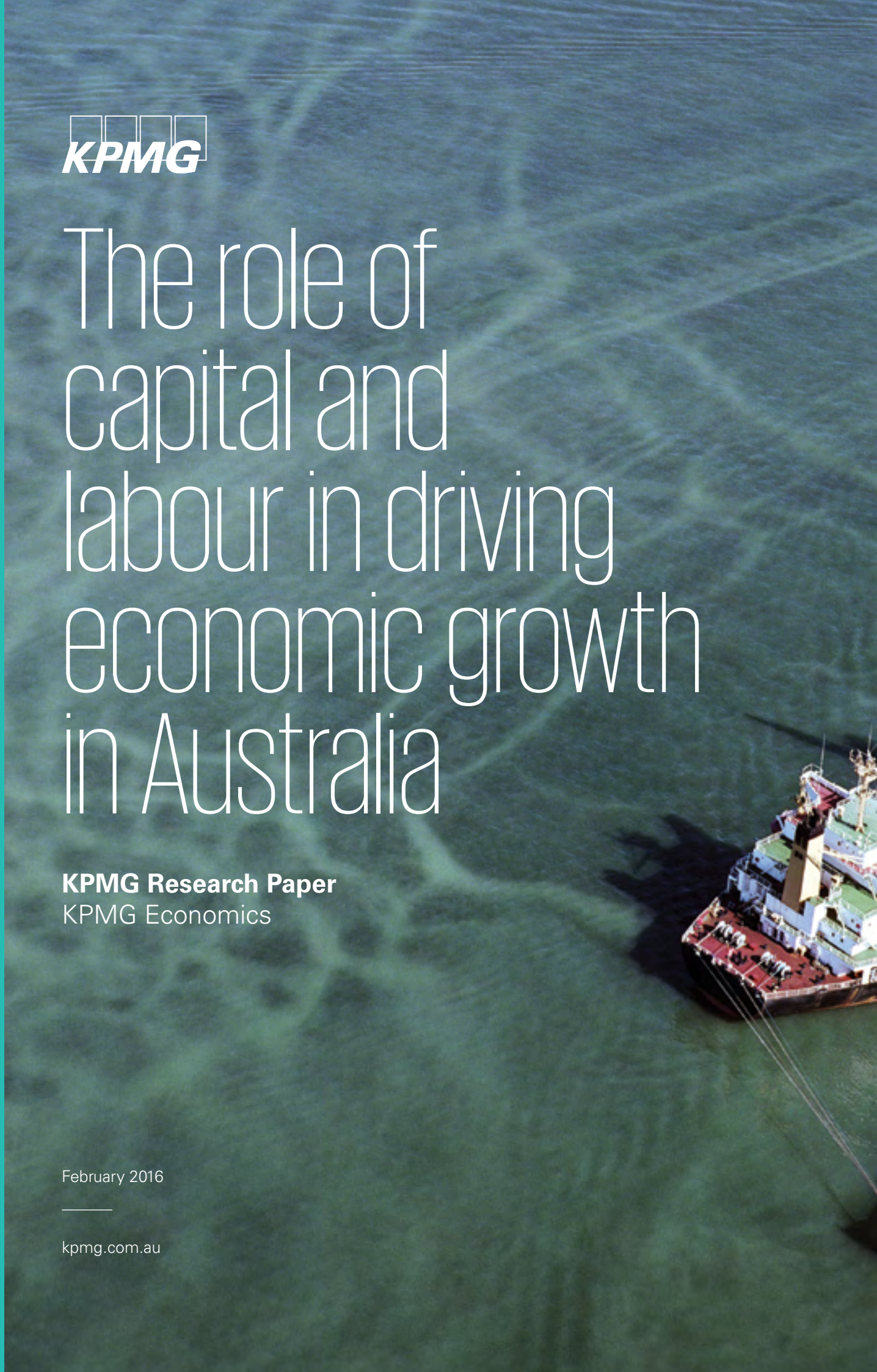

KPMG

# The role of capital and labour in driving economic growth in Australia

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# Contents

# Foreword: Australia's productivity challenge

In the world's advanced countries, productivity growth has slowed to such an extent over the last decade and a half, that genuine fears are being held that the developed world has entered an era of long-term economic stagnation. The ageing of these countries' populations and the absence of breakthrough innovations of the magnitude experienced since the Industrial Revolution – such as sewerage, railways, highways, airlines and electrification – might be consigning them to slow growth in incomes for the foreseeable future. Against this bleak background, KPMG has examined whether Australia might be afflicted with the same economic disease. Our preliminary diagnosis is not encouraging.

The best measure of productivity – multi-factor productivity – which reflects the skill and cleverness with which inputs of capital and labour are combined to produce a given amount of output, is lower now than it was more than 10 years ago.

Multi-factor productivity is difficult to measure, since it is the residual, or unexplained improvement in measured value added, after accounting for labour and capital productivity. That residual can therefore be a combination of multi-factor productivity growth and measurement errors. KPMG has analysed the data and concludes that notwithstanding any measurement errors in the national accounts, a marked slowdown in multi-factor productivity growth has occurred.

It is difficult to escape the conclusion that, as a nation, we are not generating the same benefits from our labour force and our physical assets relative to what we have in the past.

From around 2004 to 2013 the mining boom more than offset the effects of Australia's deteriorating productivity performance as income poured in from overseas buyers of our minerals. But with the passing of the mining boom the material living standards of Australians will again be determined by our productivity performance, as has overwhelmingly been the case for most of the past 40 years.

Australia experienced a productivity surge in the second half of the 1990s, built on a comprehensive microeconomic reform program designed to open up the economy to competition from within and from abroad. The ability of the newly opened economy to adopt and adapt the information and communications technologies being developed overseas from the late-1990s provided a second-round boost to productivity.

KPMG's macroeconomic forecasts are predicated on a slow return to long-term productivity growth rates. But our modelling shows that if productivity growth fails to return to the historical trend rate, the negative impact on economic growth would be larger than any positive effect of productivity performance overshooting by a similar amount.

These results support our contention that productivity growth will need to do almost all the heavy lifting if Australians are to enjoy rising living standards in an ageing population.

In order for productivity to be lifted, a new, comprehensive productivity-raising agenda is needed. KPMG considers the new agenda should fall into eight categories (shown on the right).

Implementing these reforms would be challenging but in their absence it is difficult to see any major new sources of productivity growth on the horizon. In an ageing population, and with no new mining boom in prospect, a continuation of Australia's recent poor multi-factor productivity performance would threaten existing living standards and prevent any chance of average living standards rising in the foreseeable future.

## Unlocking productivity

There is no 'one' solution to the challenge of boosting productivity across different industry sectors. Beyond this report examining the role of capital and labour, and our widely published views on tax reform, KPMG has explored some of the above agenda points in a series of additional short articles.

In *Infrastructure – The Path to Progress* – Partners, Paul Foxlee and Stan Stavros discuss how crucial infrastructure is to creating a more competitive Australia. In their view, we need to get better at implementing more holistic infrastructure solutions to drive efficiency through all aspects of the infrastructure lifecycle.

Facilitating competition is crucial, argues our Chief Economist Brendan Rynne. In a succinct article, *Honing our competitive instinct*, he explores how Australia can redefine and embrace forms of competition to achieve this.

Another area is technology and embracing it across government, enterprise and personal use. In *Systematising innovation*, KPMG Head of Management Consulting Ian Hancock looks at how investment in technology has a multiplier effect on productivity. He asks, 'what's holding us back?'

High quality education could be another ticket to a more productive future, according to Partner Elise Wherry. But in *Educating Australia* she says work needs to done in the sector to ensure a more effective partnership with industry.

Finally, another area that needs review through a productivity lens is workplace relations, argues KPMG Partner Paul Howes. In *Laying down their arms – the great Australian workplace relations challenge*, he looks at the connection between the two, and how reform of this area could help us become as productive as other advanced nations.

Australia should not be left behind in the productivity stakes. We have the great ideas, talented people and motivation to *surge* ahead. KPMG is pleased to weigh in on the productivity debate, proposing solutions to achieve the best outcomes for Australia.

**John Somerville**
National Managing Partner
Advisory

# Comprehensive productivity-raising agenda

**1 Investment in productive infrastructure**
Exploring new ways to engage the private sector in infrastructure funding, including innovative approaches to the financing of projects involving large capital outlays and long lead times.

**2 Regulatory reform**
Reducing unwarranted business regulation and ensuring regulation that is justified on social and environmental grounds is efficient in achieving its stated aims; that is, that it keeps compliance costs to the minimum necessary level.

**3 Competition policy**
Implementing the pro-competitive recommendations of the recently completed competition policy review, prioritising those reforms that are likely to have the largest productivity payoff.

**4 Dissemination of new technologies**
Providing practical government support for the rapid dissemination of new technologies through assistance with trade fairs, expositions and conduit websites.

**5 Insolvency laws**
Examining the scope for further reforms to insolvency laws, building on those announced in the federal government's innovation statement in December 2015, with a view to encouraging risk taking without overly compromising the protections provided to creditors, shareholders and consumers.

**6 Business failures**
Allowing businesses and indeed whole industries to fail when they lose competitiveness, enabling resources to flow to their most productive uses.

**7 University funding**
Supporting research and development at our universities to help boost Australia's innovation performance.

**8 Tax reform**
Making an important objective of any overall tax reform proposal the sharpening incentives for innovation.

# 1. Executive summary

Productivity is a fundamental driver of economic growth and a nation's prosperity. Productivity growth has been responsible for around 80 percent of the growth in Australia material living standards over the past 40 years. Facilitating productivity growth should be a priority for government if Australia is to maintain and enhance its living standards. The private sector, particularly that part exposed to global markets, has a strong incentive to seek ways of improving productivity. In doing so, national boundaries are becoming increasingly irrelevant. Capital is highly mobile, both nationally and internationally, and investors seek out opportunities that maximise returns. Skilled workers and entrepreneurs are also becoming increasingly internationally mobile.

Since the mid 2000s, multi-factor productivity (MFP) growth in Australia has been negative. Over this period there have been two productivity cycles. Over the most recent cycle MFP growth[1] is estimated to have contracted at an average annual rate of 0.2 percent. Over the previous cycle MFP contracted at an average annual rate of 0.3 percent. In contrast, moderate MFP growth characterised the three cycles from the early 1980s to the mid-1990s before surging during the period 1993-94 to 1998-99. The drivers of this productivity surge continues to be debated by economists. However, there is a degree of consensus around the roles played by microeconomic reform and by the rapid improvement and take-up of information and communication technologies (ICT).

On the basis of recent productivity measures, some commentators have been suggesting that Australia is experiencing a 'productivity crisis'. However, various economists have argued against this assessment and pointed to potential errors in the methodology used to measure productivity growth. KPMG acknowledges the methodological difficulties but believes that there are large pay-offs from better understanding the drivers of Australia's economic growth. A better understanding of how labour and capital contribute to economic growth and the role of scale economies provides a stronger platform for making positive contributions to policy debates.

Our research shows that between 1995 and 2015, capital productivity has on average accounted for about 69 percent of Australia's output growth (as measured by gross value added (GVA) in the market sectors).[2] Labour productivity has also been important, explaining approximately 18 percent of the growth in output during that period, while only around 12 percent of total GVA growth has been attributed to MFP.

The contributions of capital and labour to industry GVA over the period 1990-91 to 2014-15 reveals:

- growth in value added in the *mining and electricity, gas, water and waste services* sectors was virtually all accounted for by the capital employed
- the *transport, postal and warehousing, construction* and *financial and insurance services* sectors achieved most of the growth in their value added through labour inputs
- the *manufacturing* sector relied noticeably more on labour than on capital in creating economic value, and
- the contributions of capital and labour to growth in value added in the *health care and social assistance* sector are relatively balanced.

Our analysis also shows that the administration and support services and the professionals, scientific and technical services sectors were consistently able to achieve economies of scale[3] during the past 30 years. In contrast, deteriorating diseconomies of scale were evident in the mining and electricity, gas, water and wastewater sectors over the same time period.

1 For 'selected industries' being: Agriculture, forestry and fishing; Mining; Manufacturing; Electricity, gas, water and waste services; Construction; Wholesale trade; Retail trade; Accommodation and food services; Transport, postal and warehousing; Information, media and telecommunications; Financial and insurance services; Arts and recreational services.

2 Market sectors are defined by the Australian Bureau of Statistics as including the following industry divisions: Rental, hiring and real estate services; Professional, scientific and technical services; Administrative and support services; Other services.

3 Defined as being achieved when the cost of producing a good or service decrease as the volume of the output increases.

KPMG's macroeconomic forecasts are predicated on a slow return to long run productivity growth rates in the future. However, if productivity growth turns out to be faster (or slower) than we have assumed then our projections for Australia's GDP growth will under-estimate (or over-estimate) the outcome (other things equal). Importantly, the effects on our GDP projections of mis-estimating productivity growth are not symmetrical, as our modelling shows an asymmetrical relationship between productivity growth assumptions and GDP impacts. This means that if productivity growth is slower than assumed it will have a larger downside effect on GDP growth that the upside effect of productivity growth being faster than assumed. For this reason, there is a strong economic argument for focussing the economic policy debate on productivity growth. Failure to do so would increase downside risk in living standards to our society.

The proposition that government should facilitate productivity growth by addressing market failures and by eliminating or reducing distortions introduced by government policy is compelling. In practice, reducing policy-induced distortions, which are often long standing, is very difficult because there are real costs to doing so. However, government could adopt a range of policies that have the potential to make significant contributions to productivity growth in Australia, including the following:

- Continuing to explore innovative ways of encouraging the development of infrastructure with greater involvement of the private sector, including increasing the number of partnership arrangements with the private sector; addressing gaps in financial markets, especially with regard to long-term project finance; and designing appropriate regulatory structures so that the private sector can play a larger role in the provision and operation of infrastructure.
- Reducing complexity, duplication and compliance costs (i.e. reducing unnecessary 'red' and 'green' tape) to free up resources that can be used for more productive purposes. In addition, designing regulatory structures that align the incentives of private sector investors with the interests of consumers has the potential to increase productivity by facilitating greater investment by the private sector in brownfield and greenfield assets, particularly in the utility and transport sectors.
- Implementing recommendations identified in the recently completed Competition Policy Review (the 'Harper Review') that have the potential to re-invigorate the micro-economic reform process and generate benefits for the economy and living standards similar to those that flowed from the Hilmer-inspired reforms.
- Providing 'practical and commercial' assistance to business through the dissemination of information on new technologies and how they could be adopted and applied for the productivity benefit of the economy. Financially supporting the private sector provision of trade fairs, expositions, conduit websites, and other information sharing mechanisms is a key way government can assist Australian businesses to quickly adopt new, proven technologies.
- Implementing further reforms to insolvency laws to encourage risk-taking without overly compromising the protections provided to creditors, consumers and shareholders.
- Allowing individual companies, and even whole industries, to cease operating if they are structurally unprofitable, thereby allowing resources to flow to parts of the economy that have competitive advantages. Implicit in this idea is a more flexible labour force policy that facilitates organisational change and innovation as required, while also maintaining fairness for workers involved.
- Supporting higher education outcomes which is more than just funding university places; it includes appropriately funding and promoting research and development at universities to ensure core innovation outcomes in Australia.
- Ensuring tax policy settings assist rather than hinder innovation, since tax incentives can make a significant difference to the innovation environment.[4]

4 We thank Grant Wardell-Johnson, KPMG Partner and Leader, Australian Tax Centre, for suggesting this point.

# 2. Introduction

Productivity is a fundamental driver of economic growth and a nation's prosperity. Economists have long recognised the importance of productivity to the well-being of nations. The concept of productivity was formalised in models of economic growth developed in the early 20th century. This early work and subsequent refinements are exemplified by the Harrod-Domar[5] model developed in the 1940s and the Solow-Swan[6] model developed in the 1950s. The basic ideas about productivity encapsulated in these models continue to guide research on the topic to this day.

The central importance of productivity growth to economic well-being is summarised succinctly by William E. Simon, the former Secretary of the United States Treasury, and Inaugural Chairman of the United States National Productivity Advisory Committee, who noted:

*Productivity and the growth of productivity must be the first economic consideration at all times, not the last. That is the source of technological innovation, jobs, and wealth.*[7]

Since the late 1970s productivity growth has contributed much more to the growth of the Australian economy (as measured by GDP) than has workforce growth (made up of growth in working-age population and workforce participation). In fact the various intergenerational reports suggest that productivity growth has contributed more than 80 percent of the growth in real GDP over the past 40 years. This is a positive outcome for the Australian economy as it has allowed output per capita to increase, which is necessary for enhancing living standards. Following the end of the mining boom, and as Australia's population ages and the dependency ratio rises, productivity growth will be required to do the 'heavy lifting' to maintain and improve material living standards.

After a long stretch of strong economic growth, the impact of the 1970s oil price shocks on a highly regulated Australian economy re-focussed the attention of economists on the importance of productivity and on the role of government in promoting productivity growth. This focus has helped guide government policy since, by clarifying the role of government in a market-based economy and by quantifying the cost of policies that adversely distorted the allocation of resources. The influence of this work was exemplified by the micro-economic reforms implemented in the 1980s.

Historical experience suggests that in a market-based economy like Australia's, government is not particularly adept at directly driving private sector productivity growth by 'picking winners' or by implementing policies that, advertently or inadvertently, distort the allocation of resources.[8] Rather, experience suggests that government is well suited to facilitating productivity growth by addressing market failures and by eliminating or reducing distortions introduced by government policy.

On the basis of recent estimates of productivity growth, some commentators have suggested that Australia is experiencing a 'productivity crisis'. This interpretation of the data is not universally held. KPMG's view is that whether or not Australia's recent productivity performance constitutes a 'crisis' is of lesser importance than whether there are impediments to maximising productivity growth and, if so, how they can be eliminated or minimised.

To maintain and enhance living standards it is in Australia's interest to maximise productivity growth. In a market-based economy, it is the private sector, particularly that part exposed to global markets, which drives productivity growth because it has a strong incentive – the profit motive – to seek ways of improving productivity. In so doing, national boundaries are less relevant than they once were. Capital is highly mobile, both nationally and internationally, and investors will seek out opportunities that maximise risk-adjusted returns. Skilled workers and entrepreneurs are also becoming increasingly internationally mobile. It is now commonly accepted that governments cannot shield businesses from competition without compromising aggregate welfare. Against this back-drop, focus is now turning to the role of government in facilitating productivity growth.

5 Developed independently by Harrod (1939) and Domar (1946).

6 Developed independently by Australian economist Trevor Swan (1956) and Nobel Prize winning economist Robert Solow (1956).

7 As quoted in Kidd (2008).

8 Baldwin, R.E, Robert-Nicoud, F., *Entry and Asymmetric Lobbying: Why Governments Pick Losers*, London School of Economics, Political Science and Political Economy Working Paper, No.3/2007.

KPMG is well placed to contribute to the discussion about productivity in Australia. It has recently completed independent research on Australian productivity guided by key ideas distilled from a large body of productivity-related work undertaken on behalf of KPMG's private and public sector clients. This Research Paper is the first in a series that will focus on the key issues affecting productivity growth in Australia. The purpose of this introductory paper is to set the scene by examining Australia's recent productivity performance in a broader historical context. We examine the contributions that labour and capital have made to productivity at a sector level and assess the role played by economies of scale. Finally, we canvass a range of possible government policy reforms that we believe warrant further attention.

On the basis of recent estimates of productivity growth, some commentators have suggested that Australia is experiencing a 'productivity crisis'.

# 3. Productivity in Australia

Productivity is the efficiency with which a set of inputs can be combined to produce a unit of output (a good or a service). The set of inputs can include primary factors, such as various types of labour and fixed capital (e.g. plant and equipment, buildings, etc.), and produced inputs (i.e. intermediate inputs). In this paper we focus on the relationship between labour and capital inputs and output. Productivity growth emanates from innovation that allows firms to produce a unit of output with fewer inputs (or to produce more or a higher quality output with the same inputs).[9] Sources of innovation include new inventions, learning-by-doing and adoption of best-practice management techniques.

In its submission to the *Inquiry into Raising the Level of Productivity Growth in the Australian Economy* by the House Standing Committee on Economics in 2010, the Australian Bureau of Statistics provided a good summary of how economists think about productivity:

*In a very general sense, the best way to think about productivity is by thinking of production. You can have increased production from an increase in inputs, you can have increased production due to a more efficient use of those inputs or a combination of both of those things. In a growth accounting framework you can, in simple terms, measure productivity by looking at the ratio of output to one or more inputs. When you decompose it, in a sense, productivity is actually the residual of that calculation.*[10]

While there is clarity around what is meant by productivity, its measurement continues to be more elusive. In the next sections we describe commonly used measures of productivity and apply these to Australian data.

## 3.1 Measures of productivity

Commonly used measures of productivity fall into two categories.

- Partial factor productivity measures the change in output per unit of a particular input. Included in this category are measures of labour productivity[11] and capital productivity.[12]
- Multi-factor productivity (MFP, or total factor productivity) measures the change in output per unit of productively combined inputs (i.e. the bundle of inputs required to produce the particular output).

While partial factor productivity is relatively easy to calculate, it is generally regarded to be a less comprehensive measure of productivity than multi-factor productivity (MFP). Measures of partial factor productivity are also conceptually challenging because it is very difficult to isolate the impact of a particular input on productivity. For example, in measuring labour productivity it is difficult to disentangle the capital deepening[13] effects of new plant and equipment from improvements arising from the adoption of new technologies and better management practices. The increased comprehensiveness of MFP as a measure comes at a cost because it is more difficult to calculate.

The Reserve Bank of Australia (RBA) noted that one of the difficulties when analysing developments in productivity growth is separating short-term cyclical effects from changes in underlying trend productivity growth (D'Arcy and Gustafsson, 2012). To measure MFP[14] a particular form for the function used to aggregate inputs must be assumed, and the start of a new productivity cycle and the end of the previous cycle is identified as the peak deviation of the market sector measure of MFP from its long term trend. As such, productivity cycles can only be determined *ex post*,

9 The productivity measures that we apply at the sectoral level capture a compositional effect that is not directly related to innovation. Firms within an industry will have different levels of productivity and industry-wide productivity measures will capture the impact of any changes in the composition of firms within the industry (e.g. entry of high productivity firms at the expense of low productivity firms will be recorded as an increase in industry productivity).

10 House of Representatives (2010), *Inquiry into raising the productivity growth rate in the Australian economy*, The Parliament of the Commonwealth of Australia. This residual is also known as the Solow residual due to Robert Solow and his contribution to the growth accounting literature.

11 Measured as the volume of output per hour worked.

12 Measured as the volume of output per unit of capital employed.

13 Capital deepening occurs where the capital per worker is increasing in the economy.

14 In the remainder of this paper we use a measure of MFP that only includes labour and capital inputs and where the aggregation function is a homothetic form of the Cobb-Douglas production function. See Section 7 for a detailed technical discussion on the methodology applied here.

although productivity growth tends to be cyclical and often follows the general business cycle (Shapiro, 1987).

Various economists have suggested this generalisation does not hold universally for all industries and circumstances, as there are examples where productivity falls during economic expansions and rises during contractions. It is possible that the investment cycle is the primary cause of this outcome. Economic expansions are often driven by investment booms that mean activity is high, but output may not be (at least) matching this input growth until new plant and equipment are in place and able to positively contribute to higher production. Economic contractions are often driven by a collapse in investment, so the reverse occurs in that case. Another reason that productivity may be anti-cyclical in certain circumstances is that during a cyclical expansion firms are hiring the least productive workers (i.e. people previously unemployed or underemployed whose relative skills and capabilities are less than others in the workforce), resulting in diminishing marginal labour productivity; as a consequence, average labour productivity will fall. During an economic contraction firms will shed their least productive workers first, so the opposite occurs, and average productivity will tend to rise.

Zheng and Block (2012) found that MFP in the Australian mining industry is counter-cyclical, meaning that when the industry is booming (as reflected by a surge in prices) and output is increasing, its productivity performance is deteriorating, and to a lesser extent measured productivity is increasing when there is a decline in output prices.[15]

Farinas and Ruano (2004) also found that within industries there is a productivity spectrum along which individual firms sit, with new entrants and exiting firms often recording lower productivity than incumbent firms. Consequently, in periods where there is positive net entry, and there is a shift in the relative weights of incumbent, entering and existing firms, MFP growth can be negatively affected generating counter-cyclical productivity movements. That is, a positive net entry of firms occurring in cyclical expansions tends to decrease productivity whereas a negative net entry of firms occurring in cyclical slumps tends to improve productivity.

15 Block (2010) also finds this outcome for the mining sector in Canada.

### 3.2 Trends in Australian MFP

Figure 1 superimposes average annual MFP growth for the current and previous seven cycles on annual growth in MFP since 1981-82. We see that:

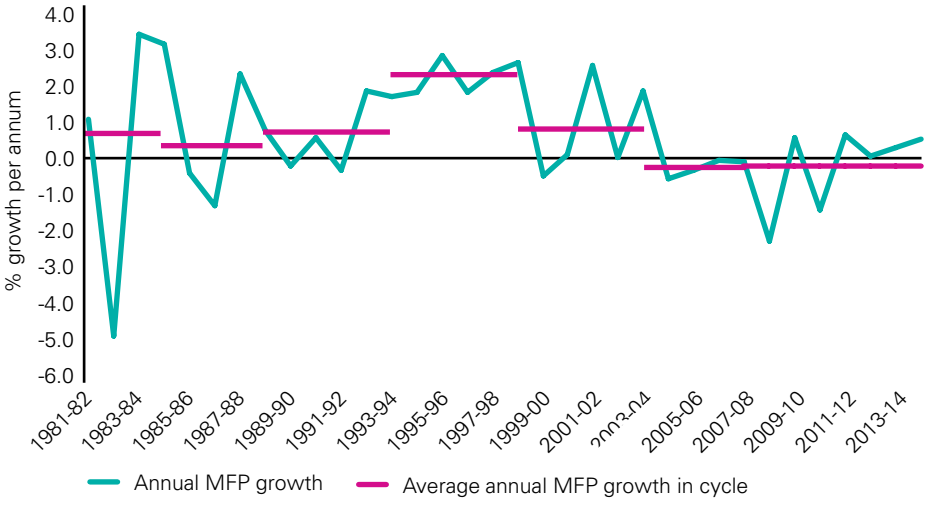
- average annual growth in MFP over the current and previous productivity cycle has been negative (-0.2 percent and -0.3 percent respectively)
- MFP growth was moderate in the three cycles between the early 1980s and the mid-1990s, before increasing noticeably during the period 1993-94 to 1998-99. The drivers of this increase in productivity continue to be debated by economists. However, there is a degree of consensus around the roles played by microeconomic reform implemented during the 1980s and early 1990s and by the rapid improvement and take-up of ICT during this period.

MFP growth has slowed since the early 2000s and was negative in most years between 2004 and 2012. Our analysis reveals that the main contributors to this result have been the *mining and electricity, gas and water services* sectors, which have recorded sharp reductions in MFP growth over this period (see Figure 2).

Figure 2 reveals that the mining sector has contributed most to the decline in aggregate MFP over the period 2003-04 to 2013-14. Nevertheless, in common with all other industries, the decline in mining MFP growth has plateaued and is showing signs of reversing in the most recent years. The measured decline in mining productivity is related to that sector's recent investment boom.

**Figure 1**

**Multi-factor productivity growth by year and cycle for selected industries**
**Australia, FY82 – FY15***

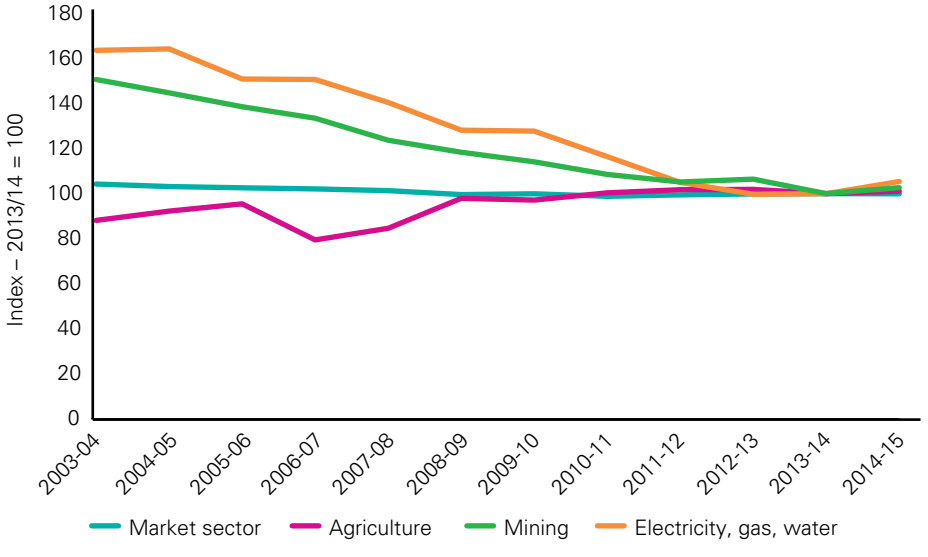



*Source: KPMG Economics, ABS*

* For 'selected industries' being: Agriculture, forestry and fishing; Mining; Manufacturing; Electricity, gas, water and waste services; Construction; Wholesale trade; Retail trade; Accommodation and food services; Transport, postal and warehousing; Information, media and telecommunications; Financial and insurance services; Arts and recreational services.

**Figure 2**

**MFP Index for agriculture, mining, and electricity, gas and water sectors**
**Australia, FY04 – FY15**




*Source: KPMG Economics, ABS*

Investment in the mining sector is lumpy in nature and subject to long gestation lags. Investment activity in the mining sector ramped up around 2005 and peaked somewhere around 2013. This investment was in major projects that took several years to complete. During this investment phase the mining sector increased its use of inputs to expand capacity (i.e. investment). Although capacity expanded significantly and output growth was at historical highs, because there was a long lag before this capacity came on stream, output growth did not match input growth. With many of the major mining projects developed during the boom now operational and in the process of increasing production, we expect productivity in the mining sector to rebound.

Figure 3 shows that measured labour productivity growth has been stronger than measured capital productivity growth since the mid-1990s. Over this period, labour productivity growth has dipped into negative territory on just two occasions whilst small positives were recorded for capital productivity growth on just three occasions. Since around 2004-05 MFP growth has generally been negative, with negative growth in capital productivity more than offsetting the positive growth in labour productivity. Insofar as the performance of capital productivity is an artefact of the investment boom in mining, the weak growth in MFP is unlikely to be a reliable indicator of underlying productivity growth.

The apparent decline in capital productivity over the last decade and the associated weakness in MFP, which has recorded negative growth in 6 out of the past 10 years, appears to be behind the suggestion by some commentators that Australia has a 'productivity crisis'. Nevertheless, this interpretation of the data is not universally held. For example, Foster (2014) has suggested that there is more likely to be a fundamental error in the methodology used to measure productivity growth estimates.

**Figure 3**

**Labour, capital and multi-factor productivity for market sector industries**

**Australia, FY96 – FY15***


*Source: KPMG Economics, ABS*

* For 'selected industries' being: Agriculture, forestry and fishing; Mining; Manufacturing; Electricity, gas, water and waste services; Construction; Wholesale trade; Retail trade; Accommodation and food services; Transport, postal and warehousing; Information, media and telecommunications; Financial and insurance services; Arts and recreational services.

The Cobb-Douglas specification[16] that is commonly used to calculate multi-factor productivity growth may be problematic because it relies on the assumption of constant returns to scale, i.e. a one unit increase in total inputs will lead to a one unit increase in output. This is to be contrasted with 'economies of scale', i.e. a one unit increase in total inputs will lead to a greater than one unit increase in output. In its 2013 report, the Productivity Commission attributed some of the measured MFP growth to economies of scale.

Measures of productivity are imperfect and must be interpreted with care. Indeed, analysts can plausibly interpret the same set of measures differently. For example, Foster (2014) interprets the evidence as follows:

*What we seemed to have observed is not a productivity crisis but, rather, relatively high rates of labour productivity growth made possible by well-managed investments in capital goods and a workforce which has been able to up-skill to take advantage of the capabilities of new capital goods, particularly computers of all kinds that have enabled massive increases in network connections and consequent scale advantages. This has resulted in increases in both wages and profits with a secular shift in the share of GDP towards the latter.*

The fact that Australia's recent productivity performance is subject to debate makes it difficult to frame policy responses. KPMG acknowledges the methodological difficulties with productivity measures but believes that there are large pay-offs to better understanding the drivers of Australia's economic growth. A better understanding of how labour and capital contribute to economic growth and the role of scale economies provides a stronger platform for making positive contributions to policy debates. The remainder of this report considers these issues in more detail.

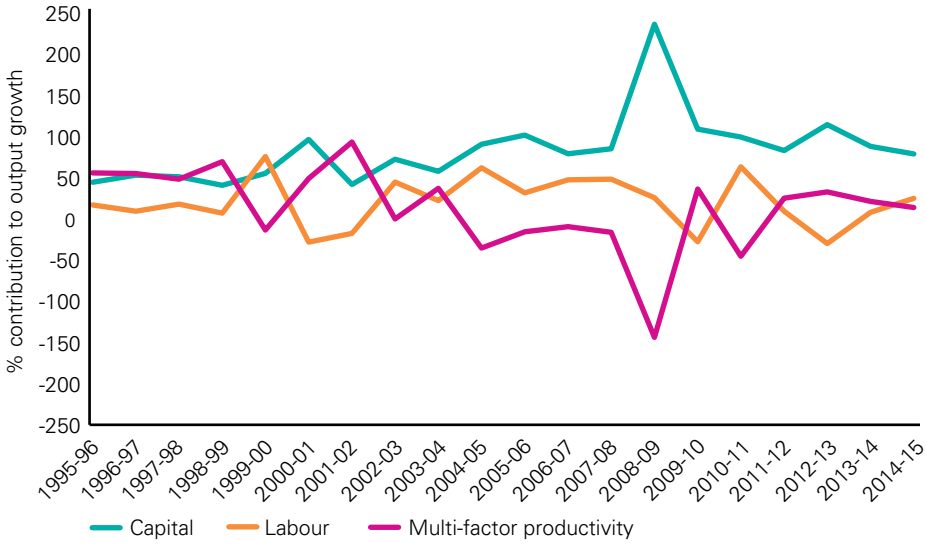
16 See Section 7.1 for an explanation of the Cobb-Douglas production function.

# 4. Role of capital and labour in explaining productivity

Figure 4 presents a decomposition of Australia's output growth as measured by the growth in gross value added (GVA) in the market sectors.[17]

Growth in the net fixed capital stock,[18] which averaged 3.3 percent per annum over the last two decades, has been the dominant contributor to growth in Australian GVA. Over this time period growth in net fixed capital accounted, on average, for about 69 percent of Australia's GVA growth. In contrast, the average annual contribution of labour to GVA growth over this period was around 18 percent. Multi-factor productivity accounted for the residual growth in GVA, making a contribution of approximately 12 percent on average during that period.

**Figure 4**
**Contribution to output growth***




*Source: KPMG Economics, ABS*

*Market sector industry aggregates

17 Market sectors are defined by the Australian Bureau of Statistics as including the following industry divisions: Agriculture, forestry and fishing; Mining; Manufacturing; Electricity, gas, water and waste services; Construction; Wholesale trade; Retail trade; Accommodation and food services; Transport, postal and warehousing; Information, media and telecommunications; Financial and insurance services; Rental, hiring and real estate services; Professional, scientific and technical services; Administrative and support services; Arts and recreational services; Other services.

18 Defined as the sum of incorporated and unincorporated productive capital stock (in chain volume measures).

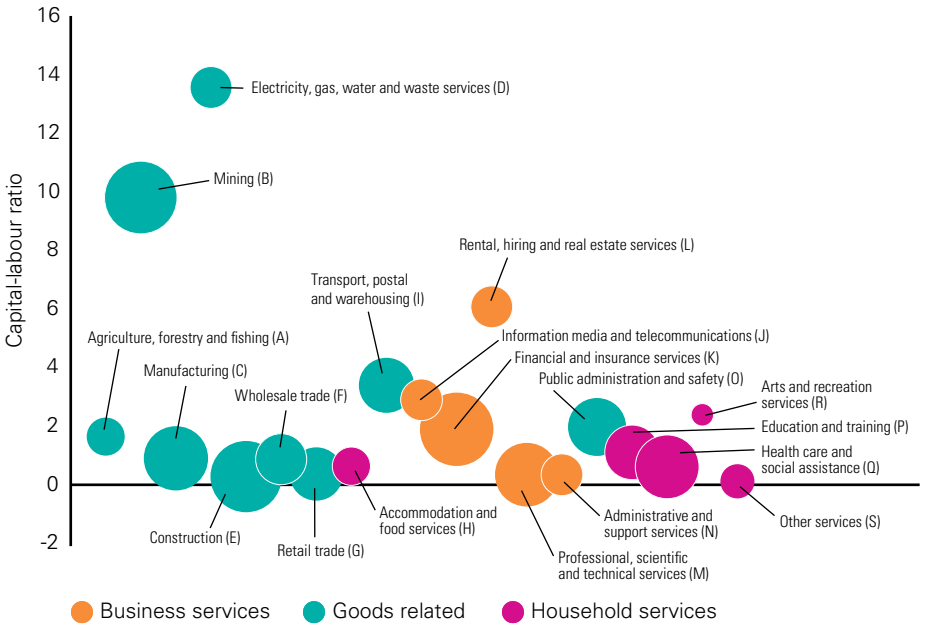
It is apparent that growth in the net capital stock has made a larger contribution to Australia's economy-wide growth than has growth in labour. It is instructive to decompose this result and examine the role that labour and capital play at the industry level. The capital-labour ratio of each industry ultimately determines the contribution of capital and labour to GVA.

In Figure 5 we show the average capital-labour ratios (defined as the ratio of the value of the capital services in thousands of dollars to hours worked) between 1990 and 2014 for 19 industrial sectors that make up the Australian economy. The size of the bubbles in the chart reflects the relative size of each industry (as measured by GVA in 2014). For presentational purposes we have grouped the 19 industries into three broad sectors that are distinguished in Figure 5 by different colours.

**Figure 5**

**Capital-labour ratios by industry**

**Australia, FY90 – FY14**




*Source: KPMG Economics, ABS*

The goods-related industries tend to have higher capital-labour ratios relative to business and household services industries. Based on the data from 1990 to 2014, goods-related industries use inputs of capital services worth on average $3,642 for every hour of labour input. In comparison, inputs of capital services worth $2,309 and $913 are used in the business services and household services industries for every hour of labour input.

Several industries have experienced significant changes in their capital-labour ratios over time. Table 4.1 (p.18) shows industry capital-labour ratios for three sub-periods spanning 1990 to 2014. Notably, the sectors with the highest capital-labour ratios in the first sub-period (1990–1998), *mining* and *electricity, gas, water and waste services,* also recorded the biggest increases in this ratio in the second sub-period (1999–2007). In the case of the *mining* sector, this increase is likely to reflect the impact of the surge in the terms of trade and the subsequent boom in investment that was well underway in the second half of the second sub-period. In the case of the *electricity, gas, water and waste services*, a variety of factors are likely to have led to the increase in the capital-labour ratio. This includes the development of a range of large infrastructure projects to deal with peak electricity demands, higher energy supply security standards, emissions constraints, renewable energy policy and droughts (desalination plants).

As revealed in Table 4.1, the capital-labour ratios in the *mining* and *electricity, gas, water and waste services* sectors are marginally lower in the sub-period 2008–2014 than in the sub-period 1998–2007. Capital augmentation, particularly in the mining sector, peaked towards the end of the 2008–2014 sub-period and has fallen sharply since. Renewed focus on how the regulatory structure has pushed up energy prices and uncertainty over carbon policy have both had the effect of reducing investment in the utilities sector. For most other sectors the capital-labour ratio over the three sub-periods was either relatively stable or trending higher, indicating increased reliance on physical structures, equipment and/or technology in their production processes.

**Table 4.1**

**Capital – labour ratio* by industry sector**
**Australia**

| Industry | 1990-1998 | 1999-2007 | 2008-2014 |
|---|---|---|---|
| Agriculture, forestry and fishing | 1.3 | 1.5 | 2.2 |
| Mining | 8.7 | 10.5 | 10.3 |
| Manufacturing | 0.7 | 0.9 | 1.3 |
| Electricity, gas, water and waste services | 11.9 | 14.9 | 14.0 |
| Construction | 0.3 | 0.3 | 0.3 |
| Wholesale trade | 0.6 | 0.9 | 1.1 |
| Retail trade | 0.3 | 0.4 | 0.4 |
| Accommodation and food services | 0.6 | 0.6 | 0.7 |
| Transport, postal and warehousing | 3.0 | 3.3 | 4.0 |
| Information media and telecommunications | 2.1 | 2.7 | 4.1 |
| Financial and insurance services | 1.7 | 2.0 | 2.0 |
| Rental, hiring and real estate services | 4.8 | 6.0 | 7.8 |
| Professional, scientific and technical services | 0.3 | 0.4 | 0.4 |
| Administrative and support services | 0.2 | 0.4 | 0.5 |
| Public administration and safety | 1.9 | 1.9 | 2.1 |
| Education and training | 1.0 | 1.1 | 1.2 |
| Health care and social assistance | 0.6 | 0.6 | 0.7 |
| Arts and recreation services | 1.8 | 2.3 | 2.3 |
| Other services | 0.0 | 0.1 | 0.2 |

* The ratio of the value of the capital services in thousands of dollars to hours worked

*Source: KPMG Economics, ABS*

# 5. Contribution of capital and labour to GVA in each industry

## 5.1 Introduction

In this section we analyse how capital, labour and scale economies at the industry level have contributed to Australia's economic growth. Before turning to the industry-level analysis we provide additional background on labour and capital inputs at the aggregate level. To do this, we have decomposed aggregate GVA into the contributions of capital services and actual hours worked over the period of 1986-87 to 2014-15.[19]

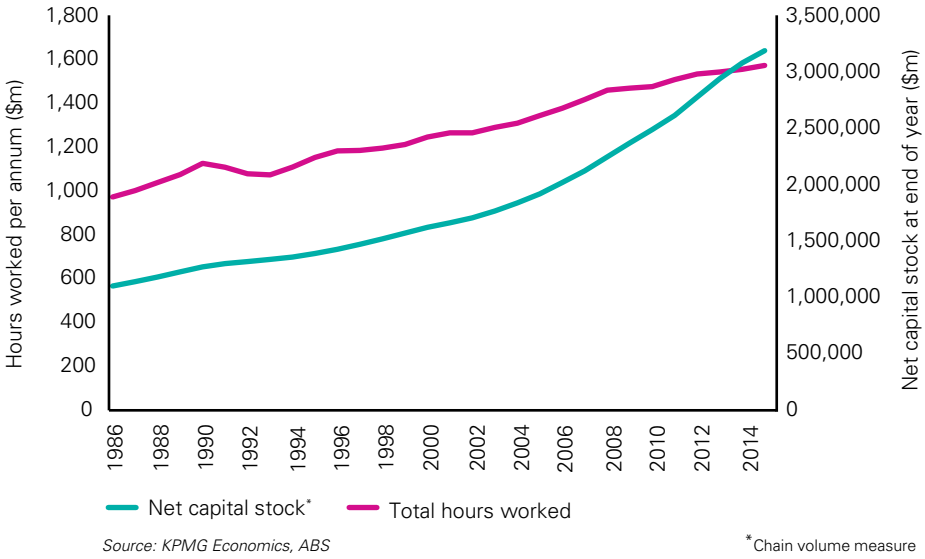
## 5.2 Background

Figure 6 shows that in real terms the stock of capital in the Australian economy grew twice as fast as hours worked over the 30 years between 1985-86 and 2014-15. The average annual rates of growth for capital and labour between 1985-86 and 2014-15 were 3.7 percent and 1.7 percent.

Figure 6 shows that growth in capital stocks accelerated from the early 2000s, averaging over 4.5 percent per annum since 1999.

**Figure 6**

**Hours worked and value of capital stock**
**Australia, FY86 – FY14**




*Source: KPMG Economics, ABS*

*Chain volume measure

19 The technical appendix presents details on the analytical method and regression estimates.

Figure 7 shows that over this period private new capital expenditure, which hovered around $40 billion to $50 billion during the 1990s, more than doubled during 2000s, peaking at just over $160 billion in 2013-14.

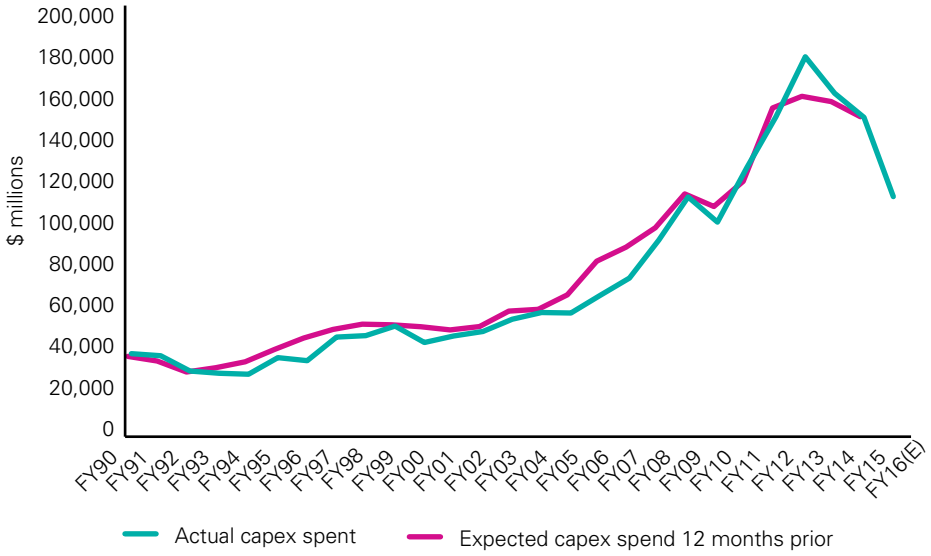
Close to $1.6 trillion has been invested in Australia's capital stock since the start of the new millennium, with almost $600 billion invested in the mining sector. A consequence of this unprecedented boom in capital expenditure has been the reordering of the relative importance of individual sectors in the Australian economy.

Figure 8 shows the contribution of individual sectors to Australia's GDP (measured as the ratio of industry GVA to aggregate GVA) and each sector's share of the nation's capital stock. For each sector two data points are identified: the first, identified by light blue circles and incorporating the value '1' in its reference name, relates to 1997-98 (which is recognised as the end of a productivity cycle); and the second, identified by orange triangles and incorporating the value '2' in its reference name, refers to 2014-15. Several notable structural changes are revealed in Figure 8.

- The *mining* sector (identified by points B1 and B2) recorded the most movement of any sector, both in terms of its share in aggregate GVA (moving from 3.5 percent in FY98 to 9.8 percent in FY15) and in terms of its share of the national capital stock (11 percent to 21 percent).
- The *financial* services sector also recorded a significant increase in its share of GVA between 1998 (K1, 4.4 percent) and 2015 (K2, 9.9 percent) but it did so at the same time as its share of the nation's capital fell (from 6 percent to 4 percent). It is important to note that the *financial services* sector's capital stock expanded by almost 40 percent in real terms between 1997-98 and 2014-15 (from about $87 billion to $121 billion). Despite this increase,

## Figure 7

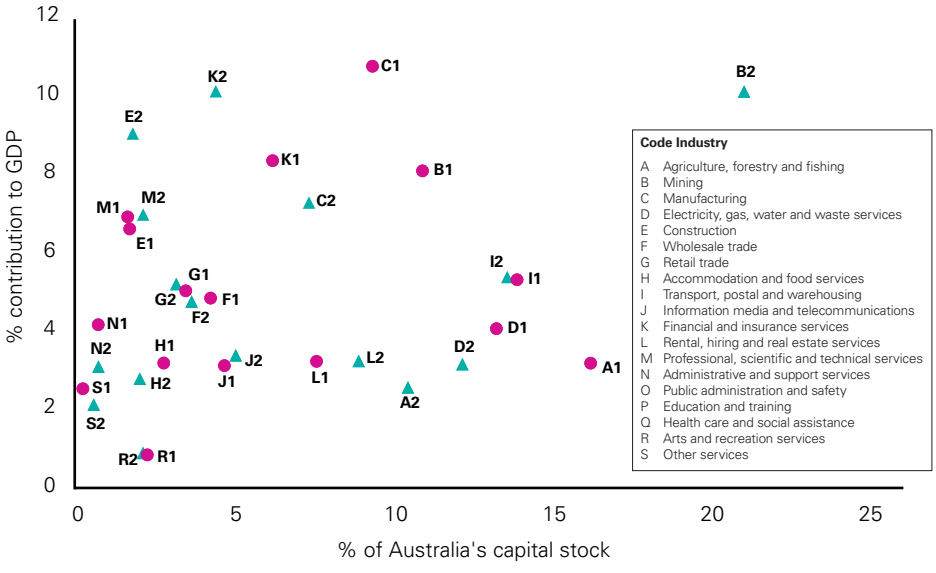
**Private new capital expenditure**
**Actual and expected, original**




*Source: KPMG Economics, ABS*

## Figure 8

**Share of capital stock and contribution to GDP by market industry**
**Australia, FY02 and FY15**




*Source: KPMG Economics, ABS*

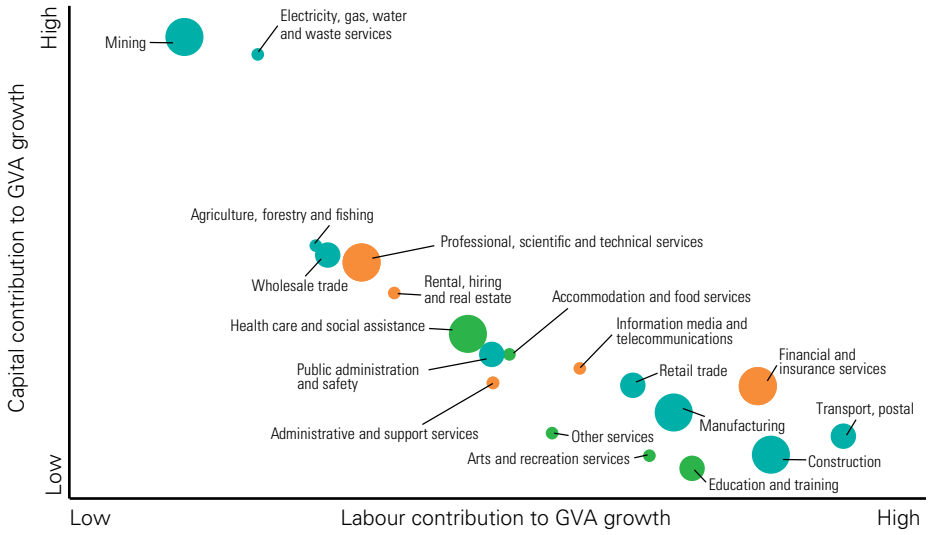
the *financial services* sector's share of the nation's capital stock contracted because the extraordinary increase in capital expenditure in the *mining* sector has skewed the distribution of the nation's capital stock strongly towards the *mining* sector.

- The *electricity, gas, water and waste services* sector (identified by points D1 and D2) experienced a significant increase in capital expenditure over this period, with many jurisdictions upgrading and improving the reliability of their electricity networks in an attempt to 'de-risk' their operations. Despite this, the sector's share of aggregate GVA fell from 4.2 percent in 1997-98 to 3.2 percent in 2014-15. Tightening of competition and regulatory policy together with significant organisational reforms contributed to the decline in the sector's share in the economy.
- The *agricultural* sector (identified by points A1 and A2) recorded only a minor fall in relative contribution to GDP over the analysis period, but its share of Australia's capital stock fell significantly from 16 percent in the first period to 11 percent in thew second period.
- Conversely, the *manufacturing* sector (identified by points C1 and C2) recorded a notable decline in its contribution to GDP, but its use of Australia's capital stock reduced by a proportionally smaller amount. This suggests the two sectors have been experiencing opposite capacity utilisation impacts during the second analysis period, with the agricultural sector seeing improving outcomes, while the manufacturing sector experienced a decline.

**Figure 9**

**Relative contribution to Industry GVA by labour and capital**

**Australia, FY91 – FY15**




*Source: KPMG Economics*

## 5.3 Contribution of capital and labour to GVA

Figure 9 shows the contribution of capital and labour to industry GVA over the period 1990-91 to 2014-15.[20] Results that stand out include:

- value added in the *mining* and *electricity, gas, water and waste services* sectors was dominated by capital inputs
- value added in the *transport, postal and warehousing*, *construction* and *financial and insurance services* sectors was dominated by labour inputs;
- the *manufacturing* sector relied noticeably more on labour inputs than capital inputs in generating value added, and
- the *health care and social assistance* sector relied fairly evenly on the contributions of capital and labour inputs to generate value added.

The relative contributions of capital and labour to industry GVA have been recomputed for two time periods, with the results presented in Figure 10. The first period spans 1986-87 to 2001-02[21] and the second period spans 1999-2000 to 2014-15[22]. The first sub-period overlaps the second because our historical data started in 1986-87 and a sample of 15 years was considered the minimum required for robust analysis.

20 The size of the bubble represents the relative importance each industry is to total Australian GDP as at 30 June 2015.

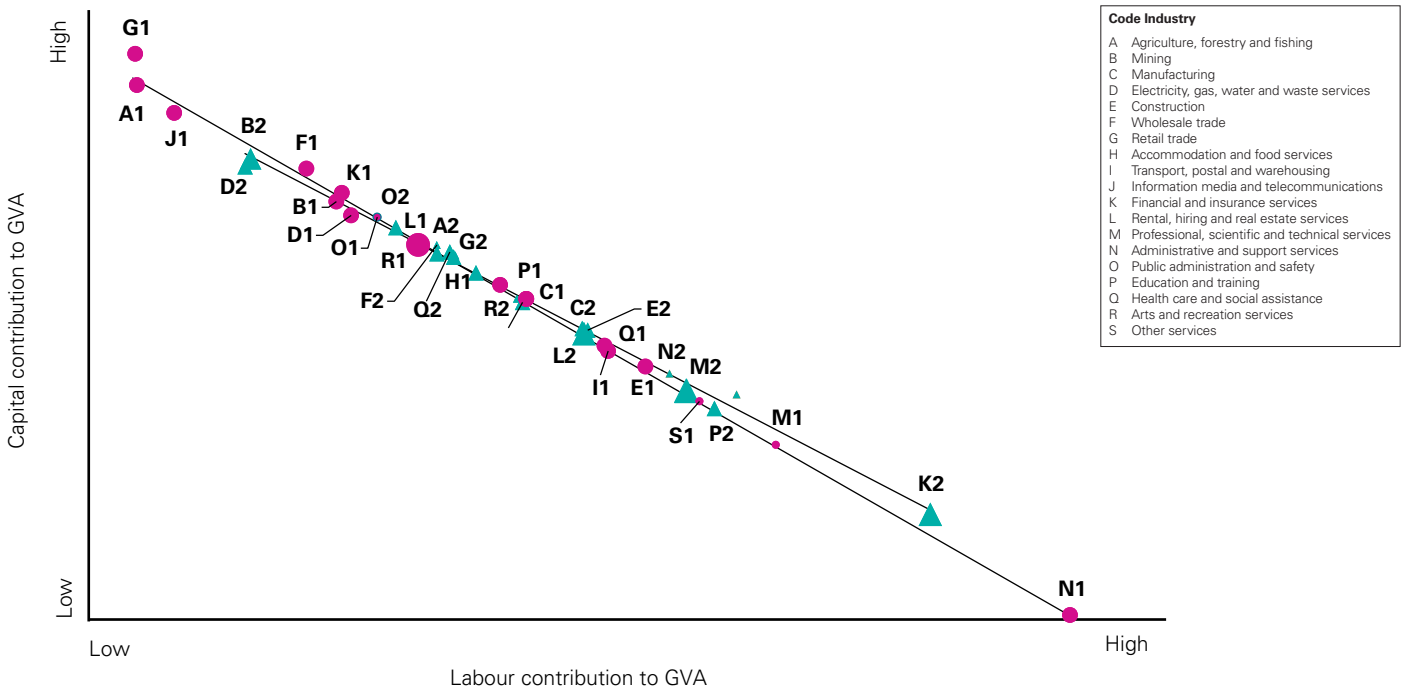
21 As nominated by the term '1' in Figure 10.

22 As nominated by the term '2' in Figure 10.

## Figure 10

### Relative contribution to Industry GVA by capital and labour

**Australia, FY87/02 and FY00/15**




*Source: KPMG Economics*

## Figure 11

### Scale effects by industry

**Australia, FY87/02 and FY00/15**


*Source: KPMG Economics*

The results presented in Figure 10 show that during the period 1986-87 to 2001-02:

- the *agriculture, forestry and fishing, retail trade* and *information, media and telecommunications* sectors were the most heavily reliant on capital inputs to generate value added, and
- the *administrative and support services* and *professional, scientific and technical services* sectors were the most heavily reliant on labour inputs.

This statistical analysis affirms the experience of the time. For example, the agriculture sector saw a consolidation in the number of industry participants, with farms getting larger and more reliant on machinery. The telecommunications sector saw the launch of Australia's first satellite in 1985 and increased competition with the privatisation of AUSSAT and the establishment of OPTUS in 1991. However, while there were major advances in ICT technologies during this period, wholesale adoption of these productivity enhancing innovations in the workplace took time. Personal computers, user-friendly software and mobile phones became business 'norms' from the mid-1990s.

Over the second 15 year sub-period, spanning 1999-2000 to 2014-15, Figure 10 reveals that:

- the *mining and electricity, gas, water and waste services* sectors became even more dependent on capital in their production processes
- the *financial and insurance services* sector switched dependency from capital in the first period to labour in the second, and
- the *manufacturing and* t*ransport, postal and warehousing* sectors employed combinations of labour and capital that were broadly similar across the two periods.

As part of our analysis we have tested whether industries have experienced economies or diseconomies of scale in their production processes. The results of this work are summarised in Figure 11.

According to our results the *administration and support services* and the *professionals, scientific and technical services* sectors were consistently able to achieve economies of scale over both time periods. In contrast, the *mining and electricity, gas, water and wastewater* sectors experienced diseconomies of scale over both periods, with the second period worse than the first.

Management and Board focus on increasing their individual company's supply into the market, combined with amplified operational complexity, resulted in both the mining and electricity, gas, water and wastewater sectors investing significantly relative to their economic output during the period 1999-2000 to 2014-15. While these sectors both can expect strong increases in production after new long-lived assets are commissioned, factors such as poor capital management, lax project oversight and unplanned price escalations also appear to have significantly contributed to diseconomies of scale effects.

Australia's *financial and insurance services* sector recorded a substantial increase in scale economies in the second period. This sector experienced significant change with the deregulation of financial markets starting in the 1980s, the implementation of a compulsory superannuation system in the 1990s and the global financial crisis in the 2000s. The adoption of ICT technologies, workforce redesign, focus on risk-return outcomes in a member-choice superannuation system, and consolidation of major institutions (including superannuation funds, banks and insurance companies) are all likely to have contributed to the scale economies in the sector.

# 6. Implications

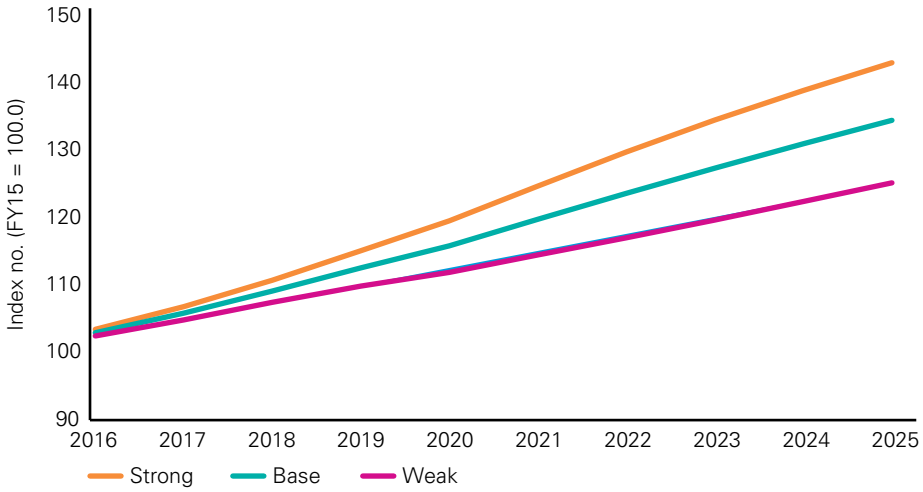
## 6.1 Impact of productivity growth on economic output

Like other maturing economies, Australia will face a range of economic challenges over the coming years and decades. The 2015 Intergenerational Report[23] has indicated that unless there is a shift upwards in the birth rate or level of net overseas migration, we – like most other western economies – will experience lower population growth in the future than was achieved in the past. As part of this demographic shift, the population will be relatively older and thus it is likely that the dependency ratio (the ratio of those not in the workforce to those in the workforce) will be higher. With lower population growth and labour participation rates, Australia will need to rely on productivity growth just to maintain our standard of living at comparable levels to what we enjoy today.

**Figure 12**

**Deviation from baseline GDP forecasts due to different assumptions of productivity growth**

**Australia, FY16 – FY25**




*Source: KPMG Economics*

KPMG has produced macroeconomic forecasts to 2025 based on a range of future productivity growth assumption. These are presented in Figure 12. The baseline or business-as-usual forecast assumes annual productivity growth of 1.6 percent. This is based on a slow return to long-run trend growth in productivity levels of 1.8 percent, which is on average lower than what was experienced during the productivity surge of the 1990s. However, if Australia experiences productivity growth[24] higher or lower than in the baseline, GDP growth will also be affected.

Assuming that productivity growth is 5 percent higher than baseline (strong productivity scenario) and 5 percent lower than baseline (weak productivity scenario) from 2015-16 to 2020-21, all else being equal, cumulative GDP over the period 2015-16 to 2024-25 is:

- $768 billion or 6.5 percent lower than baseline in the weak productivity growth scenario; and
- $715 billion or 6.3 percent higher than baseline in the strong productivity growth scenario.

While this differential is relatively small – some $53 billion over 10 years – the point of this example is the wider the downside gap is between actual productivity outcomes and expected productivity outcomes, the proportionally more it hurts our economy.

This means there is a real economic incentive to bias our focus and efforts on overachieving productivity outcomes because if we do not, the impact on the downside to our society is correspondingly more, albeit marginally. However, margins matter.

23 Commonwealth Treasury (2015).

24 Defined in KPMG-MACRO as labour augmenting technical progress.

### 6.2 What should government do to help with productivity growth?

In an economy like Australia's, the private sector will have a strong incentive to seek and adopt innovations that increase their productivity unless they are shielded from competition. Businesses operating in competitive markets are unlikely to survive unless they innovate at least at the same rate as their competitors. In this context it is important to examine what role the government can play in facilitating productivity growth. From time to time governments have sought to actively promote productivity by targeting particular industries and providing assistance in various forms (protection from competition, tax incentives, subsidies etc.). This type of approach has been shown to be sub-optimal, often leading to unintended outcomes (e.g. the motor vehicle industry). Governments have also inadvertently affected productivity by implementing policies that are primarily aimed at other objectives but have adverse consequences for aggregate productivity and for the industrial distribution of productivity (e.g. certain taxes/subsidies, fiscal policy and certain government activities, including running utilities and transport businesses).

Since the late 1970s analysts and governments, perhaps influenced by the availability of more sophisticated analytical tools, have sought to better understand how government policy affects productivity. This work has helped clarify the role of government in a market-based economy and to quantify the cost of policies that adversely distort the allocation of resources. The influence of this work was exemplified by the micro-economic reforms implemented in the 1980s and 1990s.

The proposition that government should facilitate productivity growth by addressing market failures and by eliminating or reducing distortions introduced by government policy is compelling. In practice, reducing policy-induced distortions, which are often of long standing, is very difficult because there are real costs in doing so. Often, these costs are very tangible and concentrated on a group of people or businesses that are readily identifiable while the benefits are less tangible, more dissipated and likely to be realised over a longer time frame. For governments, being able to articulate a credible strategy for managing the costs of adjustment is an important part of the reform process.

On the next page, we list a range of policy areas that have the potential to make significant contributions to productivity growth in Australia. It is encouraging to note that state and federal governments are focused on many of these areas.

# Market failure

Infrastructure is regarded as an 'enabler' for the efficient functioning of an economy. The 'public good' nature of some classes of infrastructure has meant that governments have shouldered the burden of providing much of this type of infrastructure in the past. Even in cases where the 'public good' aspect of infrastructure is less evident, private sector investment has been difficult because financial markets are not well-suited to assess price and manage the risks of large long-lived assets with pay-offs that extend far off into the future. Pressure on government budgets has made it increasingly difficult for government to keep up with the economy's infrastructure requirements. Continuing to explore innovative ways of encouraging the development of infrastructure with greater involvement of the private sector is a priority. This may include: partnership arrangements with the private sector; addressing gaps in financial markets, especially with regard to long-term project finance; and designing appropriate regulatory structures so that the private sector can play are larger role.

Regulatory policy is important for achieving key societal objectives but has become overly complex and onerous for businesses. Reducing complexity, duplication and compliance costs (reducing unnecessary 'red' and 'green' tape) can free up resources that can be used for more productive purposes. In addition, designing regulatory structures that align the incentives of private sector investors with the interests of consumers has the potential to increase productivity by facilitating greater investment by the private sector in brownfield and greenfield assets, particularly in the utility and transport sectors.

The Hilmer review in the early 1990s resulted in a major transformation of the way competition policy was framed and implemented. The Productivity Commission found that the reforms emanating from this review delivered substantial net benefits to the Australian economy. The recently completed Harper Review has reviewed 'competition policy, laws and institutions to assess their fitness for purpose' in light of major changes in the economic landscape, including increased globalisation and the rise of China and other economies in the region, and population aging and the emergence of new technology This report has the potential to reinvigorate the micro-economic reform process and generate benefits for the economy similar to those that flowed from the Hilmer-inspired reforms.

The ability of businesses to undertake their own R&D activities to develop bespoke new technologies that can assist them to achieve productivity growth is, like many things, not uniform across the economy. Regardless of this fact, all businesses have the incentive to be 'fast followers' and adopt new technologies as they become available in the market. While all businesses have this incentive, they may not have the practical capability to keep up-to-date with global innovations. So while government should encourage new innovation, it should provide 'practical and commercial' assistance through the dissemination of information on new technologies and how they could be adopted and applied for the productivity benefit of the economy. Financially supporting the private sector provision of trade fairs, expositions, conduit websites, and other information sharing mechanisms is a key way the government can assist Australian businesses quickly adopt new, proven technologies.

While the recent proposed reforms to Australia's insolvency laws announced in the National Innovation and Science Agenda[25] are very important, they represent only a step in the right direction, and more steps down this path should be followed. Simply, concerns of business failure stifles risk-taking which discourages innovation. There may be scope for further reforms to insolvency laws to encourage risk-taking without overly compromising the protections provided to creditors, consumers and shareholders.

25 See http://www.kpmg.com/AU/en/IssuesAndInsights/ArticlesPublications/Pages/science-innovation-policy-2015.aspx

# Policy reform

Worse than government attempting to 'pick winners' is allowing the 'losers paradox'[26] to determine government policy. However, government should allow individual companies, and even whole industries, to cease operating if they are structurally unprofitable, thereby enabling resources to flow to parts of the economy that have competitive advantages. This is easier said than done, as short term pain associated with job losses due to business closure is often priced politically higher than the economic cost of providing publicly funded financial support. However, letting resources be utilised in highly productive industries, and providing government support to assist in this transition process, is a much better use of public finances than funding structurally unprofitable businesses or industries. Implicitly incorporated within this action is the implementation of a more flexible labour force policy that facilitates organisational change and innovations as required, while also maintaining fairness for workers involved.

Supporting higher education outcomes is more than just funding university places, although this as a productivity goal is also part of the puzzle.[27] Promoting research and development at universities is a fundamental building block to ensuring core innovation outcomes in Australia. There has been a recent recognition of the need to promote science, technology, engineering and maths (STEM) as subjects for students to study at school and university to help Australia 'grow' our own innovators. However, as discussed above, core innovation activities often have public good characteristics as they generally do not provide enough private return on the monies invested. Supporting STEM research and development at universities provides job opportunities for those individuals to carry out core innovation activities in a supportive environment.

Australia is in the middle of a broad ranging debate about its future taxation policy, *Re:think, Better tax, better Australia,* and the recognition that tax policy settings are important to shaping the innovation environment. Positively, as part of these considerations the Federal Government has recognised the link between tax policy, innovation, productivity and growth.

While some tax reforms have already been announced, including tax offsets for 'Angel Investors' and venture capitalists; utilisation of 'predominately similar' losses; and changes to the amortisation of intangible assets, a reduction in the corporate tax rate and amending tax rules around employee share plans would also be seen as other positive steps toward promoting innovation through tax policy. Finally, the importance of having tax policy settings that assist rather than hinder innovation should not be underestimated. KPMG have noted previously:

*Getting the funding and taxation policy setting right can make a significant difference to the innovation environment*[28].

26 Baldwin and Robert-Nicoud note 'Declining industries (i.e. 'losers') have sunk market-entry costs (e.g. unrecoverable investments in product development, training, and brand name advertising) such that profits in these industries can be raised without attracting entry as long as the level of quasi-rents does not rise above a normal rate of return on the sunk capital…the result is that losers lobby harder, so it is not government policy that picks losers but rather the losers who pick government policies.'

27 See http://apo.org.au/research/measuring-impact-productivity-agenda-kpmgreport

28 Grant Wardell-Johnson, Leader KPMG Australian Tax Centre.

# 7. Technical appendix

The methodology applied in the report and associated analytical results are presented in this technical appendix. Additional diagnostic tests are also reported here.

In developing econometric models we have applied the logarithmic transformation of current values in each calendar year, and did not choose a specific lag. We note that we considered whether there is an optimal lag length that could improve the fitness of the estimation. However, our initial investigation using statistical criteria[29] to determine the optimal lagging structure found no significant improvement in estimation outcomes with the different lag lengths.

One key assumption of our regressions is that the parameters of the model remain constant over time. Nevertheless the economic environment changed significantly during the analytical period (1990-2014) so it may not be reasonable to make this assumption.

Given this, an important diagnostic test that was considered in our analysis related to parameter constancy, that is, how stable the estimated elasticities of the production factors, $\alpha$ and $\beta$, are over the sample period. A common technique to assess the constancy of a model's parameters is to compute parameter estimates over a rolling window of a fixed size through the sample. If the parameters are truly constant over the entire sample, then the estimates over the rolling windows should not be too different. But if the parameters change at some point during the sample, then the rolling estimates should capture this instability.

Fifteen-year rolling estimates for equation (1) and associated measures of model goodness of fit are displayed for each of 19 industries in Table 7.1. We note that the statistical tests performed for the model show a reasonable R-squared for all industries except a*griculture, forestry and fishing,* and *rental, hiring and real estate services*. Further, the Durbin-Watson statistic of greater than one is observed for the majority industries and many rolling samples, suggesting little autocorrelation of errors and proving validity of the model.

To analyse Australia's economic growth due to the use of capital and labour, we estimate the classical and homothetic form of the Cobb-Douglas production function to decompose the contribution to GVA. We do this for the 19 broad ANZSIC industries using hours worked and capital input and then compare the relative contribution of these two factors. The relative importance of different capital inputs (dwellings, non-dwellings, etc.) is also explored.

29 Akaike Information Criterion.

### 7.1 Contribution of production factors

In the first part of the analysis, we apply the Cobb-Douglas production function in its classic and homothetic forms to identify the relative contribution of capital input, labour input and multi-factor productivity to output growth.

We start with the conventional form of the Cobb-Douglas production function:

$$Y = A_t K_t^{\alpha} L_t^{\beta} \quad ,\alpha,\beta > 0 \qquad (1)$$

where:

Y is output (production)

K is the production factor capital

L is the production factor labour

A, α, β are constants.

The constant A can deliver information about the total efficiency of production factors. This interpretation is based on the possibility of rewriting the relation (1) as:

$$A = \frac{Y}{K^{\alpha} L^{\beta}} \qquad (2)$$

Equation (2) underscores the link between the inputs – capital K and labour force L – and Y. As an expression of production over input units, the parameter A arguably represents a better measure of productivity compared to the partial productivity of the production factors such as Y/L and Y/K. The parameters α and β measure the proportion of total production that is generated by capital and labour.

The Cobb-Douglas production function in (1) is used to estimate the following regression for each industry:

$$GVA_t = LnA + \alpha K_t + \beta L_t + \varepsilon_t \qquad (3)$$

$GVA_t$ is the natural logarithm of gross value added of each industry at time t, $K_t$ is the natural logarithm of net capital stock for each industry at time t, and $L_t$ is the natural logarithm of actual hours worked in each industry at time t.[30] $LnA$ indicates the efficiency of capital and labour usage in each industry.

We have also considered a variant of the production function where percentage change growth of production is proportional to percentage change growth in the quantities of factors (without changing factor usage shares); that is, the constant-return-to-scale form of the production function. When the production function exhibits constant returns to scale, the sum of exponents in the production function is equal to one: α + β = 1. That is, doubling the usage of each factor would lead to a doubling of production.

A variation of the Cobb-Douglas production function in (1) is then applied to estimate the following regression for each industry:

$$GVA_t = LnA + \alpha K_t + (1 - \beta) L_t + \varepsilon_t \qquad (4)$$

The estimation of the Cobb-Douglas production function, based on industry GVA data, capital input and hours worked, was conducted under the conditions of adopting or dismissing the homothetic character of the function, as specified in equations (3) and (4).

30 The measure of the number of hours worked does not recognise changes in the skills composition of the workforce.

**Table 7.1 Results from rolling estimations**

| | | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | α | 1.85 | 1.5w | 1.28 | 1.24 | 1.25 | 1.24 | 1.14 | 1.06 | 1.07 | 1.06 | 1.01 | 0.97 | 0.91 | 0.88 |
| | β | -1.52 | -0.98 | -0.6 | -0.53 | -0.54 | -0.52 | -0.35 | -0.21 | -0.23 | -0.21 | -0.13 | -0.06 | 0.03 | 0.09 |
| | R-Squared | 0.06 | 0 | 0 | 0.06 | 0.19 | 0.33 | 0.35 | 0.37 | 0.46 | 0.51 | 0.6 | 0.68 | 0.67 | 0.73 |
| | DW Stat | 0.33 | 0.21 | 0.39 | 0.43 | 0.49 | 0.53 | 0.55 | 0.6 | 0.82 | 0.82 | 1.22 | 1.54 | 1.65 | 1.98 |
| B | α | 1.18 | 1.17 | 1.11 | 1.08 | 1.04 | 1.03 | 1.08 | 1.14 | 1.2 | 1.25 | 1.28 | 1.32 | 1.37 | 1.42 |
| | β | -0.45 | -0.42 | -0.3 | -0.24 | -0.16 | -0.15 | -0.25 | -0.35 | -0.48 | -0.57 | -0.64 | -0.72 | -0.81 | -0.91 |
| | R-Squared | 0.9 | 0.9 | 0.94 | 0.95 | 0.95 | 0.95 | 0.94 | 0.92 | 0.87 | 0.81 | 0.79 | 0.77 | 0.73 | 0.68 |
| | DW Stat | 0.75 | 0.61 | 0.7 | 0.95 | 1.12 | 1 | 0.95 | 0.89 | 0.71 | 0.6 | 0.56 | 0.54 | 0.41 | 0.37 |
| C | α | 0.62 | 0.67 | 0.7 | 0.76 | 0.78 | 0.7 | 0.63 | 0.58 | 0.54 | 0.5 | 0.47 | 0.46 | 0.44 | 0.42 |
| | β | 0.57 | 0.5 | 0.45 | 0.36 | 0.32 | 0.44 | 0.55 | 0.63 | 0.69 | 0.75 | 0.8 | 0.82 | 0.85 | 0.88 |
| | R-Squared | 0.9 | 0.86 | 0.86 | 0.89 | 0.92 | 0.88 | 0.85 | 0.81 | 0.79 | 0.73 | 0.73 | 0.73 | 0.73 | 0.72 |
| | DW Stat | 0.61 | 0.51 | 0.46 | 0.54 | 0.87 | 0.59 | 0.42 | 0.38 | 0.39 | 0.42 | 0.54 | 0.73 | 1.05 | 1.11 |
| D | α | 1.1 | 1.08 | 1.06 | 1.04 | 1.02 | 1.02 | 1.02 | 1.07 | 1.15 | 1.25 | 1.3 | 1.32 | 1.35 | 1.38 |
| | β | -0.37 | -0.34 | -0.3 | -0.25 | -0.22 | -0.21 | -0.22 | -0.32 | -0.48 | -0.68 | -0.78 | -0.81 | -0.88 | -0.94 |
| | R-Squared | 0.93 | 0.92 | 0.94 | 0.93 | 0.9 | 0.85 | 0.77 | 0.55 | 0.35 | 0.42 | 0.74 | 0.94 | 0.77 | 0.62 |
| | DW Stat | 0.75 | 0.78 | 0.96 | 1 | 0.71 | 0.5 | 0.36 | 0.32 | 0.33 | 0.63 | 1.7 | 2.42 | 1.58 | 1.13 |
| E | α | 0.23 | 0.31 | 0.22 | 0.16 | 0.17 | 0.17 | 0.22 | 0.22 | 0.23 | 0.25 | 0.28 | 0.35 | 0.42 | 0.44 |
| | β | 1.21 | 1.1 | 1.22 | 1.31 | 1.3 | 1.31 | 1.22 | 1.23 | 1.21 | 1.18 | 1.13 | 1.04 | 0.93 | 0.9 |
| | R-Squared | 0.86 | 0.92 | 0.92 | 0.94 | 0.96 | 0.97 | 0.97 | 0.97 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 | 0.98 |
| | DW Stat | 0.82 | 0.91 | 1.38 | 1.56 | 1.44 | 1.62 | 1.4 | 1.32 | 1.32 | 1.26 | 1.29 | 1.47 | 1.47 | 1.39 |
| F | α | 1.37 | 1.34 | 1.33 | 1.32 | 1.33 | 1.34 | 1.32 | 1.23 | 1.15 | 1.07 | 1.01 | 0.98 | 0.95 | 0.93 |
| | β | -0.61 | -0.56 | -0.55 | -0.53 | -0.54 | -0.57 | -0.53 | -0.39 | -0.26 | -0.13 | -0.04 | 0.01 | 0.07 | 0.09 |
| | R-Squared | 0.83 | 0.84 | 0.87 | 0.87 | 0.89 | 0.92 | 0.91 | 0.91 | 0.92 | 0.95 | 0.97 | 0.97 | 0.97 | 0.97 |
| | DW Stat | 0.78 | 0.78 | 0.82 | 0.69 | 0.7 | 0.51 | 0.37 | 0.37 | 0.44 | 0.49 | 0.42 | 0.55 | 0.51 | 0.57 |
| G | α | 2.03 | 2.17 | 2.25 | 2.17 | 2.17 | 1.94 | 1.67 | 1.56 | 1.29 | 1.08 | 0.94 | 0.87 | 0.87 | 0.87 |
| | β | -1.53 | -1.75 | -1.88 | -1.74 | -1.75 | -1.41 | -1 | -0.83 | -0.42 | -0.12 | 0.09 | 0.2 | 0.2 | 0.19 |
| | R-Squared | 0.88 | 0.9 | 0.9 | 0.91 | 0.92 | 0.92 | 0.94 | 0.97 | 0.98 | 0.98 | 0.99 | 0.99 | 0.99 | 0.99 |
| | DW Stat | 0.51 | 0.54 | 0.6 | 0.65 | 0.7 | 0.56 | 0.48 | 0.63 | 0.63 | 0.52 | 0.59 | 0.69 | 0.99 | 1.09 |
| H | α | 0.7 | 0.58 | 0.49 | 0.43 | 0.36 | 0.38 | 0.58 | 0.76 | 0.99 | 1.08 | 1.04 | 1.01 | 0.92 | 0.86 |
| | β | 0.43 | 0.62 | 0.76 | 0.85 | 0.96 | 0.93 | 0.62 | 0.34 | -0.03 | -0.16 | -0.1 | -0.05 | 0.09 | 0.18 |
| | R-Squared | 0.88 | 0.93 | 0.94 | 0.94 | 0.94 | 0.93 | 0.91 | 0.93 | 0.95 | 0.97 | 0.96 | 0.96 | 0.95 | 0.93 |
| | DW Stat | 0.26 | 0.26 | 0.32 | 0.36 | 0.35 | 0.23 | 0.1 | 0.17 | 0.6 | 0.61 | 0.54 | 0.71 | 0.72 | 0.78 |
| I | α | 0.32 | 0.29 | 0.34 | 0.29 | 0.4 | 0.32 | 0.21 | 0.26 | 0.74 | 1.03 | 0.98 | 0.79 | 0.71 | 0.6 |
| | β | 1.01 | 1.06 | 0.99 | 1.08 | 0.89 | 1.03 | 1.22 | 1.14 | 0.31 | -0.19 | -0.11 | 0.23 | 0.36 | 0.55 |
| | R-Squared | 0.69 | 0.69 | 0.6 | 0.64 | 0.67 | 0.73 | 0.79 | 0.84 | 0.88 | 0.93 | 0.95 | 0.96 | 0.97 | 0.97 |
| | DW Stat | 0.1 | 0.12 | 0.11 | 0.14 | 0.11 | 0.14 | 0.18 | 0.2 | 0.19 | 0.42 | 0.52 | 0.5 | 0.58 | 0.74 |
| J | α | 1.69 | 1.58 | 1.5 | 1.42 | 1.31 | 1.18 | 1.02 | 0.97 | 0.93 | 0.89 | 0.87 | 0.85 | 0.8 | 0.77 |
| | β | -1.32 | -1.13 | -0.99 | -0.83 | -0.65 | -0.42 | -0.14 | -0.04 | 0.02 | 0.1 | 0.13 | 0.17 | 0.26 | 0.3 |
| | R-Squared | 0.92 | 0.93 | 0.93 | 0.94 | 0.94 | 0.95 | 0.96 | 0.98 | 0.99 | 0.99 | 0.99 | 0.99 | 0.98 | 0.98 |
| | DW Stat | 0.53 | 0.6 | 0.58 | 0.54 | 0.44 | 0.33 | 0.34 | 0.58 | 0.85 | 0.98 | 1.17 | 1.44 | 1.38 | 1.23 |

| | | R1 | R2 | R3 | R4 | R5 | R6 | R7 | R8 | R9 | R10 | R11 | R12 | R13 | R14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| K | α | 1.23 | 1.23 | 1.31 | 1.58 | 1.74 | 1.96 | 1.55 | 0.14 | -0.29 | -0.52 | -0.6 | -0.61 | -0.64 | -0.62 |
| | β | -0.42 | -0.43 | -0.56 | -1.02 | -1.29 | -1.66 | -0.97 | 1.43 | 2.18 | 2.56 | 2.7 | 2.72 | 2.78 | 2.74 |
| | R-Squared | 0.86 | 0.82 | 0.82 | 0.89 | 0.88 | 0.84 | 0.71 | 0.71 | 0.75 | 0.79 | 0.82 | 0.9 | 0.94 | 0.94 |
| | DW Stat | 0.67 | 0.45 | 0.4 | 0.34 | 0.42 | 0.44 | 0.16 | 0.13 | 0.17 | 0.25 | 0.31 | 0.73 | 1.46 | 1.63 |
| L | α | 0.94 | 0.94 | 0.89 | 0.92 | 0.98 | 1.35 | 1.57 | 1.68 | 1.42 | 0.86 | 0.89 | 0.6 | 0.52 | 0.45 |
| | β | -0.03 | -0.02 | 0.07 | 0.01 | -0.11 | -0.79 | -1.21 | -1.41 | -0.94 | 0.12 | 0.05 | 0.59 | 0.74 | 0.87 |
| | R-Squared | 0.89 | 0.85 | 0.86 | 0.84 | 0.79 | 0.79 | 0.7 | 0.3 | -0.4 | -1.43 | -2.38 | -2.49 | -1.95 | -0.99 |
| | DW Stat | 0.42 | 0.38 | 0.44 | 0.35 | 0.32 | 0.66 | 0.85 | 0.64 | 0.28 | 0.1 | 0.09 | 0.12 | 0.16 | 0.21 |
| M | α | -0.22 | 0.19 | 0.4 | 0.45 | 0.41 | 0.39 | 0.34 | 0.33 | 0.19 | 0.15 | 0.23 | 0.25 | 0.22 | 0.09 |
| | β | 1.91 | 1.29 | 0.98 | 0.9 | 0.96 | 0.99 | 1.06 | 1.08 | 1.29 | 1.33 | 1.22 | 1.18 | 1.23 | 1.43 |
| | R-Squared | 0.53 | 0.64 | 0.73 | 0.8 | 0.84 | 0.86 | 0.86 | 0.86 | 0.89 | 0.88 | 0.89 | 0.89 | 0.87 | 0.85 |
| | DW Stat | 0.13 | 0.14 | 0.13 | 0.15 | 0.18 | 0.24 | 0.28 | 0.32 | 0.47 | 0.53 | 0.46 | 0.4 | 0.39 | 0.45 |
| N | α | -1.2 | -1.15 | -1.21 | -1.04 | -0.94 | -0.79 | -0.48 | -0.18 | 0.04 | 0.08 | 0.15 | 0.19 | 0.19 | 0.19 |
| | β | 3.49 | 3.42 | 3.51 | 3.25 | 3.1 | 2.86 | 2.39 | 1.92 | 1.57 | 1.52 | 1.41 | 1.34 | 1.34 | 1.34 |
| | R-Squared | 0.8 | 0.8 | 0.8 | 0.8 | 0.81 | 0.82 | 0.81 | 0.8 | 0.81 | 0.79 | 0.77 | 0.66 | 0.47 | 0.12 |
| | DW Stat | 0.67 | 1.31 | 1.35 | 1.19 | 1.15 | 1.14 | 0.93 | 0.67 | 0.58 | 1.11 | 1.06 | 0.91 | 0.88 | 0.92 |
| O | α | 1.09 | 0.94 | 0.86 | 0.85 | 0.8 | 0.82 | 0.82 | 0.85 | 0.89 | 0.91 | 0.93 | 0.98 | 0.99 | 1.03 |
| | β | -0.23 | 0.03 | 0.15 | 0.18 | 0.26 | 0.23 | 0.23 | 0.17 | 0.11 | 0.07 | 0.04 | -0.04 | -0.07 | -0.13 |
| | R-Squared | 0.95 | 0.93 | 0.93 | 0.93 | 0.94 | 0.94 | 0.96 | 0.97 | 0.98 | 0.98 | 0.96 | 0.94 | 0.91 | 0.89 |
| | DW Stat | 0.58 | 0.52 | 0.64 | 0.69 | 0.58 | 0.55 | 0.75 | 0.92 | 1.19 | 1.09 | 0.72 | 0.51 | 0.36 | 0.34 |
| P | α | 0.62 | 0.54 | 0.57 | 0.64 | 0.69 | 0.83 | 0.93 | 1.15 | 1.26 | 1.27 | 1 | 0.56 | 0.33 | -0.01 |
| | β | 0.57 | 0.7 | 0.65 | 0.54 | 0.45 | 0.23 | 0.07 | -0.29 | -0.46 | -0.48 | -0.05 | 0.66 | 1.03 | 1.58 |
| | R-Squared | 0.98 | 0.98 | 0.98 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.97 | 0.9 | 0.72 | 0.56 | 0.41 | 0.33 |
| | DW Stat | 1.3 | 1.39 | 1.32 | 1 | 0.93 | 0.69 | 0.56 | 0.55 | 0.81 | 0.67 | 0.24 | 0.18 | 0.22 | 0.38 |
| Q | α | 0.35 | 0.42 | 0.61 | 0.78 | 0.72 | 0.68 | 0.63 | 0.59 | 0.6 | 0.59 | 0.67 | 0.79 | 0.84 | 0.89 |
| | β | 0.99 | 0.88 | 0.6 | 0.33 | 0.42 | 0.49 | 0.56 | 0.63 | 0.62 | 0.62 | 0.5 | 0.32 | 0.23 | 0.16 |
| | R-Squared | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 |
| | DW Stat | 1.64 | 1.44 | 1.02 | 0.62 | 0.52 | 0.75 | 0.97 | 1.33 | 1.36 | 1.44 | 1.26 | 0.7 | 0.46 | 0.39 |
| R | α | 0.93 | 0.8 | 0.76 | 0.68 | 0.59 | 0.86 | 0.76 | 0.81 | 0.58 | 0.55 | 0.6 | 0.6 | 0.62 | 0.62 |
| | β | -0.01 | 0.22 | 0.27 | 0.43 | 0.59 | 0.1 | 0.28 | 0.19 | 0.59 | 0.65 | 0.55 | 0.55 | 0.52 | 0.52 |
| | R-Squared | -0.08 | 0.02 | 0.08 | 0.25 | 0.47 | 0.58 | 0.72 | 0.81 | 0.9 | 0.95 | 0.98 | 0.98 | 0.98 | 0.98 |
| | DW Stat | 0.07 | 0.09 | 0.09 | 0.14 | 0.2 | 0.14 | 0.19 | 0.24 | 0.55 | 1.05 | 1.7 | 2.14 | 1.97 | 2.12 |
| S | α | 0.03 | 0.07 | 0.12 | 0.15 | 0.18 | 0.19 | 0.21 | 0.19 | 0.19 | 0.2 | 0.18 | 0.15 | 0.13 | 0.07 |
| | β | 1.5 | 1.44 | 1.38 | 1.33 | 1.29 | 1.27 | 1.25 | 1.27 | 1.27 | 1.26 | 1.29 | 1.33 | 1.37 | 1.44 |
| | R-Squared | 0.82 | 0.83 | 0.87 | 0.87 | 0.88 | 0.89 | 0.9 | 0.87 | 0.85 | 0.83 | 0.76 | 0.77 | 0.73 | 0.6 |
| | DW Stat | 0.65 | 0.71 | 0.69 | 0.67 | 0.64 | 0.63 | 0.74 | 0.96 | 0.96 | 0.9 | 0.78 | 0.93 | 1.03 | 1.24 |

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