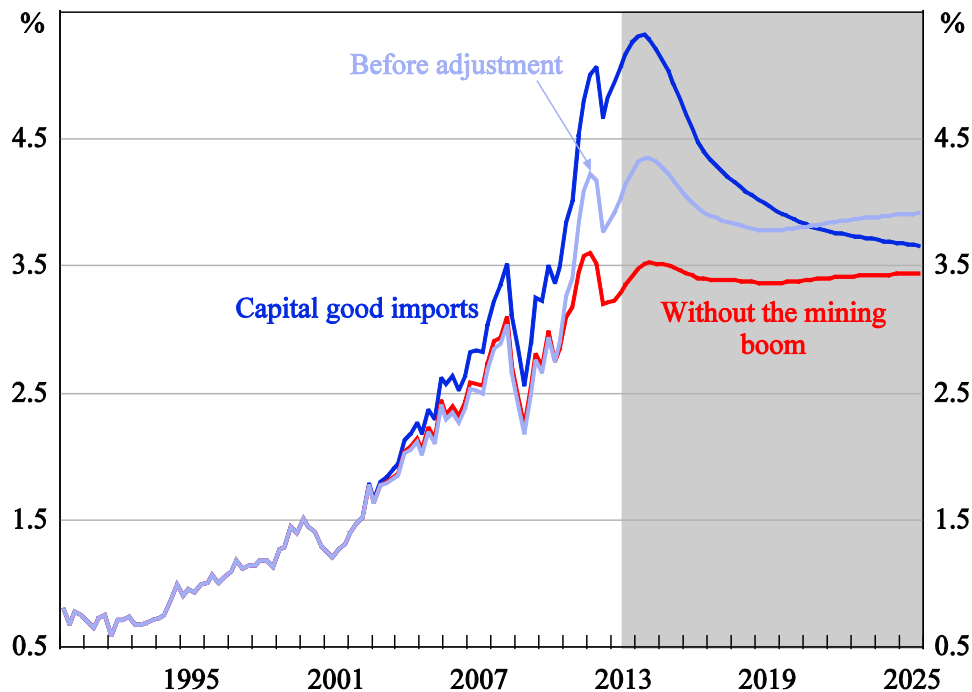
Sources: ABS; Authors' calculations and AUS-M model database and simulations

C.2   Adjustment to Capital Goods Imports

The mining boom has led to a surge in imports of equipment. However, the model's equation for equipment imports only explains part of this surge, with large positive residuals. A large part of this unusual increase seems attributable to compositional and technological changes. In particular, company-level information examined by Connolly and Orsmond (2011, p 40) indicates that an unusually high proportion of the construction investment in mining is imported, including floating platforms and LNG modules, and materials used in construction. Sheehan and Gregory (2012) similarly estimate that the import content of mining investment will rise to around 45 per cent by 2014/15 and thereafter decline.

On the assumption that the unexplained strength of capital goods imports is attributable to the mining boom, we remove the positive residuals from this equation in the counterfactual. The impact of this is shown in Figure C2. For consistency, we make a partly offsetting adjustment to construction output, which is jointly estimated. That is, with less demand for construction equipment being sourced overseas, more is sourced domestically. These adjustments subtract around ¾ of a per cent of GDP from capital goods imports by 2014/15, and add about ½ a per cent to domestically supplied construction.

Figure C2: Capital Goods Imports – Actual and Counterfactual
Per cent of GDP

Sources: ABS; Authors' calculations and AUS-M model database and simulations

C.3   Net Migration

Our adjustment for net migration follows the same logic as the previous adjustments. The net migration data have been surprisingly strong and this is plausibly attributable to the mining boom. The mining industry directly increases immigration through demand for skilled workers and hence for 457 visa holders. Probably more important are the indirect effects via a high exchange rate and lower unemployment, which makes Australia a more attractive place to work relative to overseas. (In addition the official migration program has been procyclical in the past, and probably would have been more restrictive in a less buoyant

environment.) So we reduce net migration in the counterfactual (Figure C3), which then feeds through to other demographic variables.

Figure C3: Net Migration
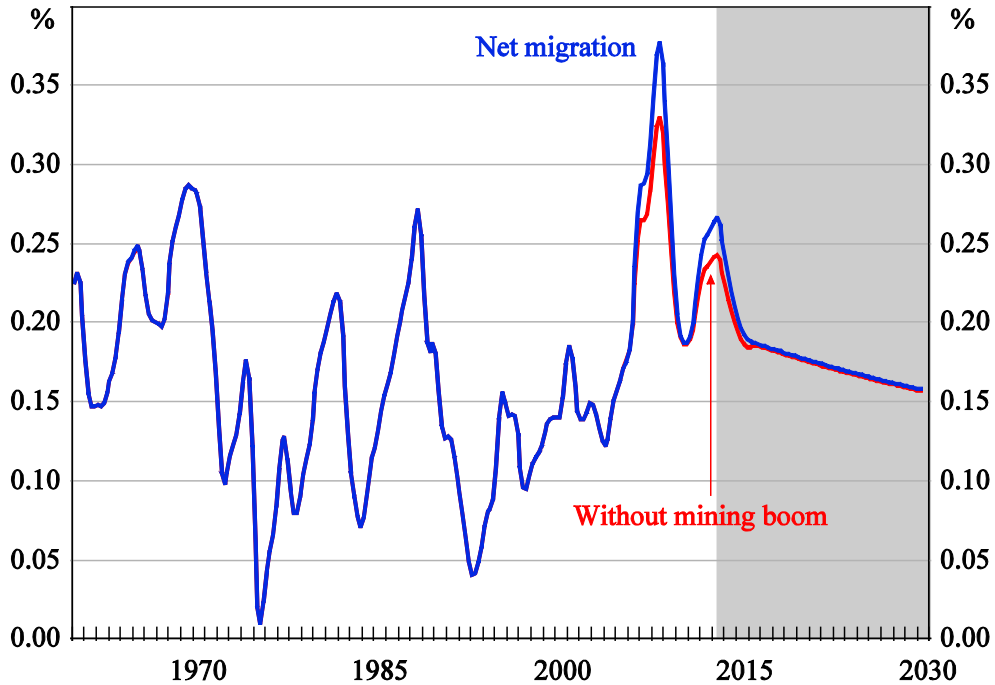
Notes: Net migration as a smoothed percentage of resident population at a quarterly rate; data on net migration are adjusted to be consistent with the ABS estimate of the resident population assuming birth and death data are accurate

Sources: ABS; Authors' calculations and AUS-M model database and simulations

References

Barber J, T Shael, S Cowling, A Bialowas and O Hough (2013), *Resources and Energy Major Projects April 2013*, Bureau of Resources and Energy Economics, Canberra, May.

Bean C (1987), 'The Impact of North Sea Oil', in R Dornbusch and R Layard (eds), *The Performance of the British Economy*, Clarendon Press, Oxford, pp 64–96.

Cagliarini A and W McKibbin (2009), 'Global Relative Price Shocks: The Role of Macroeconomic Policies', RBA Research Discussion Paper No 2009-10.

Centre of Policy Studies (2008), *MMRF: Monash Multi-Regional Forecasting Model; A Dynamic Multi-Regional Applied General Equilibrium Model of the Australian Economy,* Centre of Policy Studies, Monash University, June.

Connolly E and D Orsmond (2011), 'The Mining Industry: From Bust to Boom', RBA Research Discussion Paper No 2011-08.

Cook LH and E Seiper (1984), 'Minerals Sector Growth and Structural Change', in LH Cook and MG Porter (eds), *The Minerals Sector and the Australian Economy*, Centre of Policy Studies, Monash University Special Study No 6, George Allen & Unwin, Sydney, pp 85–127.

Corden WM (1984), 'Booming Sector and Dutch Disease Economics: Survey and Consolidation', *Oxford Economic Papers*, 36(3), pp 359–380.

Corden WM and JP Neary (1982), 'Booming Sector and De-Industrialisation in a Small Open Economy', *The Economic Journal*, 92(368), pp 825–848.

Deaton A and J Muellbauer (1980), 'An Almost Ideal Demand System', *The American Economic Review*, 70(3), pp 312–326.

Douglas J, H Thompson and P Downes (1997), 'Modelling the Exchange Rate and Commodity Prices in the Treasury Macroeconomic (TRYM) Model', Paper presented at the 1997 Conference of Economists, Hobart, 28 September–1 October.

Downes P and K Hanslow (2009), 'Modelling of the Macroeconomic Impact of the Fair Pay Commission's Minimum Wage Decisions', Australian Fair Pay Commission Research Report No 12/09. Available at <http://www.fwc.gov.au/sites/afpc2009wagereview/research/ModellingoftheMacr oeconomicImpactofAFPCMWD.pdf>.

Downes P and A Stoeckel (2006), 'Drivers of Structural Change in the Australian Economy', Centre for International Economics Report.

Edwards J (2014), *Beyond the Boom*, Lowy Institute Paper, Penguin Special, Penguin Australia, Melbourne.

Giesecke J (2004), 'The Extent and Consequences of Recent Structural Changes in the Australian Economy, 1997-2002: Results from Historical/Decomposition Simulations with Monash', Centre of Policy Studies, General Working Paper No G-151. Available at <http://www.copsmodels.com/ftp/workpapr/g-151.pdf>.

Gregory RG (1976), 'Some Implications of the Growth of the Minerals Sector', *The Australian Journal of Agricultural Economics*, 20(2), pp 71–91.

Jääskelä J and P Smith (2011), 'Terms of Trade Shocks: What are They and What Do They Do', RBA Research Discussion Paper No 2011-05.

McKissack A, J Chang, R Ewing and J Rahman (2008), 'Structural Effects of a Sustained Rise in the Terms of Trade', Treasury Working Paper 2008 — 01.

Minifie J, I Cherastidtham, D Mullerworth and J Savage (2013), *The Mining Boom: Impacts And Prospects*, Grattan Institute Report No 2013-9, Grattan Institute, Carlton.

Plumb M, C Kent and J Bishop (2013), 'Implications for the Australian Economy of Strong Growth in Asia', RBA Research Discussion Paper No 2013-03.

Productivity Commission (2009), 'E.3 Computable General Equilibrium Analysis of the Economic Effects of Improved Labour Mobility', in *Review of Mutual Recognition Schemes*, Research Report, Productivity Commission, Canberra, pp 380–383.

Rayner V and J Bishop (2013), 'Industry Dimensions of the Resource Boom: An Input-Output Analysis', RBA Research Discussion Paper No 2013-02.

Sheehan P and RG Gregory (2012), 'The Resources Boom and Economic Policy in the Longer Run', Paper prepared for the 'Structural Change and the Rise of Asia' Conference, Jointly hosted by the International Monetary Fund, the Australian Treasury and the Reserve Bank of Australia, Canberra, 19 September.

Stoeckel A (1979), 'Some General Equilibrium Effects of Mining Growth on the Economy', *The Australian Journal of Agricultural Economics*, 23(1), pp 1–22.

Stone A, Wheatley T and L Wilkinson (2005), 'A Small Model of the Australian Macroeconomy: An Update', RBA Research Discussion Paper No 2005-11.

Taplin B, P Jilek, L Antioch, A Johnson, P Parameswaran and C Louis (1993), 'Documentation of the Treasury Macroeconomic (TRYM) Model of the Australian Economy', TRYM Paper No 2.

Thompson G, T Murray and P Jomini (2012), 'Trade, Employment and Structural Change: The Australian Experience', in D Lippoldt (ed), *Policy Priorities for International Trade and Jobs*, OECD, Paris, pp 113–143.

RESEARCH DISCUSSION PAPERS

These papers can be downloaded from the Bank's website or a hard copy may be obtained by writing to:

Mail Room Supervisor
Information Department
Reserve Bank of Australia
GPO Box 3947
SYDNEY NSW 2001

Enquiries:

Phone: +61 2 9551 9830
Facsimile: +61 2 9551 8033
Email: rbainfo@rba.gov.au
Website: http://www.rba.gov.au

2013-13	Inventory Investment in Australia and the Global Financial Crisis	Gianni La Cava
2013-14	Reserves of Natural Resources in a Small Open Economy	Isaac Gross James Hansen
2013-15	Trends in Funding and Lending Behaviour of Australian Banks	Chris Stewart Benn Robertson Alexandra Heath
2014-01	Macroeconomic Consequences of Terms of Trade Episodes, Past and Present	Tim Atkin Mark Caputo Tim Robinson Hao Wang
2014-02	Fiscal Policy and the Inflation Target	Peter Tulip
2014-03	Household Saving in Australia	Richard Finlay Fiona Price
2014-04	Home Price Beliefs in Australia	Callan Windsor Gianni La Cava James Hansen
2014-05	The Changing Way We Pay: Trends in Consumer Payments	Crystal Ossolinski Tai Lam David Emery
2014-06	Is Housing Overvalued?	Ryan Fox Peter Tulip
2014-07	International Trade Costs, Global Supply Chains and Value-added Trade in Australia	Gerard Kelly Gianni La Cava