Economic impact of selected macroeconomic shocks

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Executive summary

This report has been prepared for the Parliamentary Budget Office (PBO). The PBO supports the Australian Parliament by providing independent analysis of the budget cycle, fiscal policy, and the financial implications of proposals. The PBO are preparing a report on the Commonwealth Budget's sensitivity to macroeconomic shocks, such as changes to underlying productivity growth. Macroeconomic shocks influence key economic parameters that affect the Budget by impacting revenue collections and government expenditure.

The PBO has commissioned the author to analyse the impact of two macroeconomic shocks on key economic parameters that influence the Budget. The outputs of the analysis will be used by PBO to adjust the 2017/18 Budget PBO medium-term projections for those economic parameters. PBO will then use its modelling of the relationship between the economic parameters and the Budget to assess the effects on the Budget of the macroeconomic shocks over the medium-term.

The impacts of the shocks on the economic parameters, expressed as percentage deviations from baseline, are presented on an annual basis from 2018/19 to 2027/28. This provides the PBO with an understanding of the short-term and the long-term economic impacts of the macroeconomic shocks on the key economic parameters that influence the Budget.

This report's analysis of the effects of the macroeconomic shocks on the key economic parameters is undertaken using Chris Murphy's Macro-econometric Model ("Macro Model"). That model is well suited to this analysis because it fully integrates short-term and long-term perspectives on the economy, as well as macroeconomic and industry perspectives.

PBO's selected macroeconomic shocks

The PBO has commissioned the author to assess the economic impact of shocks to productivity growth and non-mining business investment, both of which are important sources of uncertainty in the medium-term economic outlook. For each macroeconomic shock, symmetric 'high and 'low' scenarios around the baseline have been specified. The specific nature of each shock is outlined below.

Labour productivity

From the September quarter 2019, annual labour productivity growth is shocked by 0.25 percentage points around its baseline rate of around 1½ per cent per year. This design of the high and low scenarios is within the variability in productivity growth rates observed in recent decades, in which trend productivity growth has varied between around 1 and 2 per cent per year.

By the 2027/28 financial year, this shock translates to a 2.2 per cent gain or 2.1 per cent loss in the level of underlying productivity relative to the baseline scenario. This small difference in the magnitude of the cumulative gains and losses reflects the effects of compounding.

It has been assumed that the source of the variation in productivity growth between scenarios is variation in the rate of improvement in technology. In the modelling, this involves adjusting the assumed rates of underlying improvement in the efficiency of use of labour, land and natural resources in each industry. As technology is transferable across borders, similar variations in productivity growth are assumed for other countries. This assumption is implemented by varying the rate of growth in world GDP.

Speed of recovery

With the waning of the boom in mining investment, attention has turned to the outlook for non-mining business investment and uncertainty around the speed of recovery.

The recovery scenarios vary the strength of non-mining business investment over the 4-year period from 2019/20 to 2022/23, compared to its path in the baseline scenario. In the fast recovery scenario, stronger non-mining business investment generates a boost to real GDP that peaks at 0.5 per cent in the middle years of 2020/21 and 2021/22. Conversely, in the slow recovery scenario the loss in real GDP peaks at 0.5 per cent in the same years. Thus, to a 5-year horizon, the outlook for the level of real GDP varies by 1 per cent between the slow and fast recovery scenarios, which is well within the normal margins of error in such medium-term projections.

Beyond 2022/23, the outlook for non-mining business investment in both the slow and fast recovery scenarios converges to the baseline scenario. Thus, long-term real economic outcomes are similar across all three scenarios.

Approach

The economic impact of the selected macroeconomic shocks has been estimated using the Macro Model. This model is well suited for analysing the economic effects of macroeconomic shocks for the following reasons.

- It is able to *consistently analyse the economic impacts of macroeconomic shocks in the short, medium and long term*. Consistent modelling through time is particularly important for analysing economics shocks where there are different, important effects in both the short-term and long-term.

- It features *fully-integrated industry modelling*, which models the inter-linkages between six different industries (including mining) and the broader economy within one model. This allows for a fuller analysis of the effects of macroeconomic shocks.

- The Macro Model has a *fully-integrated demographic model*. This allows the Macro Model to robustly estimate the economic effects of population ageing.

- The model incorporates a *sophisticated production structure* that allows for the importance of fixed factors such as land and natural resources in industries such as Agriculture, Mining and housing services (Ownership of Dwellings). This enables the model to provide more realistic estimates of the responses of these industries to macroeconomic shocks, such as changes in labour productivity.

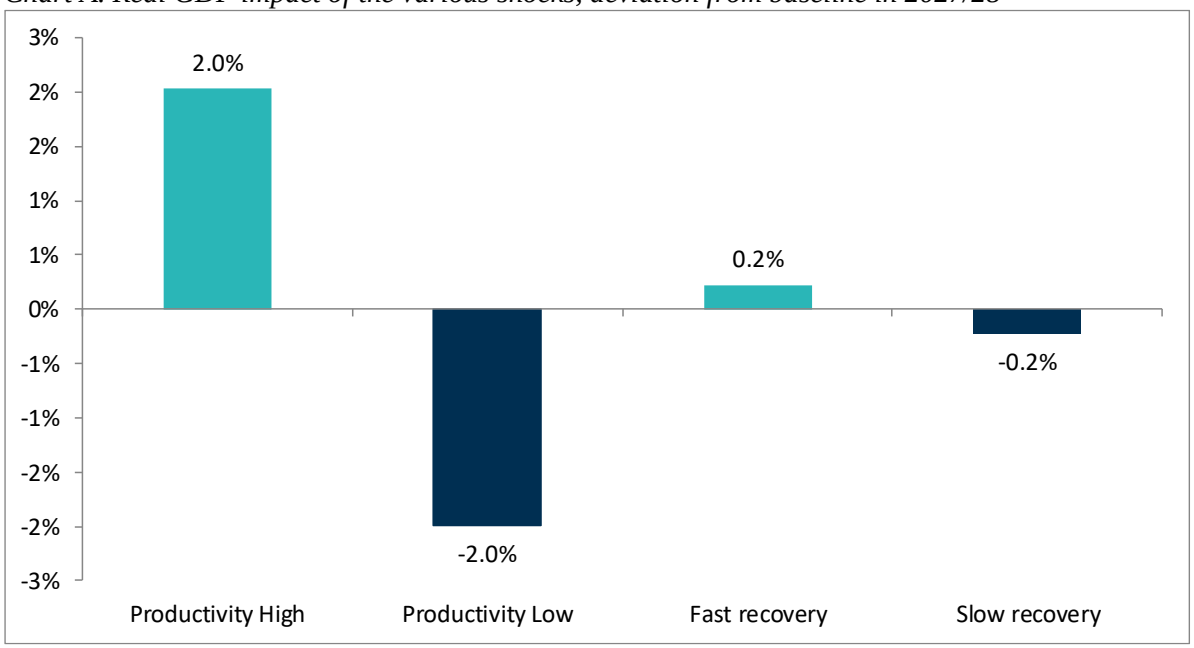
Each of the macroeconomic shocks are introduced into the Macro Model under a separate alternative scenario. The outcomes for the economic parameters under each alternative scenario are then compared to the outcomes for the same parameters under the baseline scenario. The percentage differences in outcomes for economic parameters provide estimates of the economic impacts of the macroeconomic shock. For example, to estimate the economic impacts of higher underlying productivity growth, the alternative scenario where underlying productivity growth is boosted is compared to the baseline scenario. The impact on an economic parameter, such as GDP, from the shock to underlying productivity growth is then assessed as the percentage difference in the outcome for the path of real GDP in the alternative scenario compared to the baseline scenario.

Importantly, while the baseline scenario for the economy used in this analysis was generated using the Macro Model, the economic impacts of the macroeconomic shocks are largely unaffected by the precise economic outcomes in the baseline scenario. This is because the deviations in economic parameters (or economic impacts) are driven largely by the deviations in model inputs, rather than by the levels of economic variables in the baseline scenario. In light of the minor role of the baseline scenario in influencing the estimates of the economic impacts, this report does not discuss the baseline scenario.

Results

Charts A and B compare the impacts of the shocks between the high and low scenarios. Chart A conducts the comparison for the impacts on real GDP, while Chart B makes the same comparison for the impacts on nominal GDP.

Chart A. Real GDP impact of the various shocks, deviation from baseline in 2027/28



Source: Macro Model

By 2027/28, the two recovery scenarios show relatively little deviation from the baseline scenario. For example, in the slow recovery scenario the impact on real GDP has shrunk from a trough of -0.5 per cent to -0.2 per cent (Chart A). It shrinks further to -0.1 per cent by 2034/35 and to zero after another decade.

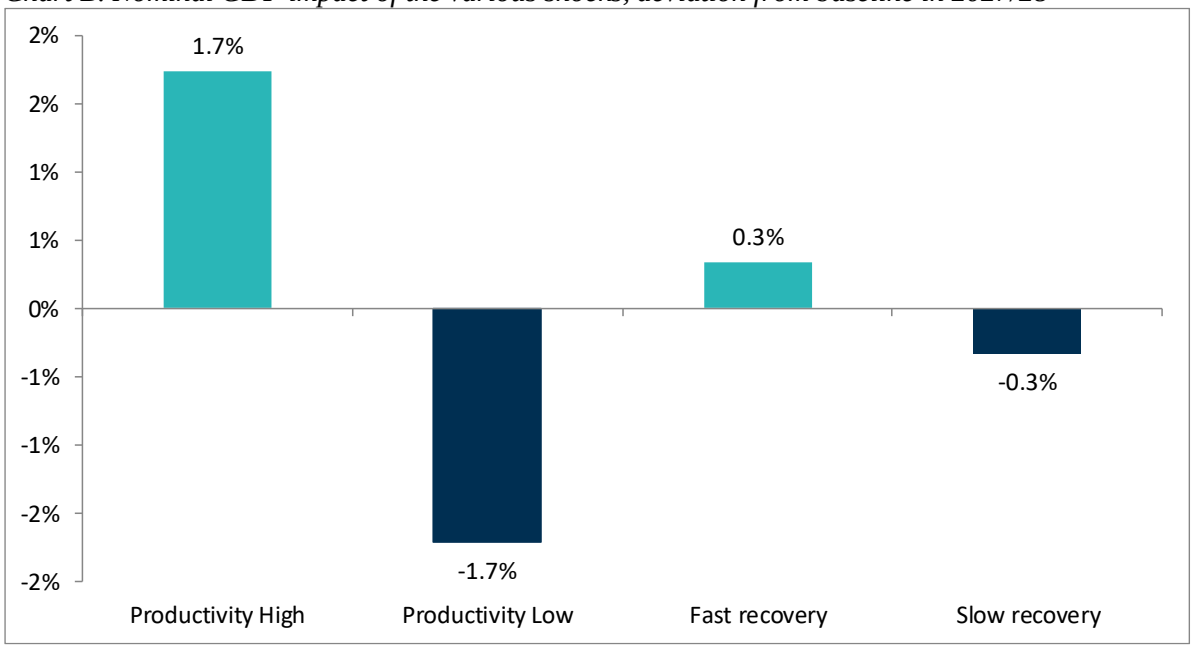
Thus, eventually all three scenarios (fast recovery, slow recovery and baseline) follow the same, sustainable path for GDP. The relatively drawn out nature of the adjustment process to a changed capital stock is reflective of the speeds of adjustment of the capital stocks in each sector. Adjustment processes are considerably faster for other shocks, such as demand shocks.

In contrast to the ephemeral responses to the investment shocks, the shocks to productivity growth have cumulative effects on the economy. Charts A and B show that the effects are broadly symmetric between the high and low scenarios.

The general impact of each scenario on prices can be inferred by comparing the results between Charts B and A. For example, higher productivity growth leads to a gain of 2.0 per cent in real GDP by 2027/28 but prices are lower by 0.3 per cent, leading to the gain in nominal GDP to 1.7 per cent. The negative

of higher productivity growth on price inflation would be greater except for the fact that the Reserve Bank gradually pursues an inflation target in the Macro Model. As a result of this approach to monetary policy, higher productivity growth leads to gains in real wages more via higher growth in nominal wages than via lower price inflation.

Chart B. Nominal GDP impact of the various shocks, deviation from baseline in 2027/28



Source: Macro Model

If monetary policy responded in a more (less) aggressive way, this decrease in the general price level would be less (more), but the long-run impact on real variables, including real GDP, would be unaffected. This suggests that the main focus should be on the long-run impacts of the shocks on real variables and relative prices, rather than on the general price level. This is consistent with the fact that the Reserve Bank does not aim to target any particular price level with monetary policy, but rather targets the inflation rate.

Because the economic impacts are broadly symmetric between the high and low scenarios, the discussion that follows focusses only on one scenario for each shock.

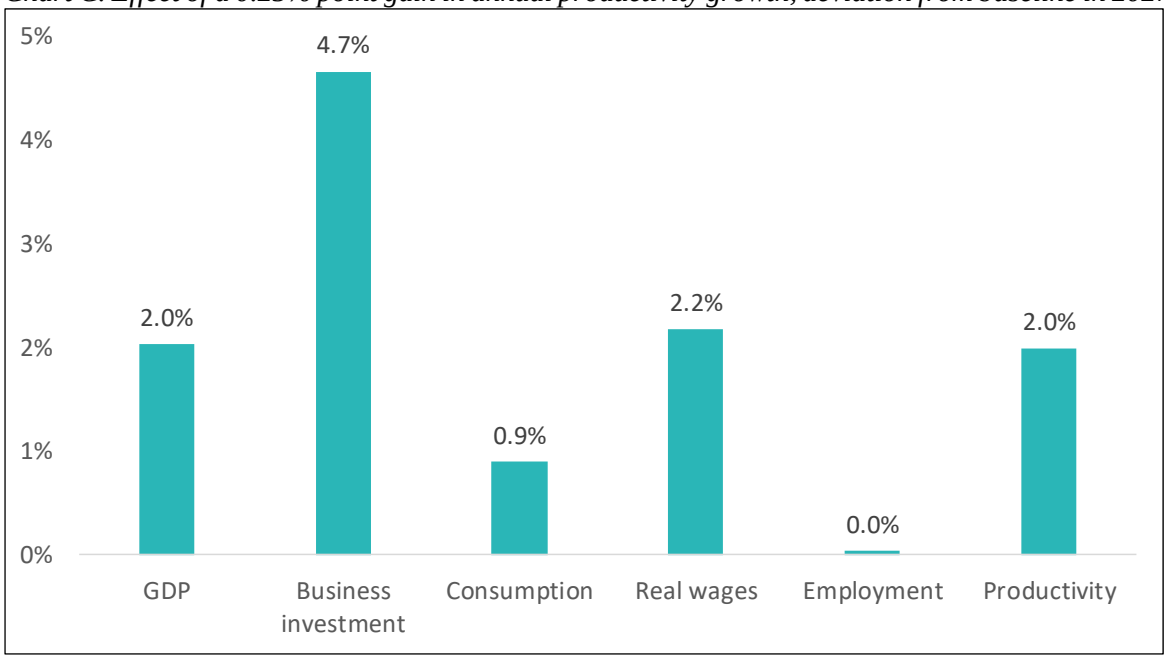
Labour productivity

In the high scenario, underlying annual labour productivity growth is 0.25 percentage points per year above its baseline rate from 2019/20. Over the nine years to 2027/28, this cumulates to a gain in the level of underlying labour productivity, relative to baseline, of 2.2 per cent.

As seen in Chart C, this flows through to a similar gain in actual labour productivity of 2.0 per cent. With unemployment driven to its sustainable rate or NAIRU (non-accelerating inflation rate of unemployment), employment is little affected. Therefore the gain in actual productivity flows through to a similar percentage gain in GDP. Real wages gain approximately in line with productivity, leaving real unit labour costs broadly unaffected.

In a faster growing economy, a higher share of GDP needs to be allocated to investment, to support faster growth in capital stocks. Thus, there is a shift in the pattern of spending in favour of investment, including a gain of nearly 5 per cent in total private business investment. To make room for this, the gain in household consumption is around 1 per cent, below the gain in GDP as a whole of 2 per cent.

Chart C. Effect of a 0.25% point gain in annual productivity growth, deviation from baseline in 2027/28



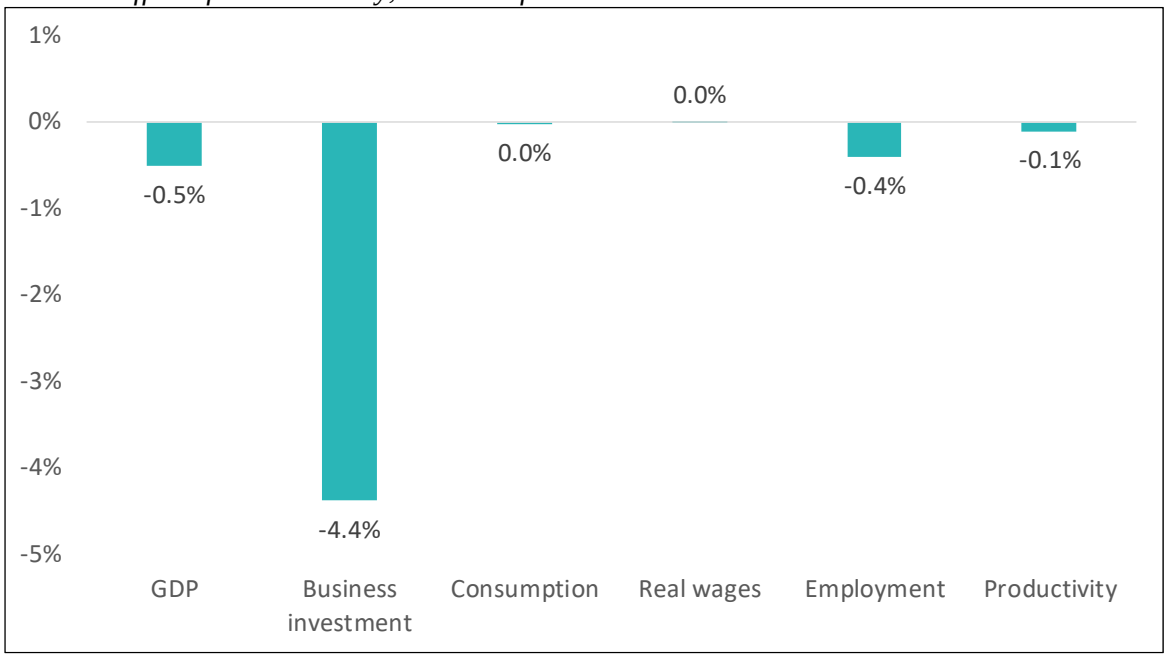
Source: Macro Model

Slow Recovery

The slow recovery scenario is generated by a negative shock to non-mining business investment over the 4-year period beginning from 2019/20. Chart D shows the peaks impacts, which occur in 2021/22. By then, total private business investment is more than 4 per cent below baseline.

This temporary weakness in business investment leads to a temporary loss in real GDP. This GDP loss reaches 0.5 per cent in 2021/22 and occurs for two reasons. Weaker business investment directly reduces demand for GDP, although this is partly offset weaker imports. Weaker investment also has a cumulating negative impact on business capital stocks, reducing the potential supply of GDP.

Chart D. Effect of Slow recovery, deviation from baseline in 2021/22



Source: Macro Model

1 Introduction

This report has been prepared for the Parliamentary Budget Office (PBO). The PBO supports the Australian Parliament by providing independent analysis of the budget cycle, fiscal policy, and the financial implications of proposals. The PBO are preparing a report on the Commonwealth Budget's sensitivity to macroeconomic shocks, such as changes to underlying productivity growth. Macroeconomic shocks influence key economic parameters that affect the Budget by impacting revenue collections and government expenditure.

The PBO has commissioned work to analyse the impact of two macroeconomic shocks on key economic parameters that influence the Budget. The macroeconomic shocks involve changes to productivity and non-mining business investment. For each macroeconomic shock, symmetric 'high and 'low' scenarios around the baseline have been specified.

The impacts of the shocks on the economic parameters, expressed as percentage deviations from baseline, are presented on an annual basis for the 10 years from 2018/19 to 2027/28. This provides the PBO with an understanding of the short-term and the long-term economic impacts of the macroeconomic shocks on the key economic parameters that influence the Budget.

The outputs of the analysis will be used by PBO to adjust the 2017/18 Budget PBO medium-term projections for those economic parameters. PBO will then use its modelling of the relationship between the economic parameters and the Budget to assess the effects on the Budget of the macroeconomic shocks over the medium-term.

1.1 Methodology: the macro model

This report's analysis of the effects of the macroeconomic shocks on the key economic parameters is undertaken using Chris Murphy's Macro-econometric model ("Macro Model"). This model is well suited for analysing the economic effects of the macroeconomic shocks for the following reasons.

- It is able to *consistently analyse the economic impacts of macroeconomic shocks in the short, medium and long term*. Consistent modelling through time is particularly important for analysing macro shocks as the short and long term impacts often differ substantially.

- It features *fully-integrated industry modelling*, which models the inter-linkages between six different industries (including mining) and the broader economy within one model. This allows for a fuller analysis of the effects of macroeconomic shocks, such as changes to world mining prices. The six industries are Agriculture, Mining, Manufacturing, Government Services, Other Services and Housing Services

- The Macro Model has a *fully-integrated demographic model*. This allows the Macro Model to robustly estimate the economic effects of population ageing, including its effects on the participation rate.

- The model incorporates a *sophisticated production structure* that allows for the importance of fixed factors such as land and natural resources in industries such as Agriculture, Mining and housing services (Ownership of Dwellings). This enables the model to provide more realistic

estimates of the response of these industries to macroeconomic shocks, such as changes in labour productivity.

Other features of the model that are useful for the analysis include:

- forecasts on a quarter-by-quarter basis to a long-term horizon;
- strong data consistency for more accurate forecasting;
- solid theoretical foundations for more robust policy analysis;
- an understanding of how the Reserve Bank pursues its inflation target in setting monetary policy, taking into account developments in inflation, unemployment and the bond market;
- modelling of consumer and investment behaviour that allows for the GFC;
- a new approach to modelling household consumption that uses a target for asset holdings based on labour income;
- a detailed representation of the interactions between building and construction activity in each industry and the broader economy;
- an allowance for structural change in the labour market;
- sophisticated modelling of financial markets in which market agents are forward looking and instantaneously respond to new information. This is a more realistic approach to modelling financial markets and helps the model provide credible short-term forecasts;
- an industry satellite model that disaggregates selected forecasts for the six broad industries in the macro model to 37 more detailed industries; and
- a states satellite model that disaggregates selected national forecasts from the macro model to the state level.

1.2 Outline of this report

The report is set out as follows.

- **Section 2** provides further details on the design of the scenarios.
- **Section 3** explains the impact on the economy of shocks to productivity growth;
- **Section 4** explains the impact on the economy of different rates of economic recovery;
- **Appendix A** provides a detailed explanation of the Macro Model, which has been used to develop the results presented in this report; and
- **Appendix B** provides detailed results for each of the four scenarios.

While all care, skill and consideration has been used in the preparation of this report, the findings refer to the terms of reference of PBO and are designed to be used only for the specific purpose set out below. If you believe that your terms of reference are different from those set out below, or you wish to use this report or information contained within it for another purpose, please contact us.

The specific purpose of this report is to provide PBO with an analysis of the economic impact of selected economic shocks.

The findings in this report are subject to unavoidable statistical variation. While all care has been taken to ensure that the statistical variation is kept to a minimum, care should be taken whenever using this information. This report only takes into account information available to the author up to the date of this report and so its findings may be affected by new information. The information in this report does not represent advice, whether express or inferred, as to the performance of any investment. Should you require clarification of any material, please contact us.

2 The macroeconomic shocks

This section explains how the four scenarios from the Macro Model were generated. This includes the high and low cases for both of the macroeconomic shocks.

Each of the macroeconomic shocks is introduced into the Macro Model under a separate alternative scenario. The outcomes for the economic parameters under each alternative scenario are then compared to the outcomes for the same parameters under the baseline scenario. The percentage differences in outcomes for economic parameters provide estimates of the economic impacts of the macroeconomic shock. For example, to estimate the economic impacts of higher growth in labour productivity, the alternative scenario where underlying productivity growth is boosted is compared to the baseline scenario. The impact on an economic parameter, such as real GDP, from the shock to productivity growth is then assessed as the percentage difference in the outcome for real GDP in the alternative scenario compared to the baseline scenario.

2.1 Productivity shock

From the September quarter 2019, labour productivity growth is shocked by 0.25 percentage points around its baseline rate of around 1½ per cent per year. This design of the high and low scenarios is consistent with the variability in productivity growth rates observed in recent decades, in which trend productivity growth has varied between around 1 and 2 per cent per year.

By the 2027/28 financial year, this shock translates to a 2.2 per cent gain or 2.1 per cent loss in the level of underlying productivity relative to the baseline scenario. The small difference in the magnitude of the cumulative gains and losses reflects the effects of compounding.

It has been assumed that the source of the variation in productivity growth between scenarios is variation in the rate of improvement in technology. In the modelling, this involves adjusting the assumed rates of underlying improvement in the efficiency of use of labour, land and natural resources in each industry. As technology is transferable across borders, similar variations in productivity growth are assumed for other countries. This assumption is implemented by varying the rate of growth in world GDP.

The level of general government final demand in Australia has also been adjusted so that it expands in line with the variations in the high and low scenarios in the productive capacity of the economy.

2.2 Speed of recovery scenarios

The recovery scenarios vary the strength of non-mining business investment over the 4-year period from 2019/20 to 2022/23, compared to its path in the baseline scenario. In the fast recovery scenario, stronger non-mining business investment generates a boost to real GDP that peaks at 0.5 per cent in the middle years of 2020/21 and 2021/22. Conversely, in the slow recovery scenario the loss in real GDP peaks at 0.5 per cent in the same years. Thus, to a 5-year horizon, the outlook for the level of real GDP varies by 1 per cent between the slow and fast recovery scenarios, which is well within the normal margins of error in such medium-term projections.

Beyond 2022/23, the outlook for non-mining business investment in both the slow and fast recovery scenarios converges to the baseline scenario. Thus, long-term real economic outcomes are similar across all three scenarios.

Equations for eight different categories of business investment are shocked. These categories distinguish between four broad industry sectors beyond mining and housing: agriculture; manufacturing; government services; and other services (which account for the largest part of the economy). The categories also distinguish between investment in structures and other investment (in machinery, equipment etc).

To quantify the size of the shock to mining investment, the relative magnitudes of the shocks to each of the eight business investment categories were based on the standard errors of the estimated equations.

2.3 Timing of the shocks and expectations

The macroeconomic shocks apply from the beginning of the 2019/20 financial year, whereas the model projections commence at the beginning of the 2017/18 financial year. Given that financial markets are forward looking in the model, the question arises as to whether financial markets anticipate the macroeconomic shocks at the start of the projection period and respond then, or whether the shocks are unexpected, so that financial markets respond at the start of the 2019/20 financial year.

The default assumption in the model is that shocks are anticipated. Thus, in the absence of adjustments, forward-looking variables adjust in the first quarter of the projection period, which is the September quarter of 2017. Those forward-looking variables include the exchange rate, the government bond rate and long-term inflation expectations.

Rather than use the default assumption that shocks are anticipated, it was decided to instead assume that the shocks are unanticipated. This makes the interpretation of the results more straightforward, as it means that there are no economic impacts until the shocks are introduced at the beginning of the 2019/20 financial year. In the model, implementing the assumption that the shocks are unanticipated involves making residual adjustments to the forward-looking equations in the quarter immediately preceding the commencement of the shocks. Following these residual adjustments, the model shows no economic impacts from the shocks until they commence at the beginning of the 2019/20 financial year.

3 Productivity shock

This section explains the economic impacts of the shock to productivity. As explained in section 2, it is assumed that the source of the variation in productivity growth is in the rate of improvement in technology and that similar technology-driven variations in productivity occur in other countries.

3.1 Overview of impacts

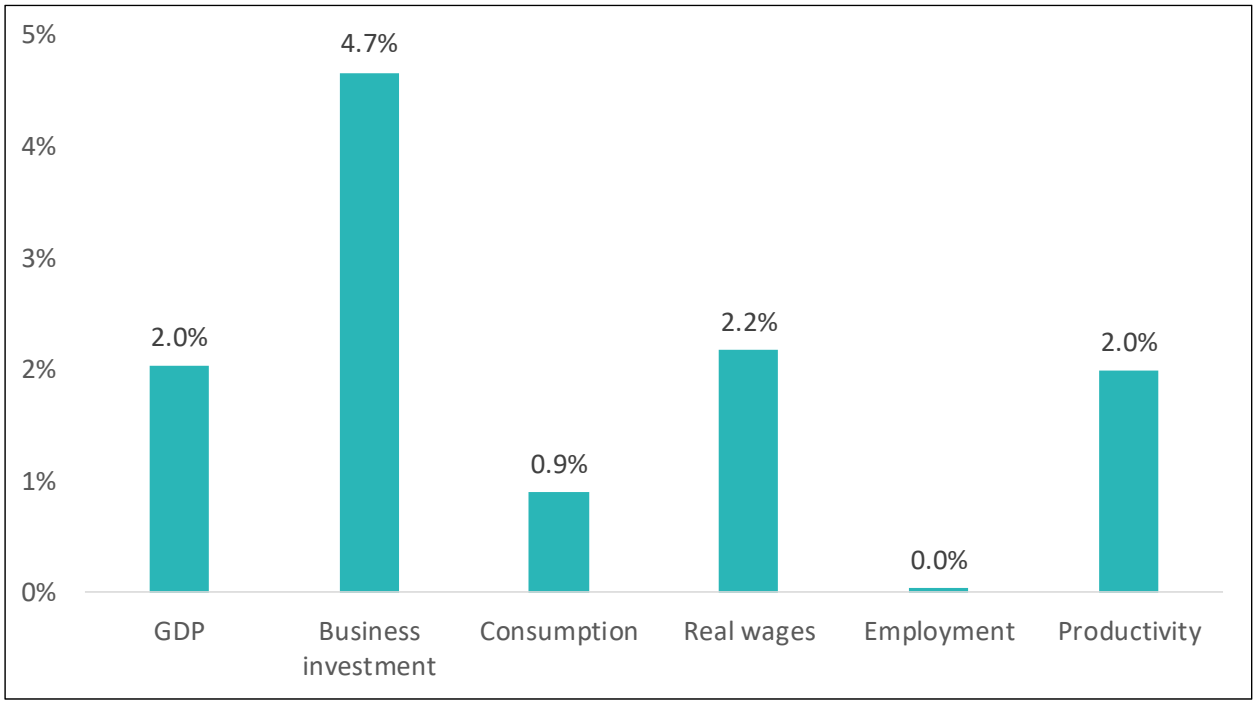
This overview of the economic impacts from the productivity shock focuses on the high scenario as the results in the low scenario are broadly symmetric.

In the high scenario, underlying annual labour productivity growth is 0.25 percentage points per year above its baseline rate, from the September quarter 2019. Over the nine years to 2027/28, this cumulates to a gain in the level of underlying labour productivity, relative to baseline, of 2.2 per cent.

As seen in Chart 3.1, this flows through to a similar gain in actual labour productivity of 2.0 per cent. With unemployment driven to its sustainable rate or NAIRU (non-accelerating inflation rate of unemployment), employment is little affected. Therefore the gain in actual productivity flows through to a similar percentage gain in GDP. Real wages gain approximately in line with productivity, leaving real unit labour costs broadly unaffected.

The gains in real wages from higher productivity growth can arise through some combination of higher nominal wages and lower prices. In the Macro Model, the Reserve Bank pursues a price inflation target, so most of the adjustment to higher productivity growth ultimately takes the form of higher nominal wages. This develops as follows.

Chart 3.1. Effect of a 0.25 percentage point increase in annual productivity growth, deviation from baseline in 2027/28



Source: Macro Model

Initially, higher productivity leads to lower price inflation. However, this leads to an easing in monetary policy as the Reserve Bank pursues its inflation target. By the time this policy response restores the inflation rate to its target, the price level has fallen 0.3 per cent below its baseline path. Because the Reserve Bank targets the inflation rate rather than the price level, this fall in prices is treated as water under the bridge and does not elicit a further policy response. Thereafter, gains in real wages are driven by higher nominal wages. For example, by 2027/28 there is a gain in real wages of 2.2 per cent (see Chart 3.1), via a gain in nominal wages of 1.9 per cent and the fall in prices of 0.3 per cent, relative to their baseline levels.

In a faster growing economy, a higher share of GDP needs to be allocated to investment, to support faster growth in capital stocks. Thus, there is a shift in the pattern of spending in favour of investment, including a gain of nearly 5 per cent in business investment. To make room for this, the gain in household consumption is around 1 per cent, below the gain in GDP as a whole of around 2 per cent.

3.2 Detailed impacts

The shock to labour productivity directly impacts the underlying or *trend* rate of economic growth in Australia. (The drivers of the trend rate of economic growth are the 'three Ps': population, participation and productivity.) In the forecast period, economic conditions drive *actual* economic growth away from trend growth in the short-term but in the long-term growth returns to its trend rate. Further, economic growth is always higher in the high productivity than in the baseline scenario, due to higher underlying growth.

This following discussion focuses on the high scenario, as the results in the low scenario are broadly symmetric.

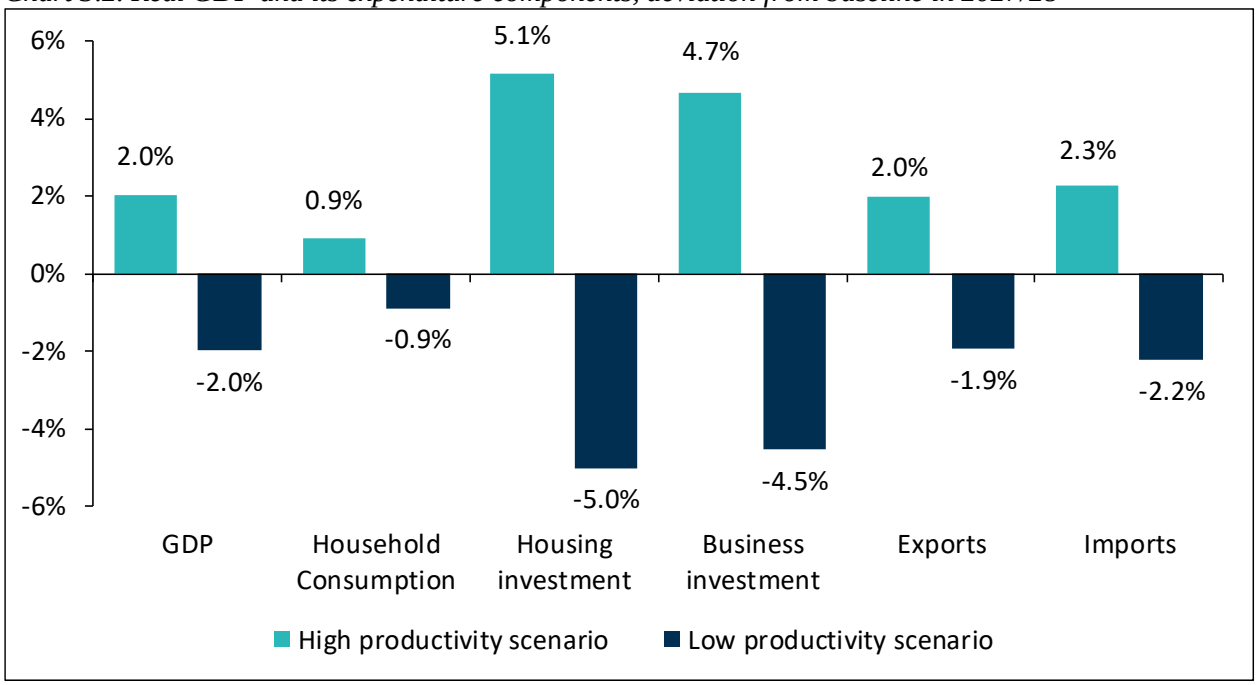
By 2027/28, the size of the economy is about 2 per cent larger in the high productivity scenario than in the baseline scenario, because this corresponds to the cumulative gain in productivity over the nine years to 2027/28. Chart 3.2 shows the economy is 2 per cent larger in the high scenario in 2027/28 compared to the baseline scenario.

Within the expenditure components of GDP, the largest percentage gains are for housing and business investment. This means investment is *larger*, when measured as a share of GDP, in the high productivity scenario than in the baseline scenario. While replacement investment to cover depreciation depends on the *level* of GDP, net investment (the creation of new capital) depends on the *change* GDP, and therefore accounts for a higher share of GDP when GDP is growing more rapidly in response to faster productivity growth.

This effect leads to gains in housing and business investment of about 5 per cent, well in excess of the gain in GDP of about 2 per cent, as seen in Chart 3.2. In 2027/28 exports and imports are higher by about 2 per cent, broadly in line with the expansion in GDP. The gain in household consumption is less at around 1 per cent, as it makes room for the larger percentage expansion in investment.

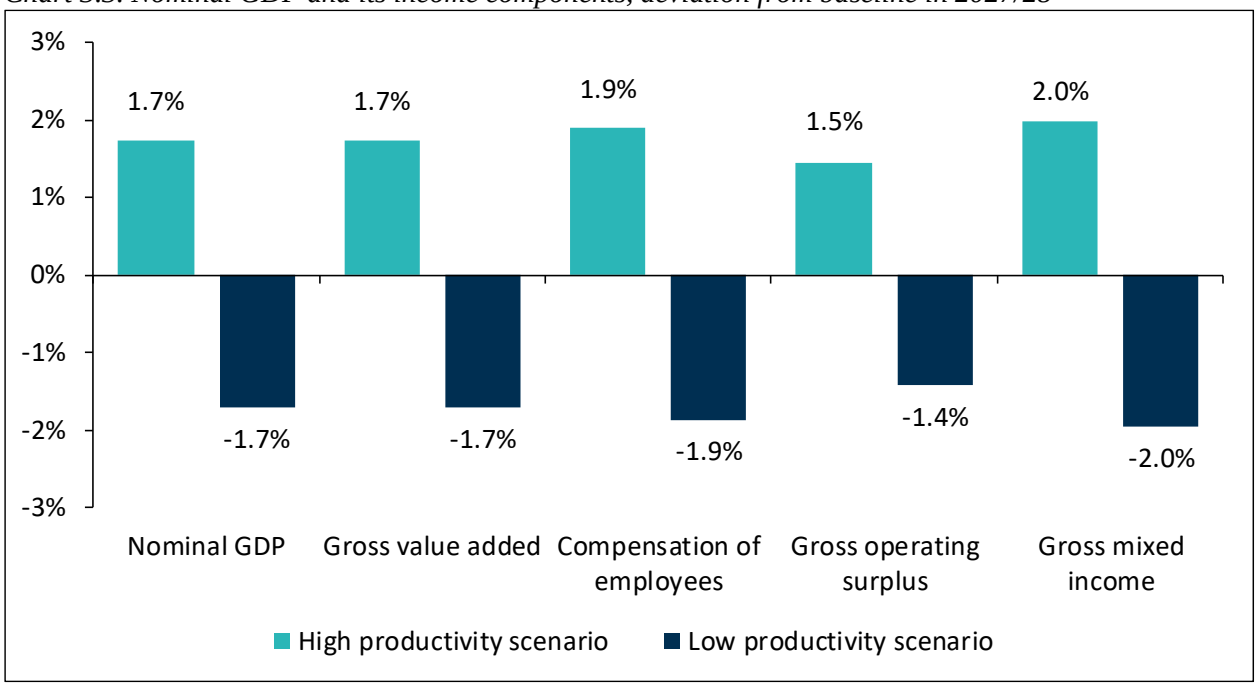
Nominal GDP is 1.7 per cent higher in 2027/28 in the high scenario than in the baseline scenario, reflecting the combined impact of the gain in real GDP of 2.0 per cent, and a small fall in the GDP price deflator of 0.3 per cent. Chart 3.3 shows that all components of nominal income expand broadly equi-proportionately with the expansion in nominal GDP. However, the percentage expansion in gross operating surplus is noticeably lower than for other components of income. This is because, as seen in Chart 3.4, the expansion of the gross operating surplus of the housing sector lags behind other sectors. Housing services account for a significant share of total gross operating surplus.

Chart 3.2. Real GDP and its expenditure components, deviation from baseline in 2027/28



Source: Macro Model

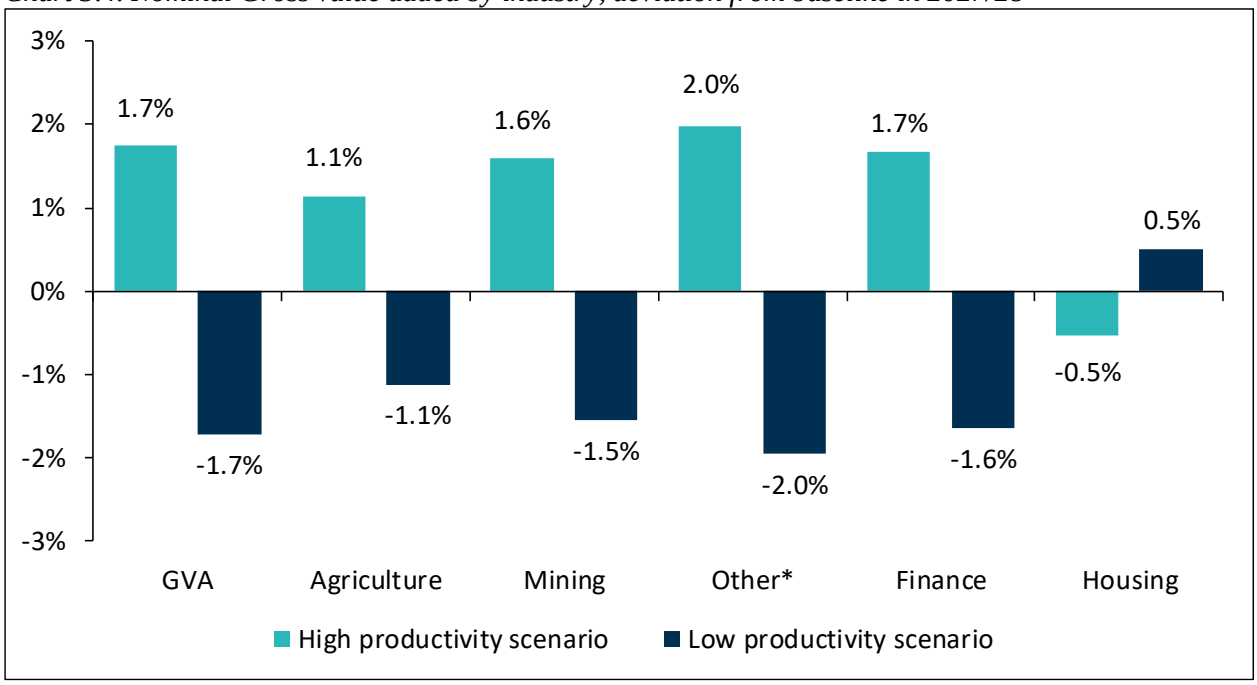
Chart 3.3. Nominal GDP and its income components, deviation from baseline in 2027/28



Source: Macro Model

Across most industries, the effects of the productivity gain are broadly uniform, as shown in Chart 3.4. This reflects the fact that the shock boosts underlying productivity for labour, land and natural resources by the same percentage in each industry. However, in the housing services sector, supply responds more quickly than demand to the productivity gains, putting downward pressure on the price of housing services in the early years of the simulation. This reflects a direct link in the model from smoothed productivity growth to rates of investment. However, beyond 2027/28, demand and prices for housing services expand strongly, gradually bringing the percentage gain in nominal gross value added more into line with that in other industries.

Chart 3.4. Nominal Gross value added by industry, deviation from baseline in 2027/28



* Includes finance and excludes housing
Source: Macro Model

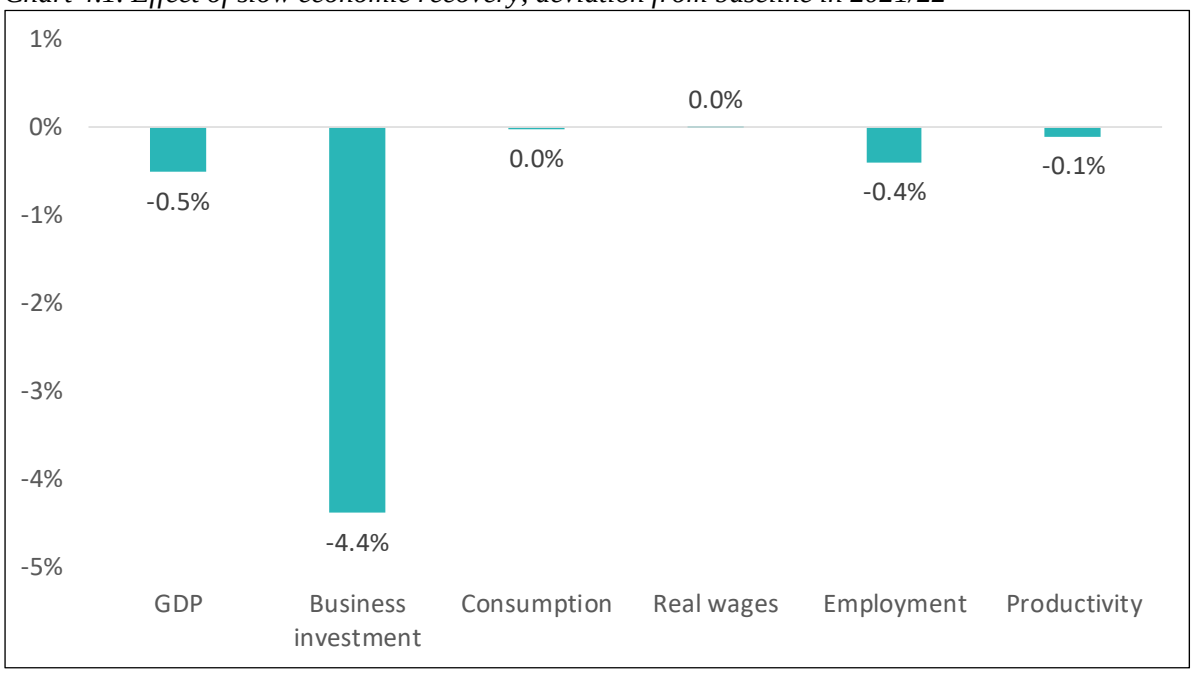
4 Speed of economic recovery

This section explains the economic impacts of the scenarios that vary the speed of economic recovery in the way described in section 2.

4.1 Overview of impacts

This overview of the economic impacts of the speed of recovery scenarios focuses on the slow recovery scenario as the results in the fast recovery scenario are broadly symmetric. The slow recovery scenario is generated by a negative shock to non-mining business investment extending from 2019/20 to 2022/23. Chart 4.1 shows the peaks impacts, which occur in 2021/22. By then, total private business investment is nearly 5 per cent below baseline.

Chart 4.1. Effect of slow economic recovery, deviation from baseline in 2021/22



Source: Macro Model

This temporary weakness in business investment leads to a cumulative loss in the business capital stock of 1.2 per cent. This in turn generates a trough loss in real GDP of 0.5 per cent in 2021/22.

Softer demand from lower business investment also puts downward pressure on inflation. By 2021/22, the CPI is 0.4 per cent below baseline. However, a similar weakness in nominal wages leaves real wages unaffected, as seen in Chart 4.1.

Lower price inflation leads to an easing in monetary policy as the Reserve Bank pursues its inflation target. This policy response restores the inflation rate to its target, stabilising the level of the CPI level at around 0.4 per cent below its baseline path. Because the Reserve Bank targets the inflation rate rather than the price level, this fall in prices relative to baseline is treated as water under the bridge and does not elicit a further policy response.

After the negative shock to investment is withdrawn, the loss in the capital stock gradually unwinds, and with it the loss in real GDP. The loss in real GDP has shrunk from 0.5 per cent to 0.1 per cent by 2034/35 and to zero after about another decade. The relatively drawn out nature of the adjustment

process to a changed capital stock is reflective of the speeds of adjustment of the capital stocks in each sector. Adjustment processes are considerably faster for other shocks, such as demand shocks.

4.2 Detailed impacts

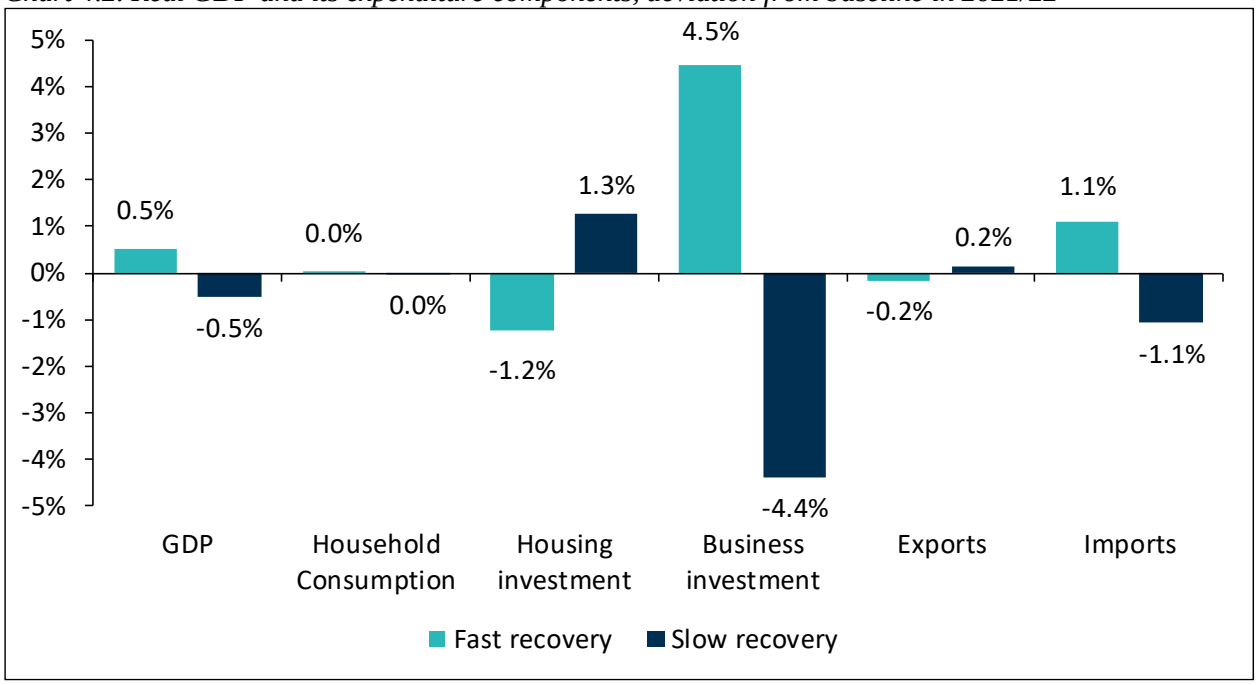
Different rates of economic recovery to a sustainable path have short-term impacts on the economy. However, because the final path is the same sustainable path, long-term economic outcomes are broadly unaffected. This following discussion focuses on the slow recovery scenario, as the results in the fast recovery scenario are broadly symmetric.

In all of the recovery scenarios, GDP is nearing its sustainable path by 2027/28, so deviations from baseline from then onwards are small. Instead, the focus here is on the peak impacts. For the fast recovery scenario the peak gain in GDP relative to baseline is achieved in 2021/22, while for the slow recovery scenario the peak loss occurs in the same year. Hence the charts are based on the year 2021/22.

Chart 4.2 shows the peak GDP loss in the slow recovery scenario of 0.5 per cent in 2021/22. This is driven by the negative shocks applied to non-mining business investment. By 2021/22, total business investment is over 4 per cent below baseline. Three factors help limit the impact of this weakness in business investment on demand for GDP.

First, weaker business investment leads to lower imports, cushioning the loss of GDP. Imports are about 1 per cent lower. Second, as noted previously, weaker demand leads to lower inflation and the Reserve Bank responds, leading to lower interest rates than in the baseline. This provides some stimulus to housing investment, which is over 1 per cent above baseline (see Chart 4.2). Third, another consequence of lower inflation is the so-called Deaton effect on household consumption. Because households tend to budget in nominal terms in the short-term, an unexpected fall in inflation leads to an unintentional rise in real consumption. Hence real household consumption is pushed up by the Deaton effect, while being pushed down by the income effect of weaker employment, leaving it broadly unaffected, as seen in Chart 4.2.

Chart 4.2. Real GDP and its expenditure components, deviation from baseline in 2021/22

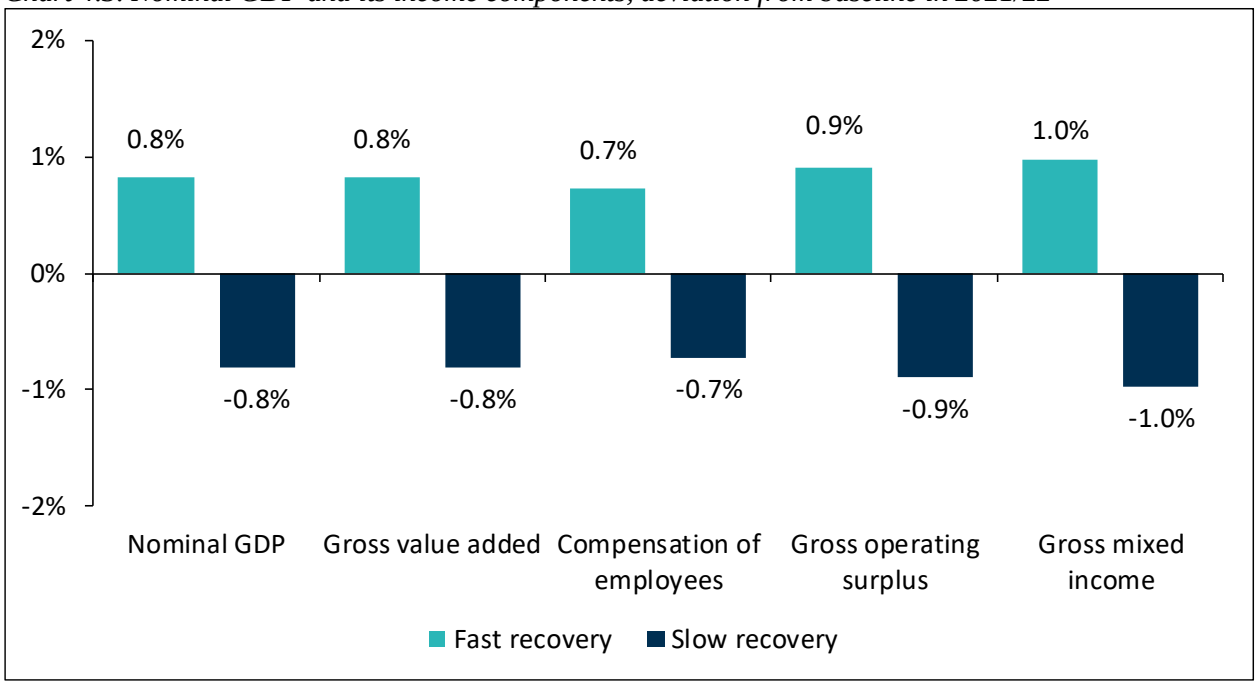


Source: Macro Model

Overall, these three effects only partly offset the effect of weaker business investment on GDP, leaving real GDP 0.5 per cent below baseline in 2021/22. This is also consistent with developments on the supply side of the economy. As noted earlier, the weakness in business investment implies a cumulating loss in the capital stock, relative to baseline, which weakens the supply of GDP.

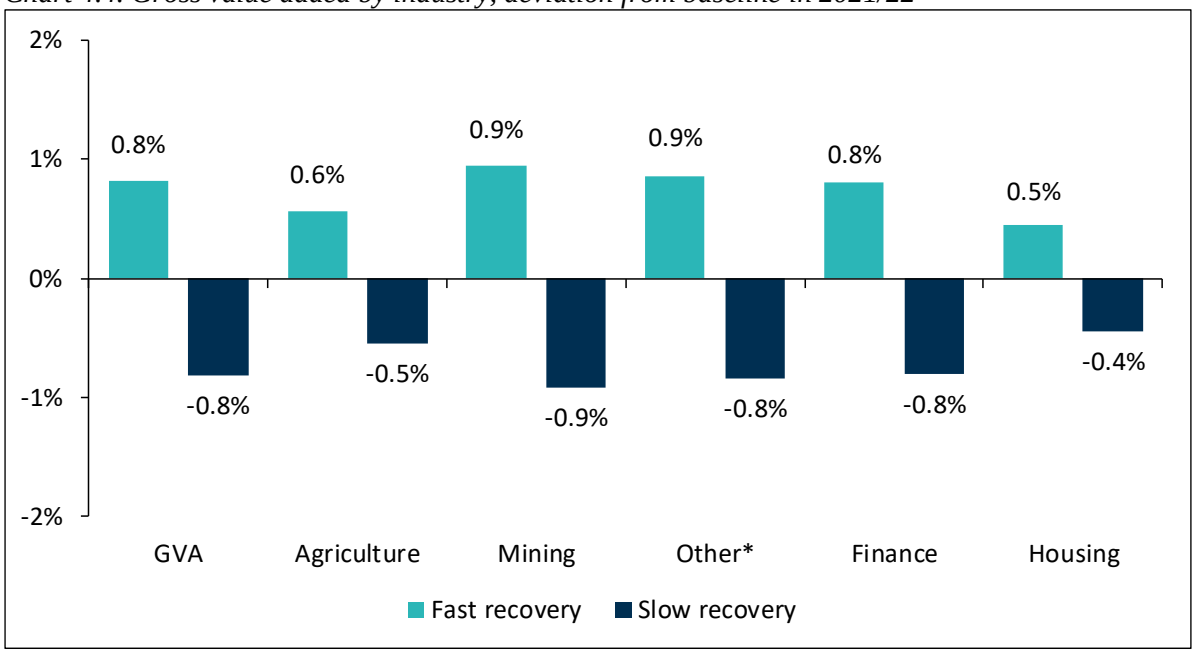
The loss in real GDP of 0.5 per cent, together with the initial fall in inflation, leads to an overall loss in nominal GDP of 0.8 per cent, as seen in Chart 4.3. All components of nominal income contract broadly equi-proportionately in line with the contraction in total nominal GDP (Chart 4.3). Similarly, the percentage effects on nominal activity are comparable across industries (Chart 4.4).

Chart 4.3. Nominal GDP and its income components, deviation from baseline in 2021/22



Source: Macro Model

Chart 4.4. Gross value added by industry, deviation from baseline in 2021/22



* Includes finance and excludes housing; Source: Macro Model

Appendix A: Macro Model

This Appendix provides an overview of the structure of Chris Murphy's Macro-econometric Model (Macro Model) that was used to generate the scenarios.

A.1 Economy-wide modelling methodology

There is a suite of linked economy-wide models that can be used to develop scenarios. This suite of models includes a demographic model, the Macro Model, a states model, and an industry satellite model. This Appendix provides more detail on the macro-econometric model.

1. Introduction

The Macro Model is a forecasting and policy model. It uses economic principles and evidence from the historical data to capture the broad workings of the Australian economy. This makes it a useful tool to enhance the robustness of economic forecasting whether the time horizon is short (to 2020) or long (to 2050). Notably, the approach taken places major emphasis on economic theory; this means that it can deliver useful insights into fiscal and monetary policies. For example, the six-sector Macro Model converges to a balanced growth path. In addition, the separate demographic model is used to provide population inputs and to determine long-term trends in the participation rate.

2. Economic Agents

Households

Households supply labour, own capital and government bonds, purchase goods and services from businesses and pay taxes to government.

The household's inter-temporal budget constraint is imposed by assuming that households have a savings target. This savings target is defined as the locally-owned stock of produced capital expressed as a multiple of labour income and its value is estimated from historical data. Since there is a target for the stock of capital that households hold, changes in the government's debt position do not affect the household's stock of real assets in the long run. Consumption gradually adjusts so that this savings target is gradually met. Consumption is positively affected by income from labour, produced capital, natural resources and bonds and transfers. Conversely, consumption is negatively affected by unanticipated inflation.

Once the aggregate level of consumption is determined it is allocated across the six industries identified in the model (Agriculture, Mining, Manufacturing, Government services and Housing services). Households choose their allocation to maximise a Constant Elasticity of Substitution (CES) utility function.

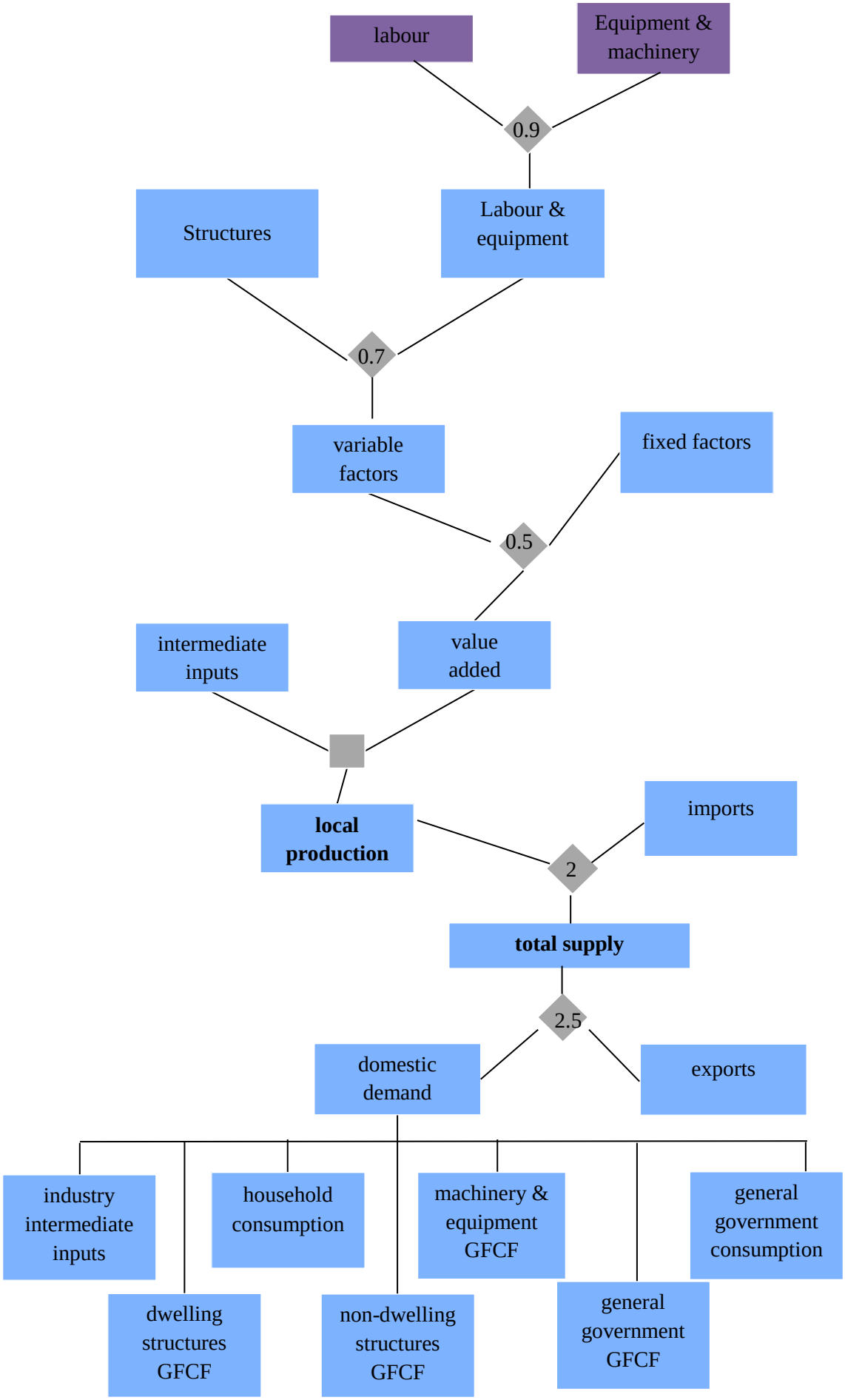
Labour supply is determined by the age and gender structure of the population, underlying trends in the participation rate and an encouraged worker effect.

Businesses

A representative business in each industry produces goods and services using labour, natural resources, structures, other types of capital and intermediate inputs. The six industries in the Macro Model are based on the Australian and New Zealand Standard Industrial Classification (ANZSIC 2006). The mapping between the model's industries and ANZSIC 2006 industries is shown in the table below.

Macro Model Industry	ANZSIC2006 Industries	ANZSIC2006 Codes
Agriculture (A)	Agriculture, forestry & fishing	A
Mining (B)	Mining	B
Manufacturing (C)	Manufacturing	C
Government services (G)	Public administration & safety Education & training Health care & social assistance	O P Q
Other Service Industries (S)	Electricity, gas, water & waste services Construction Wholesale trade Retail trade Accommodation and food services Transport, postal and warehousing Information media & telecommunications Financial & insurance services Rental, hiring & real estate services Professional, scientific & technical services Administrative and support services Arts and recreation services Other services	D E F G H I J K L M N R S
Housing services (T)	Ownership of Dwellings	-

The production technology for a typical industry in the Macro Model model is shown in the figure below.


labour
Equipment & machinery
0.9
Structures
Labour & equipment
0.7
variable factors
fixed factors
0.5
intermediate inputs
value added
local production
imports
2
total supply
2.5
domestic demand
exports
industry intermediate inputs
household consumption
machinery & equipment GFCF
general government consumption
dwelling structures GFCF
non-dwelling structures GFCF
general government GFCF

A representative business in each industry combines labour and non-structures capital (including machinery and equipment) into a labour and equipment bundle using a Constant Elasticity of Substitution (CES) technology with an elasticity of substitution of 0.9. Similarly, structures and the labour and equipment bundle are combined using CES technology to produce a variable factors bundle. Notably, this variable factors bundle is then combined with fixed factors to produce value added. The explicit modelling of fixed factors in production is a key feature of the Macro Model and is important in allowing for the role of land supply in the housing services sector and the role of mineral resources supply in the mining sector.

Local production is derived by combining value added and intermediate inputs in fixed proportions, a standard assumption in these types of models. A CES function is also used by firms to produce total supply from local production and imports. A high elasticity of substitution (2) is assumed between local production and imports. Finally, domestic businesses decide whether to sell on the domestic or export market based on a Constant Elasticity of Transformation technology, with an elasticity of transformation of 2.5.

In the short term, the quantity of output produced is determined by demand. Businesses are also constrained by the amount of capital they own. Thus, businesses choose the profit maximising level of labour, imports and exports based on a given level of domestic demand, capital, fixed factors, wages, and trade prices.

Over time, domestic prices adjust to equal marginal cost. In addition, the capital stock gradually adjusts so that the marginal product of capital is equal to its user cost. A Tobin's Q formulation is used to model capital stock adjustment. Importantly, the adjustment speed of domestic prices and the capital stock is estimated from quarterly historical data. This means that over time, the short-term constraints on firms are removed and firms simply maximise profits subject to the production technology.

Government

Governments collect taxes from households and businesses, purchase goods and services on behalf of households, invest in the economy, provide transfers to households, borrow from households, and set monetary policy.

The Macro Model recognises the key taxes collected by government and models their impact on behaviour. For example, the model forecasts revenue collections from the corporate income tax and recognises that corporate income tax affects the cost of capital and thus impacts investment decisions. Other taxes recognised in the Macro Model are labour income tax, production taxes by industry, and product taxes by end user.

The government's inter-temporal budget constraint is met by specifying a target deficit relative to nominal GDP. Labour income tax is the swing fiscal policy instrument and gradually adjusts to ensure that the deficit target is met in the long term.

Monetary policy in the Macro Model mimics how the Reserve Bank of Australia (RBA) pursues its inflation-targeting policy. Specifically, a Taylor rule is used to determine how the short-term interest rate reacts to deviations of inflation and the unemployment from their targets. The inflation target is set to 2.5 per cent, the mid-point of the RBA's target band, while the target unemployment rate is the NAIRU, which is estimated from historical data. The responsiveness of the short-term interest rates to deviations of the inflation rate and unemployment rate from their respective targets is estimated using

historical data from the mid-1990s, since this is when the RBA's inflation targeting regime began in earnest.

Foreign sector

The foreign sector provides funds, demands exports and supplies imports. As a small country, Australia is assumed to be a price taker for imports. However, it is assumed that Australia has some market power in export markets. That is, an increase in the volume of exports supplied by Australia leads to a small reduction in export prices.

Since households and the government meet their budget constraints in the long term, this means that external balance is also achieved in the long term and growth in net foreign liabilities is sustainable.

3. Market clearing

There are three key markets in the Macro Model, the labour market, goods market and asset market. For each, prices adjust to clear the market.

Wages are 'sticky' and gradually adjust to clear the labour market. An inflation-expectations augmented Phillips curve is used to model wage adjustment. In the long-run, wage growth is driven by consumer price inflation and growth in labour efficiency and the unemployment rate settles to the NAIRU.

As noted previously, in the short-term demand drives activity so that demand shocks cause business cycles. Over time, prices gradually adjust to clear the goods market. This means that, in the long term, activity is driven by supply-side factors such as the level of population, participation, productivity and the fixed factor.

In asset markets, the rate of return on capital is determined exogenously since Australia is a small, open economy. For financial assets, the rate of return on long-term bonds is based on the expectations theory of the term structure. Uncovered interest rate parity is used in determining the nominal exchange rate. The underlying assumption is that long-term domestic securities, short-term domestic securities and short-term foreign securities are perfectly substitutable.

4. Empirical aspects

Behavioural equations in the Macro Model are estimated econometrically from quarterly data starting, in most cases, from the early 1980s. The general-to-specific approach to incorporating dynamic adjustment is used, so that dynamics are fully captured. Diagnostic tests are performed on each estimated equation to check for model adequacy and statistical fit. This high level of data consistency means that the model is not only suitable for policy analysis, but also for forecasting.

Appendix B: Detailed results

Tables B1 to B4 provide year-by-year economic impacts for the four scenarios.

Table B.1. Low productivity scenario: deviation in selected variables from baseline

FY End	Real GDP	Household Consumption	Private Business Investment	Exports	Imports	Productivity	Nominal GDP	Compensation of employees	Gross operating surplus	Consumer Price Index	Exchange rate
2019	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2020	-0.1%	0.0%	-0.1%	0.0%	-0.1%	-0.1%	0.0%	0.0%	-0.1%	0.0%	-0.2%
2021	-0.3%	0.0%	-0.7%	-0.2%	-0.4%	-0.3%	-0.1%	-0.2%	-0.1%	0.2%	-0.2%
2022	-0.6%	-0.1%	-1.4%	-0.5%	-0.7%	-0.5%	-0.3%	-0.4%	-0.3%	0.3%	-0.3%
2023	-0.8%	-0.1%	-2.1%	-0.7%	-1.0%	-0.7%	-0.6%	-0.6%	-0.5%	0.3%	-0.3%
2024	-1.1%	-0.2%	-2.8%	-0.9%	-1.3%	-1.0%	-0.8%	-0.9%	-0.6%	0.4%	-0.3%
2025	-1.3%	-0.3%	-3.3%	-1.2%	-1.5%	-1.2%	-1.0%	-1.1%	-0.8%	0.4%	-0.3%
2026	-1.5%	-0.5%	-3.8%	-1.4%	-1.8%	-1.4%	-1.3%	-1.4%	-1.0%	0.4%	-0.3%
2027	-1.8%	-0.7%	-4.2%	-1.7%	-2.0%	-1.7%	-1.5%	-1.6%	-1.2%	0.4%	-0.3%
2028	-2.0%	-0.9%	-4.5%	-1.9%	-2.2%	-2.0%	-1.7%	-1.9%	-1.4%	0.4%	-0.3%
2029	-2.2%	-1.1%	-4.9%	-2.2%	-2.5%	-2.2%	-1.9%	-2.1%	-1.6%	0.4%	-0.4%
2030	-2.5%	-1.4%	-5.2%	-2.4%	-2.7%	-2.5%	-2.2%	-2.3%	-1.9%	0.5%	-0.4%
2031	-2.7%	-1.6%	-5.5%	-2.7%	-3.0%	-2.7%	-2.4%	-2.6%	-2.1%	0.5%	-0.4%
2032	-3.0%	-1.9%	-5.8%	-2.9%	-3.2%	-3.0%	-2.6%	-2.8%	-2.3%	0.5%	-0.5%
2033	-3.2%	-2.1%	-6.0%	-3.2%	-3.5%	-3.2%	-2.8%	-3.0%	-2.5%	0.5%	-0.5%
2034	-3.4%	-2.4%	-6.2%	-3.4%	-3.8%	-3.5%	-3.0%	-3.2%	-2.7%	0.5%	-0.5%
2035	-3.7%	-2.7%	-6.4%	-3.6%	-4.0%	-3.7%	-3.3%	-3.4%	-3.0%	0.5%	-0.6%

Source: Macro Model

Table B.2. High productivity scenario: deviation in selected variables from baseline

FY End	Real GDP	Household Consumption	Private Business Investment	Exports	Imports	Productivity	Nominal GDP	Compensation of employees	Gross operating surplus	Consumer Price Index	Exchange rate
2019	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2020	0.1%	0.0%	0.1%	0.0%	0.1%	0.1%	0.0%	0.0%	0.1%	0.0%	0.2%
2021	0.3%	0.0%	0.7%	0.2%	0.4%	0.3%	0.1%	0.2%	0.1%	-0.2%	0.2%
2022	0.6%	0.1%	1.4%	0.5%	0.7%	0.5%	0.3%	0.4%	0.3%	-0.3%	0.3%
2023	0.8%	0.1%	2.2%	0.7%	1.0%	0.7%	0.6%	0.6%	0.5%	-0.3%	0.3%
2024	1.1%	0.2%	2.8%	1.0%	1.3%	1.0%	0.8%	0.9%	0.7%	-0.4%	0.3%
2025	1.3%	0.3%	3.4%	1.2%	1.6%	1.2%	1.0%	1.2%	0.8%	-0.4%	0.3%
2026	1.5%	0.5%	3.9%	1.5%	1.8%	1.5%	1.3%	1.4%	1.0%	-0.4%	0.3%
2027	1.8%	0.7%	4.3%	1.7%	2.0%	1.7%	1.5%	1.7%	1.2%	-0.4%	0.3%
2028	2.0%	0.9%	4.7%	2.0%	2.3%	2.0%	1.7%	1.9%	1.5%	-0.4%	0.3%
2029	2.3%	1.1%	5.0%	2.2%	2.5%	2.3%	2.0%	2.1%	1.7%	-0.4%	0.4%
2030	2.5%	1.4%	5.4%	2.5%	2.8%	2.5%	2.2%	2.4%	1.9%	-0.5%	0.4%
2031	2.8%	1.6%	5.7%	2.8%	3.1%	2.8%	2.4%	2.6%	2.1%	-0.5%	0.4%
2032	3.1%	1.9%	6.0%	3.0%	3.3%	3.1%	2.7%	2.9%	2.4%	-0.5%	0.5%
2033	3.3%	2.2%	6.3%	3.3%	3.6%	3.3%	2.9%	3.1%	2.6%	-0.5%	0.5%
2034	3.6%	2.5%	6.5%	3.5%	3.9%	3.6%	3.1%	3.3%	2.8%	-0.5%	0.5%
2035	3.8%	2.8%	6.8%	3.8%	4.2%	3.9%	3.4%	3.6%	3.1%	-0.5%	0.6%

Source: Macro Model

Table B.3. Slow recovery scenario: deviation in selected variables from baseline

FY End	Real GDP	Household Consumption	Private Business Investment	Exports	Imports	Productivity	Nominal GDP	Compensation of employees	Gross operating surplus	Consumer Price Index	Exchange rate
2019	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2020	-0.3%	0.0%	-1.9%	0.0%	-0.5%	-0.2%	-0.3%	-0.1%	-0.5%	0.0%	-0.2%
2021	-0.5%	0.0%	-4.0%	0.1%	-1.0%	-0.2%	-0.7%	-0.5%	-0.9%	-0.2%	-0.1%
2022	-0.5%	0.0%	-4.4%	0.2%	-1.1%	-0.1%	-0.8%	-0.7%	-0.9%	-0.4%	0.1%
2023	-0.3%	-0.1%	-2.4%	0.1%	-0.5%	0.0%	-0.6%	-0.7%	-0.4%	-0.4%	0.3%
2024	-0.2%	-0.2%	-0.8%	0.0%	0.0%	-0.2%	-0.4%	-0.5%	-0.2%	-0.3%	0.4%
2025	-0.2%	-0.3%	-0.3%	-0.1%	0.1%	-0.3%	-0.3%	-0.4%	-0.3%	-0.2%	0.3%
2026	-0.3%	-0.3%	-0.2%	-0.1%	0.1%	-0.3%	-0.3%	-0.3%	-0.4%	-0.1%	0.2%
2027	-0.3%	-0.2%	-0.2%	-0.1%	0.0%	-0.3%	-0.3%	-0.3%	-0.4%	-0.1%	0.2%
2028	-0.2%	-0.2%	-0.2%	-0.1%	0.0%	-0.3%	-0.3%	-0.3%	-0.3%	-0.1%	0.2%
2029	-0.2%	-0.2%	-0.1%	-0.1%	0.0%	-0.2%	-0.3%	-0.3%	-0.3%	-0.2%	0.2%
2030	-0.2%	-0.2%	-0.1%	-0.1%	0.0%	-0.2%	-0.3%	-0.3%	-0.3%	-0.2%	0.2%
2031	-0.1%	-0.2%	-0.1%	-0.1%	0.0%	-0.2%	-0.3%	-0.3%	-0.3%	-0.2%	0.2%
2032	-0.1%	-0.2%	-0.1%	-0.1%	0.0%	-0.2%	-0.3%	-0.3%	-0.3%	-0.2%	0.2%
2033	-0.1%	-0.2%	-0.1%	-0.1%	0.0%	-0.1%	-0.3%	-0.3%	-0.3%	-0.2%	0.2%
2034	-0.1%	-0.2%	-0.1%	-0.1%	0.0%	-0.1%	-0.3%	-0.3%	-0.3%	-0.2%	0.2%
2035	-0.1%	-0.1%	-0.1%	-0.1%	0.0%	-0.1%	-0.3%	-0.3%	-0.3%	-0.2%	0.2%

Source: Macro Model

Table B.4. Fast recovery scenario: deviation in selected variables from baseline

FY End	Real GDP	Household Consumption	Private Business Investment	Exports	Imports	Productivity	Nominal GDP	Compensation of employees	Gross operating surplus	Consumer Price Index	Exchange rate
2019	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2020	0.3%	0.0%	1.9%	0.0%	0.5%	0.2%	0.3%	0.1%	0.5%	0.0%	0.2%
2021	0.5%	0.0%	4.0%	-0.1%	1.0%	0.2%	0.7%	0.5%	0.9%	0.2%	0.1%
2022	0.5%	0.0%	4.5%	-0.2%	1.1%	0.1%	0.8%	0.7%	0.9%	0.4%	-0.1%
2023	0.3%	0.1%	2.5%	-0.1%	0.6%	0.0%	0.6%	0.7%	0.4%	0.4%	-0.3%
2024	0.2%	0.2%	0.8%	0.0%	0.1%	0.1%	0.4%	0.5%	0.2%	0.3%	-0.4%
2025	0.2%	0.3%	0.3%	0.1%	-0.1%	0.3%	0.3%	0.4%	0.3%	0.2%	-0.4%
2026	0.3%	0.3%	0.2%	0.1%	-0.1%	0.3%	0.3%	0.3%	0.4%	0.1%	-0.3%
2027	0.3%	0.2%	0.2%	0.1%	0.0%	0.3%	0.3%	0.3%	0.4%	0.1%	-0.2%
2028	0.2%	0.2%	0.2%	0.1%	0.0%	0.2%	0.3%	0.3%	0.4%	0.1%	-0.2%
2029	0.2%	0.2%	0.1%	0.1%	0.0%	0.2%	0.3%	0.3%	0.3%	0.2%	-0.2%
2030	0.2%	0.2%	0.1%	0.1%	0.0%	0.2%	0.3%	0.3%	0.3%	0.2%	-0.2%
2031	0.1%	0.2%	0.1%	0.1%	0.0%	0.2%	0.3%	0.3%	0.3%	0.2%	-0.2%
2032	0.1%	0.2%	0.1%	0.1%	0.0%	0.2%	0.3%	0.3%	0.3%	0.2%	-0.2%
2033	0.1%	0.2%	0.1%	0.1%	0.0%	0.1%	0.3%	0.3%	0.3%	0.2%	-0.2%
2034	0.1%	0.1%	0.1%	0.1%	0.0%	0.1%	0.3%	0.3%	0.3%	0.2%	-0.2%
2035	0.1%	0.1%	0.1%	0.1%	0.0%	0.1%	0.3%	0.3%	0.3%	0.2%	-0.3%

Source: Macro Model