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Can Australia Match US Productivity Performance?

Staff Working Paper

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Preface

There is widespread agreement that strong productivity growth in the future will be crucial to Australia's long-term prosperity. This paper considers Australia's future productivity growth prospects and, specifically, whether it is feasible for Australia to match the performance benchmarks set by other countries now and in the foreseeable future.

An early version of the paper was presented by Dean Parham and Ben Dolman to a Commonwealth-State Forum on Economic Framework Issues, convened by the Australian Government Treasury in Canberra in August 2006. It was presented under the title, 'Frontier shifts and catch-up as influences on Australia's productivity outlook.' The paper incorporates analysis undertaken by Simon Zheng on a research project on Australia's comparative productivity performance.

Karinne Logez of the OECD and Stephen Redding from the London School of Economics generously provided data. Tony Kulys and Tracey Horsfall assisted in the preparation of the paper. Helpful comments were received from Jonathan Pincus of the Productivity Commission, Robert Inklaar of the Groningen Growth and Development Centre and Graeme Davis of the Australian Government Treasury.

The views expressed in the paper are those of the authors and are not necessarily those of the Productivity Commission. The paper should be attributed to the authors and not the Commission.

Abbreviations

ABS	Australian Bureau of Statistics
BLS	US Bureau of Labor Statistics
GDP	gross domestic product
GGDC	Groningen Growth and Development Centre
ICT	information and communications technology
MFP	multifactor productivity
NRA	National Reform Agenda
OECD	Organisation for Economic Co-operation and Development
PC	Productivity Commission
PPP	Purchasing Power Parity

Key points

- International comparisons of productivity at a national level are useful, but should be treated with care. Comparisons of productivity performance are more meaningfully made at an industry level.
- The United States can still be taken to be the world's productivity leader in an aggregate 'technological' sense. Some European countries now have higher levels of productivity, but that reflects industry mix (oil production) and policy and institutional distortions in labour markets (which have not brought overall gain in average living standards).
- Australia's catch up toward the US aggregate level of productivity since the 1950s has been generally weak. One positive (albeit transient) movement came in the 1970s, but it was associated with the US productivity growth slowdown and some unsustained influences in Australia. Another sharp rise came in the 1990s, when Australian productivity growth accelerated sooner and faster than in the United States.
- A sizeable gap between Australian and US productivity levels remains. However, the *aggregate* level of US productivity should not be regarded as a realistic target for Australia to achieve.
- The aggregate productivity comparison masks a diversity of experience at the industry level. Although industry data are of poorer quality, it appears that some Australian industry sectors have performed at the productivity frontier and have participated in frontier shifts along with US industries. Large gaps remain in other areas: manufacturing, wholesale trade, retail trade, utilities (electricity, gas & water), communications and finance.
- Australia's relative performance is constrained by differences in industry presence and composition and in access to gains from specialisation and scale. These in turn are linked to fundamental factors of history and geography, including Australia's remoteness from large markets and its pattern of settlement.
- Based on an industry-by-industry assessment, Australia appears well placed to at least maintain its overall position relative to US productivity, even with resurgent US productivity growth.
- It also seems feasible for Australia to go further and to catch up some distance on US productivity levels. However, this will not necessarily come automatically. Further policy and institutional change may be needed.

1 Introduction and summary

The 1990s and 2000s have amply illustrated the contributions that strong growth in labour productivity and large favourable movements in the terms of trade can make to economic prosperity in Australia. Record-high productivity growth in the 1990s brought strong growth in average income. Productivity has slowed so far in the 2000s, but a very large and favourable shift in the terms of trade, reflecting higher prices for commodity exports and lower prices of manufactured imports, has boosted prosperity by increasing the purchasing power of Australian income.

Productivity growth is nevertheless likely to remain the key to long-term prosperity. Diewert and Lawrence (2006) clearly showed that productivity growth (specifically multifactor productivity growth) has been the major contributor to Australian prosperity over the long term. The terms of trade have also contributed, for short periods and to a relatively minor extent overall.

The importance of long-term productivity growth in maintaining growth in living standards has also been brought to the fore by a number of 'intergenerational' studies (Australian Government Treasury 2002; PC 2005a). They have highlighted the need for strong productivity growth in the future in order to counteract the projected detrimental effects that an ageing population will have on growth in living standards through lower average workforce engagement. The National Reform Agenda has also put the spotlight on future long-term productivity growth and the policy changes that would bolster it (COAG 2006; PC 2006b).

This paper abstracts from the current downturn in productivity growth[1] and explores Australia's potential for future productivity growth against the performance benchmarks of other high-income OECD economies. After some discussion of the productivity performance of a range of OECD economies, the paper specifically focuses on whether it is feasible for Australia to emulate the productivity performance of the United States — to match US productivity growth or, by doing better, to catch up to some degree to the higher level of US productivity.

[1] Reasons for the productivity slowdown are explored in Parham (2005); Dolman, Lu and Rahman (2006); Parham and Wong (2006) and RBA (2006).

International comparisons of Australia's productivity performance at the economy-wide level are often and readily made. But a message from this exercise is that they need to be undertaken and interpreted carefully. Drilling beneath the aggregates provides a truer picture.

1.1 Background

The United States was the 'productivity leader' — it had the highest level of productivity — from early in the 20th Century. It attained and maintained this position as resources shifted away from its less-productive agriculture sector and as it accumulated knowledge and capabilities that led to the development and diffusion of major technological, management and organisational advances.

Many countries — notably Japan and European nations — moved toward the US level of productivity after WWII in a process often referred to as 'catch-up'. This notion posits that 'follower' countries, which have productivity levels below the leader, achieve faster productivity growth than the leader as they incorporate the technologies developed in the leading country and learn from its management and organisational methods. The post-war reconstruction was conducive to this process as, amongst other things, it enabled a more rapid transfer of US technology. A few countries not only moved toward the US level, but also fully caught up with it and then overtook it.

Australia, on the other hand, did not catch up strongly in the post-war era, at least in comparison to Europe and Japan. A substantial productivity gap with the United States persisted and remains today.

A number of questions can be posed against this background. If other countries have been able to substantially catch up to US productivity levels, should Australia be able to do the same? Indeed, if some countries have been able to overtake the United States, should Australia aspire to the productivity levels of the new leaders? With the evidence that the United States shifted to a stronger productivity growth trajectory in the 1990s, is any degree of catch-up feasible? Can Australia even keep up with US productivity growth?

1.2 What the paper does and says

The paper presents measures of labour productivity (output produced per hour worked) and multifactor productivity (output produced from the combined input of labour and capital). The better of the two productivity measures to use depends on the context.[2] However, labour productivity measures are more heavily relied on for international comparisons in part because very little comparative multifactor productivity data are currently available.

The next chapter examines international productivity leadership at the national economy level. It finds that some of the past catch-up and overtaking, in particular by European countries, is due to non-technological factors. Policy and institutional arrangements have distorted labour market outcomes in ways that have sustained high European productivity levels, but they have also had offsetting effects on economic welfare by inducing lower labour utilisation (hours worked per head of population). The United States remains at the international productivity frontier in a technological sense.

Taking the United States to be the leader, the chapter goes on to examine the nature of past 'frontier shifts' in that economy and finds definite time and industry characteristics. That is, productivity acceleration due to technological and other advances has been an industry rather than aggregate phenomenon.[3] Different industries have shown productivity acceleration and deceleration at different times. The chapter also reviews forecasts of US productivity growth, which suggest that the stronger productivity growth witnessed over the past decade is likely to continue. Thus catching up to the United States means catching up to a more rapidly moving target.

Chapter 3 reviews the historical evidence of catch-up by other high-income countries. It illustrates that catch-up is far from automatic. While many European countries have attained productivity levels similar to those in the United States, others such as Canada and Australia have broadly kept pace, and New Zealand has fallen further behind. Catch-up is also industry specific. That is, there has been stronger catch-up in some industries than in others.

Differences in the industry composition of economies also affect the interpretation of their aggregate productivity levels. Some countries have greater specialisation in activities with relatively high productivity levels. For example, Norway's relatively large mining sector (based on extraction of oil) — rather than an overall superiority in technology or knowledge — gives it an average productivity above the US level.

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2 Labour productivity is more proximately related to improvement in living standards, while multifactor productivity can be a better indicator of technological change and production efficiency.

3 The most recent productivity shifts in the United States have been associated with the production of information and communications technology (ICT) equipment and with innovative uses of ICT. In the latter respect, ICT is increasingly regarded as a general purpose technology that has widespread application, with the potential to enable user-based innovations. In this sense, its productivity consequences are general, rather than industry-specific.

Similarly, an industry mix that is skewed toward relatively low productivity activities can put a limit on the extent of catch-up that is feasible.

Chapter 4 focuses specifically on Australia's productivity record relative to that of the United States. There was virtually no catch-up at the aggregate level in the 1950s and 1960s, with Australian productivity remaining at around 77 per cent of the US level. There was some steady catch-up in the 1970s and the first half of the 1980s, in part because US productivity growth declined. There was further catch-up in the second half of the 1990s, when Australian productivity accelerated sooner and faster than in the US. Australia reached a peak around 87 per cent of the US level (allowing for short-term volatility). The current level is lower, although this may turn out to have a cyclical component.

The industry dimension to frontier shifts and catch-up, highlighted previously, is important. Whilst there has been a relatively stable and sizeable productivity gap at the aggregate level, there is a diversity of experience at the industry level. Although there is even greater measurement uncertainty at the industry level, it appears that some Australian industries have been 'at the frontier' or have participated in productivity accelerations along with their US counterparts. Other Australian industries appear to have maintained sizeable gaps or even fallen further behind US productivity levels.

Gaps in productivity levels appear most prominent in six industry sectors. The biggest gaps appear to be in manufacturing, wholesale and retail trade. Given their relative size, substantial catch-up at the aggregate level turns on the extent to which gaps in these three industries can be narrowed. Sizeable productivity gaps also remain in utilities, communications, and finance.

A major issue, of course, is why productivity gaps in these industries have persisted. Are there 'natural' factors, such as differences in resource endowments, which act as a more-or-less permanent constraint? Or are there factors, such as differences in the policy and institutional environment, over which governments may have some influence? In the latter case, it may be feasible to move closer to US productivity levels if Australia emulates crucial features in the United States that determine its production arrangements, accumulation and application of knowledge and so on. The paper examines just two issues — geography and differences in education.

Chapter 5 discusses the role that geography might play in constraining Australian productivity relative to the United States. One dimension is distance from large markets. The United States is itself a very large market, with generally-high internal competition and access to gains from specialisation and scale. Australia, on the other hand, is remote from large markets. Internal geography could also play a role. The long distances between urban centres also imposes higher transport costs and limits competitive pressures and the opportunities for specialisation and scale, in comparison to the United States. These geographical factors may help to explain the persistence of productivity gaps not only in the manufacture of goods but also in the provision of services such as wholesale and retail trade. They underline the importance of efficient transport, communications and energy infrastructure to a country with Australia's geographic characteristics. But they also suggest that, while Australia may be able to do better, it would not be feasible for Australia to catch up fully to US productivity levels.

Chapter 6 discusses differences in education and skill, since more educated and skilled workers are widely acknowledged to be more productive. A simple measure of years of schooling suggests that the average among Australian workers is currently below that among US workers. (This measure accounts for the duration of education received and not its type or quality.) The gap in average years of schooling largely reflects differences in the years of schooling of older generations rather than differences among the current younger generations passing through the education systems. Whereas completion of secondary education became common in Australia through the 1970s and 1980s, the majority of young Americans were high-school graduates as early as 1940. The duration of formal education now differs little between the two countries. Looking to the future, the maturation of young cohorts will see the average years of schooling of Australian workers match the US average in a couple of decades without any intervening changes in policies or preferences. To the extent that Australia's current productivity gap is due to any difference in duration of schooling, the gap will reduce over time.

Chapter 7 draws on the material presented in the paper to address the question of whether Australia can match US productivity performance. Some projections based on a range of scenarios provide a convenient device to explore rough orders of magnitude on aggregate catch-up. It seems feasible for Australia to aspire to keep up with rapid US productivity growth over coming decades. It also appears feasible for Australia to go further and close part of the gap in productivity levels, although changes in the policy and institutional environment may be needed. It does not appear feasible for Australia to catch up fully to the US level of productivity. A message from the paper is that to focus on the US aggregate productivity level as a policy target would not be appropriate.

2 The international productivity frontier

This chapter discusses the evolution of productivity leadership among high-income economies. It affirms that the United States is the leader in a sense that is most relevant to Australia — as representing the technological and efficiency frontier at the aggregate level. The chapter examines the nature of frontier shifts in the US economy and its outlook for future productivity growth.

The assessment relies on international comparisons of economy-wide productivity levels. Level comparisons are generally subject to more measurement uncertainty than comparisons of growth rates. Putting aside differences in scope and statistical method, estimates of productivity *growth* in different countries can be compared, based on national estimates in which national price deflators are used to construct output volumes. However, comparisons of productivity *levels* require common international price units and deflators. Purchasing power parity exchange rates and price deflators are used for this purpose. But their accuracy, particularly over time, is subject to debate.

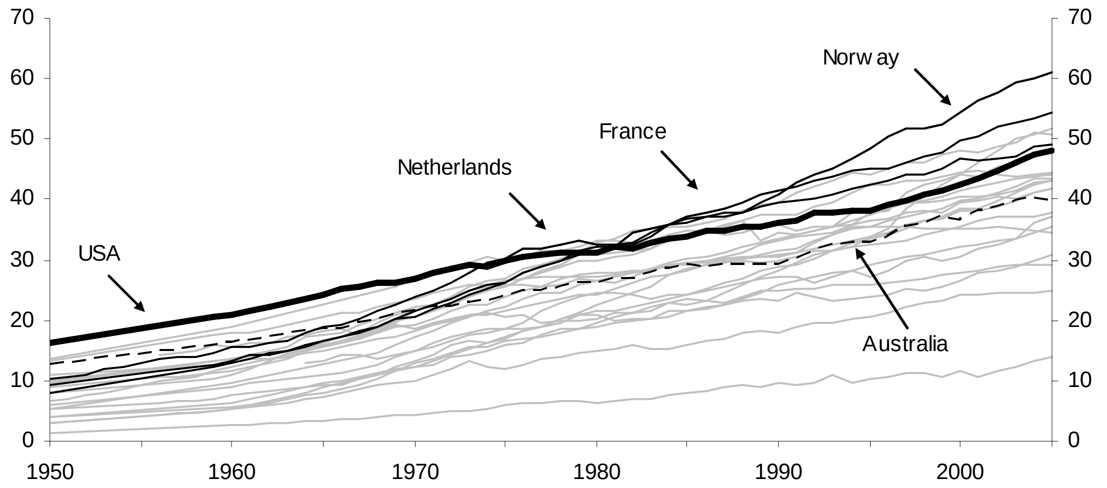
2.1 Productivity and technological leadership over the 20th century

Although the US economy is commonly taken to have been the world's productivity leader since the early stages of the 20th century, its literal entitlement to the leadership mantle has been more limited. Figure 2.1 shows that the identity of the productivity leader has changed since 1950 — the United States initially, the Netherlands from 1974, France from 1982 and Norway since 1991.

Since productivity leadership is usually associated with technological leadership, does this mean that the US started to become relatively 'backward'? The short answer is, 'No'.

Figure 2.1 **Labour productivity in selected OECD countries**[a]

2005 USD PPP per hour



[a] Data are for the pre-1994 OECD member countries, excluding Luxembourg.

Data source: The Conference Board and GGDC, (*Total Economy Database*, September 2006).

First, differences in productivity levels result partly from industry mix. The importance of oil extraction — a high-productivity activity — was a factor behind the Netherlands and Norway taking the productivity leadership in the second half of the 20th century.[1]

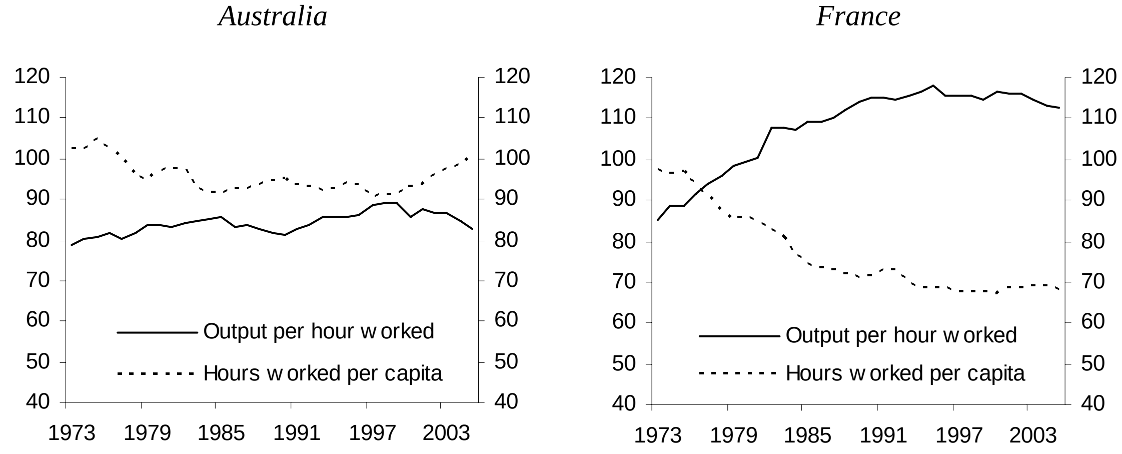
Second, the fact that a number of European countries came to outperform US productivity has to be viewed in a broader context. Their better productivity performance was accompanied by weaker labour utilisation (fewer working hours per head of population), due to shorter working hours, longer holidays and lower employment rates (Alesina, Glaeser and Sacerdote 2005). France, which became the world productivity leader for a period, is commonly held up as an example. Despite similar starting points in 1973, hours worked per capita in France sank to only two-thirds of the US level in 1995 (figure 2.2). Over the same period, French labour productivity rose very rapidly and overtook US levels. More generally in Europe, those countries in which labour utilisation fell further typically also saw their productivity levels rise further (see figure 2.3 in which European countries are represented by black diamonds).[2]

[1] The mining sector as a whole contributes almost 20 per cent of Norway's total output.

[2] Regression analysis suggests that countries in which labour utilisation fell by one percentage point per year tended to have productivity growth that was higher by 1.1 percentage points per year during the period from 1973 to 1995, a highly statistically significant relationship which explains 43 per cent of the variation in productivity growth rates.

Figure 2.2 Trends in labour productivity and labour utilisation

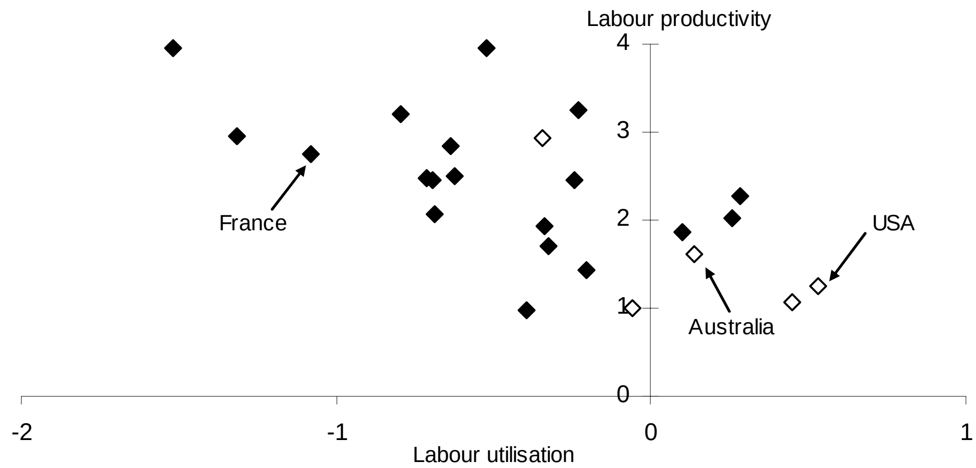
US = 100



Data source: The Conference Board and GGDC, (*Total Economy Database,* September 2006).

Figure 2.3 Labour productivity and labour utilisation among 24 OECD countries, 1973 to 1995[a]

Annual percentage change



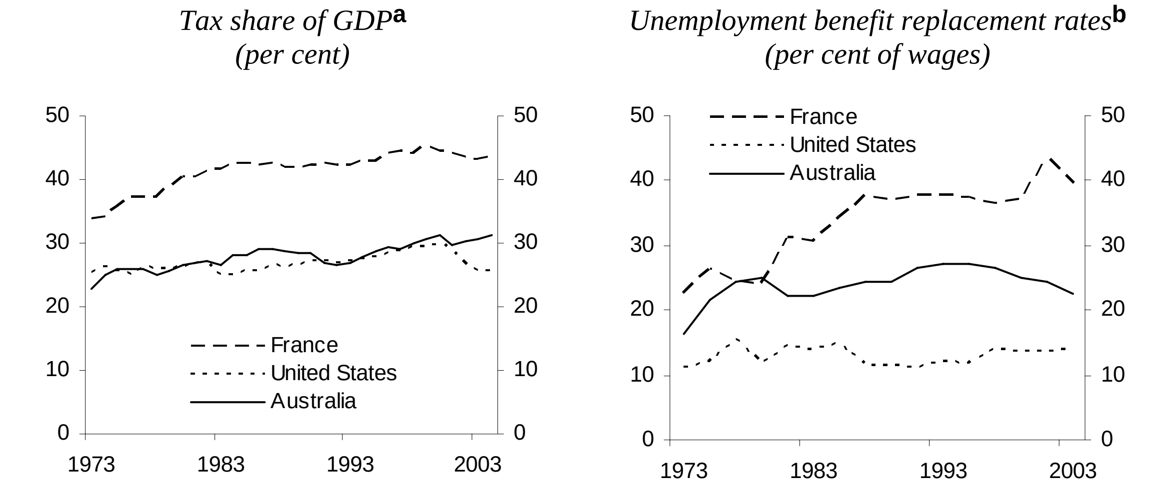
[a] Labour utilisation is measured as hours worked per head of population. Data are for the 24 longest standing OECD members. Black diamonds indicate European countries.

Data source: The Conference Board and GGDC, (*Total Economy Database,* September 2006).

Policy and institutional factors played a large part in reducing European labour utilisation. Stronger preferences for leisure could have been a factor, but it is unlikely that they alone would explain much of the large shift. Plausible explanations for the decline in labour utilisation include: disincentives to work long hours provided by large and increasing tax rates (Prescott 2004); disincentives to work provided by high and increasing unemployment benefit replacement rates (figure 2.4); a high degree of unionisation leading to negotiated and legislated reductions in standard working hours; high minimum wages, which excluded the low skilled from the work force; and lower wage disparity such that working longer hours to achieve promotion was less valuable in Europe than in the United States (Bell and Freeman 2001).

These same policy and institutional factors also affected productivity outcomes. They shifted labour demand towards the relatively skilled, reduced the ability and incentives to work longer or more effective hours and shifted factor demands toward capital and away from labour.

Figure 2.4 **Some policy differences between Australia, France and the United States**



[a] Based on total tax revenue from all levels of government. [b] These data are the average of gross unemployment benefit replacement rates for two earnings levels, three family situations and three durations of unemployment.

Data source: OECD, (*Revenue Statistics 2006 Edition, 1965 to 2005)*; OECD Tax Benefit Models.

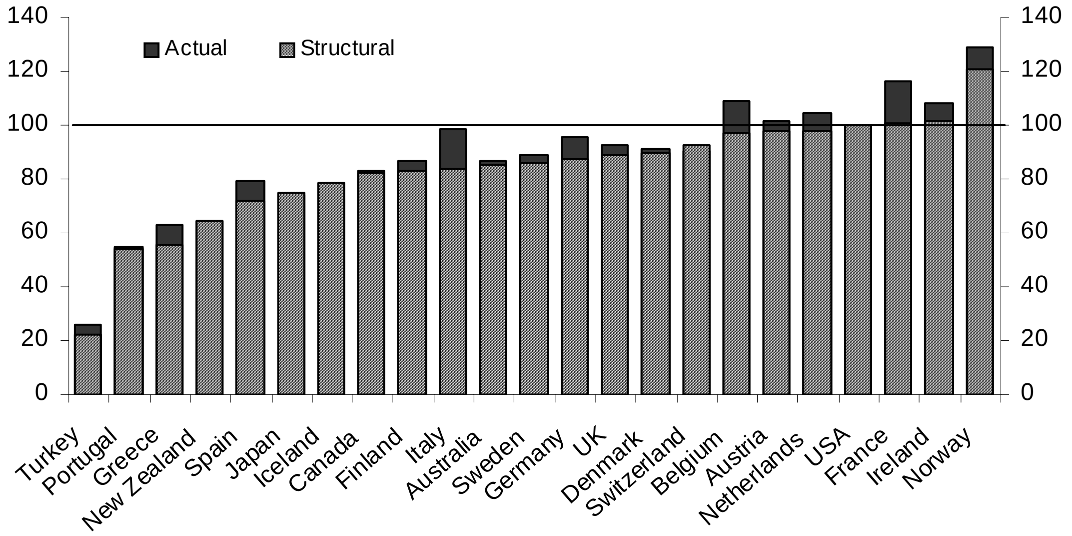
Moreover, the labour utilisation effect more than accounts for the ability of European countries to rise above US productivity. Recent analyses of economic growth patterns across OECD countries allow a rough adjustment to be made to productivity levels for the effect of overall differences in labour utilisation across countries (Belorgey, Lecat and Maury 2006; Cette 2005).[3] Figure 2.5 shows that, after making this adjustment, only Norway has a noticeably higher productivity level than the United States. As noted before, Norway's superior productivity level

[3] The experience across OECD countries during the 1990s suggests that the marginal hour worked by an employee is perhaps two-thirds as productive as the average hour worked, and the marginal worker is perhaps one-half as productive as the average worker (Belorgey, Lecat and Maury 2006).

is likely to be due to its different industry mix rather than to it outperforming the United States in production activities in general.

Overall, US productivity provides the most relevant ‘frontier’ or aggregate benchmark to use when considering Australia’s productivity performance. The United States can still be broadly interpreted as the world productivity leader in an aggregate, technological sense. Non-technological factors — policies constraining employment and industry mix (reflecting access to mining resources) — explain why some European countries report higher productivity.

Figure 2.5 **Structural productivity levels in the OECD, 2002[a]**
US = 100



[a] Structural productivity adjustments reflect differences in labour utilisation, assuming the long-run productivity elasticities to employment rates and hours worked per employed person reported in Belorgey, Lecat and Maury (2006).

Data source: Authors’ calculations based on The Conference Board and GGDC, (*Total Economy Database*, September 2006); OECD, (*Economic Outlook*, no. 78); OECD, (*Labour Force Statistics)*.

One other point is worth highlighting from an economic wellbeing perspective. Productivity and labour utilisation are both determinants of average incomes (box 2.1). Any superiority that European countries have on productivity (compared with the United States) is more than offset by lower labour utilisation, and so they rank lower than the United States on average income. The material presented here and, in particular, the higher workforce exclusion and unemployment of the unskilled, suggests that lower utilisation results largely from policy choices. The implication is that, if Australia used the same means to match European productivity, it would not enhance overall average income.

Box 2.1 **Productivity, labour utilisation and average income**

GDP per person, also called average income, is often used to rank countries in terms of their overall economic performance. Average income (GDP per person) is the product of average labour productivity (GDP per hour worked) and average labour utilisation (hours worked per person). Whilst there is long-standing debate about how well average income measures wellbeing, the focus here is merely to illustrate that the improved productivity performance of some European countries did not translate fully into improved average prosperity because better productivity came at the expense of lower labour utilisation.

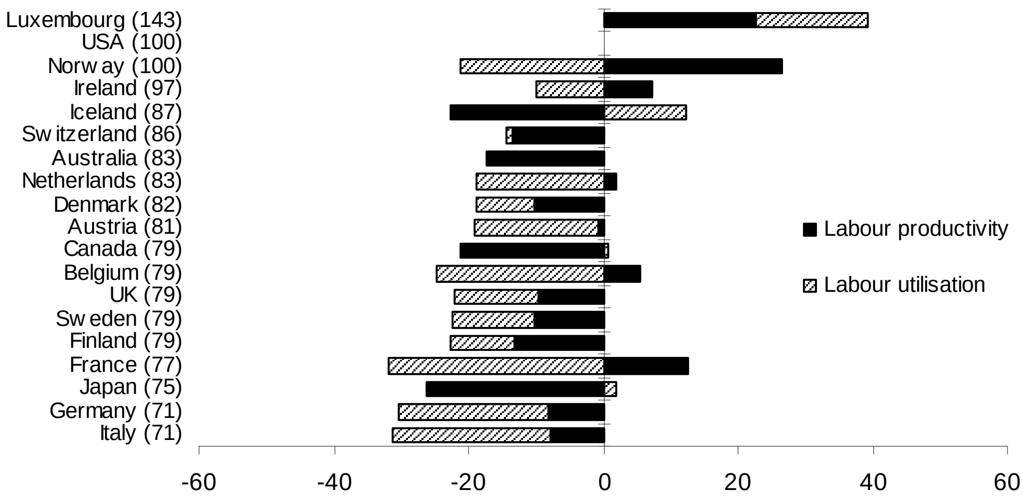
Figure 2.6 shows a 'league table' that ranks countries according to average incomes in 2005 and decomposes the differences in average income with the United States into differences in labour productivity and differences in labour utilisation.

The figure shows that, apart from the special case of Luxembourg, the countries that outrank the United States on level of productivity (Norway, Ireland, Belgium and France) are outranked by the United States on labour utilisation. Overall, they have lower levels of average income than the United States.

Australia's GDP per person was around 17 per cent lower than the US level in 2005. The figure shows this is because of weaker productivity and not lower labour utilisation.

Figure 2.6 **Contributions to average income differences, 2005**

GDP per person (US = 100) and contributions of productivity and labour utilisation to differences with US GDP per person (percentage points)



Data source: The Conference Board and GGDC, (*Total Economy Database*, September 2006).

2.2 Frontier shifts: focus on the United States

If the United States can be considered the world's productivity leader in terms of technology and efficiency of production, what does the history of US productivity growth tell us about the nature of shifts in the international productivity frontier?

First, the pace of technological change has not been steady. Shifts in the technology frontier — as indicated by labour productivity growth in the US business sector[4] — have come at distinctly different rates in three stages since 1950:

- a high rate of growth from 1950 to 1973 (3.0 per cent per year);
- a slower rate from 1973 to 1992 (1.6 per cent per year); and
- a return to stronger growth from 1992 to 2005 (2.4 per cent per year).[5]

Second, frontier shifts in the US economy have had a strong industry dimension. In terms of broad industry sectors, the strong productivity growth of the 1950s and 1960s was primarily sourced from agriculture and manufacturing and the acceleration in the 1990s came from manufacturing and services (appendix A).

The diversity in the timing and extent of productivity accelerations is more marked at the level of individual industries. For example, within the manufacturing sector, there was strong productivity growth in chemical products and transport equipment (including motor vehicles) in the 1950s and 1960s, but it subsequently faded (figure 2.7). Manufacturing of electronic and other electrical equipment showed strong multifactor productivity (MFP) growth in all periods and especially so in the 1990s. The industrial machinery and computer equipment industry joined as a major contributor in the 1970s and 1980s and was a leading performer in the 1990s. These last two industries contain the production of information and communications technology (ICT) equipment. ICT manufacturing alone contributed around 0.4 percentage points of the 1 per cent a year growth in US aggregate MFP over the decade from the mid-1990s (Jorgenson, Ho and Stiroh 2006).

The 1990s productivity acceleration in services has been associated with the innovative use of ICT equipment and has been concentrated in telecommunications, wholesale trade, retail trade and certain financial services (Triplett and Bosworth 2004). Productivity growth in wholesale and retail trade was on a par with manufacturing productivity growth and, since they are together the same size as manufacturing, they have contributed as much as manufacturing to aggregate US productivity growth.

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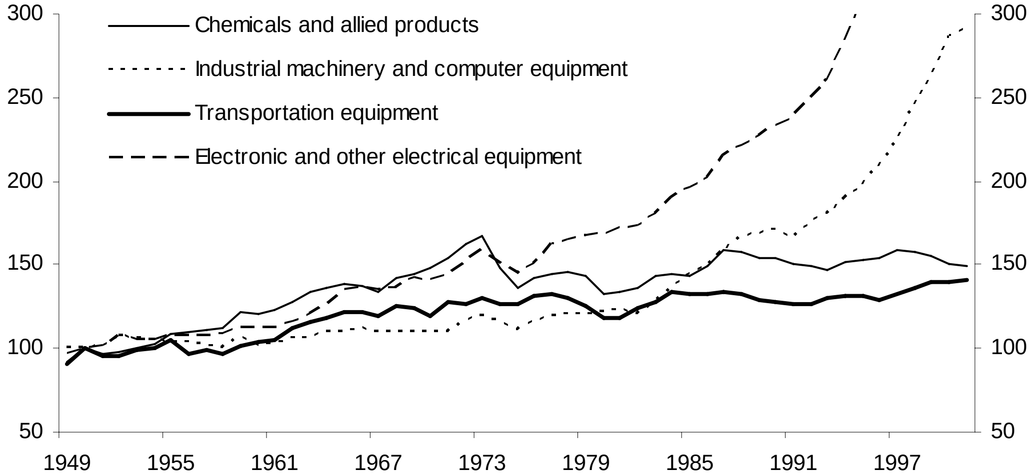
[4] The business sector excludes a range of non-marketed services in the government sector. It is broader than the market sector defined for Australia by the Australian Bureau of Statistics (ABS) in that it includes private business services.

[5] The process by which these periods were identified is presented in appendix A.

Figure 2.7 **Multifactor productivity in selected industries, United States**
Index, 1950 = 100



Data source: BLS

2.3 Future frontier shifts: the outlook for US productivity growth

Forecasting US productivity growth is inherently difficult because the future path of technological progress is unknown. Even the sharp changes in US productivity growth in 1973 and the 1990s were unanticipated.[6]

Future productivity growth can be projected by extrapolation of past growth. It is an often-used, simple and defensible method. But the choice of which past period to use is crucial. With the rates presented in the previous section, it is clear that vastly different results could be achieved if forward projections were based on the average growth in US productivity from 1950, from 1973 or from 1992.

Most forecasters are optimistic about US productivity prospects, at least in the near term, and predict rates higher than the past-30-year average of 1.6 per cent a year.[7] A range of academics and US government agencies predict medium-term productivity growth in the US of between 2 and 2½ per cent (table 2.1). This

[6] The difficulty interpreting productivity data in the 1970s is well documented (for example, Orphanides 2001). Official forecasts of productivity growth through the 1990s also lagged well behind the actual data (Jorgenson, Ho and Stiroh 2006).

[7] Longer-term forecasts are somewhat closer to this 30-year average. The Board of Trustees of the Social Security Administration (2006) expects the productivity growth of 2.1 per cent in the near term will decline to an average of 1.7 per cent over the 75-year projection period, slightly below the historical 40-year average of 1.8 per cent. The Congressional Budget Office (2005) also predicts productivity will slow from around 2020, but only by 0.1 to 0.2 percentage points.

optimism is based on: the likelihood of ongoing rapid technological advances in ICT manufacturing; accompanying rapid price declines, diffusion of technologies and increases in the ICT capital-to-labour ratio; and continuation of the pace of efficiency improvement elsewhere in the economy as firms continue to find new and more-productive ways to apply new technologies. Jorgenson, Ho and Stiroh (2006) calculate that, if the patterns evident in these areas since 1990 repeat, US productivity growth over the coming decade will be around 2¼ per cent.

Table 2.1 **Recent projections for US labour productivity growth[a]**

Source	*Annual growth rate (per cent)*	*Time period*
Jorgenson, Ho and Stiroh (2005)	Baseline 2.25 High 2.8 Low 1.2	2005 to 2015
Council of Economic Advisors (2006)	2.6[a]	2005Q3 to 2011Q4
Congressional Budget Office (2006)	2.1	2006 to 2016
Board of Trustees of the Social Security Administration (2006)	2.1	2005 to 2007
	Baseline 1.7 Low 1.4 High 2.0	2005 to 2080

a This projection relates to the non-farm business sector. It appears to be equivalent to whole-economy productivity growth of around 2¼ per cent.

Jorgenson, Ho and Stiroh (2006) illustrate the implications of extrapolating from past trends in different periods. Their high-productivity scenario assumes the economy continues its trajectory since 1995. Their low-productivity scenario assumes a reversion to the slower pace of ICT technological improvement and much slower general efficiency improvement apparent between 1973 and 1995, but with slower improvement in labour quality than in that period. The difference between the two scenarios is huge: 1.6 percentage points per year.

So will the effects of ICT continue to support above-average rates of productivity growth? There are reasons for optimism in the near term. Past experience with general purpose technologies, such as electrification, shows the process of deploying and exploiting them is quite prolonged due to the need for complementary technological and organisational innovations (Abramovitz and David 2001). In particular, there remains room for further exploitation of existing information technologies, such as expanding the role of the internet in retail trade. More generally, ICT remains only a small share of the capital stock (Jovanovic and Rousseau 2005) and rapidly falling prices should continue to support its take-up. Perhaps most importantly, competitive pressures to develop innovative new business models remain in place.

However, there are also downside risks. One risk stems from the enigmatic nature of very recent productivity performance. While talk of the 'new economy' faded after share prices declined in 2000, productivity growth actually accelerated further (Bernanke 2006). An optimist could see in this the delayed effects of heavy investment in the late 1990s as firms continue to find better ways to use their capital. A pessimist would note that this accompanied a very weak labour market. Overall, the same number of hours are worked in the business sector today as were worked in 2000, but there have been large falls within manufacturing, including both production workers and managers (Baily and Lawrence 2004). One interpretation is that structural adjustment supported the very recent productivity performance. The corporate shake-out saw firms cut entire lines of business that no longer seemed worthwhile after share prices fell. If this were correct, it raises the question of whether productivity growth from this source will be repeatable in the future.

2.4 Summary and implications

The United States provides a more useful indication of the international productivity frontier, in a technological sense, than some European countries where measured productivity appears higher. The main message from the historical United States experience is that the pace of technological progress is time and industry specific. It accelerates and decelerates without notice and the industries most strongly affected vary widely reflecting the different technological breakthroughs underlying productivity growth.

Efforts to forecast US productivity growth are highly speculative. Nevertheless, there are reasons to be optimistic that rapid improvements in technology will sustain above-average rates of productivity growth. The average forecast for US annual productivity growth over the coming decade is around 2¼ per cent. If achieved this would be unusually fast by historical standards, and sustaining this pace over the next two decades would be even more unusual. A slightly more conservative rate for the next two decades or so of around 2 per cent a year seems reasonable.

3 Catch-up and convergence

The patterns of productivity growth in other developed countries are affected by movements in the international productivity frontier and each country's ability to catch up to the frontier. How strong is the tendency for developed countries to catch up to the international frontier? How quickly do countries catch up and by what means? Answers to these questions could have a bearing on expectations about the extent to which, and how rapidly, Australia could catch up to the frontier.

3.1 Varied evidence of catch-up

It is widely recognised that productivity catch-up brought convergence in productivity levels among OECD countries over the course of the 20th century.[1] OECD countries with productivity levels at 75 per cent or more of the US level numbered 4 in 1950, 12 in 1973, and 18 in 1995.[2]

There are several qualifications, however, on viewing catch-up as an inexorable force.

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[1] Outside the OECD there is no general tendency for productivity levels to converge with those in high-income countries (Pritchett 1997). One explanation is that the potential for catch-up depends upon a range of conditions — political institutions, culture, education, natural resource endowments and savings rates (Abramovitz 1994). Among high-income OECD countries these conditions were similar and there was historical convergence to similar productivity levels. However, this theory of 'conditional catch-up' is not universally accepted. One counter-argument is that the apparent historical convergence within OECD countries merely reflects sample selection and should not be taken as evidence of a general convergence tendency. For example, de Long (1988) points out that among the group of countries with high incomes today it is almost inevitable there was historical catch-up, but many other countries had similar conditions in 1870 and did not subsequently catch-up.

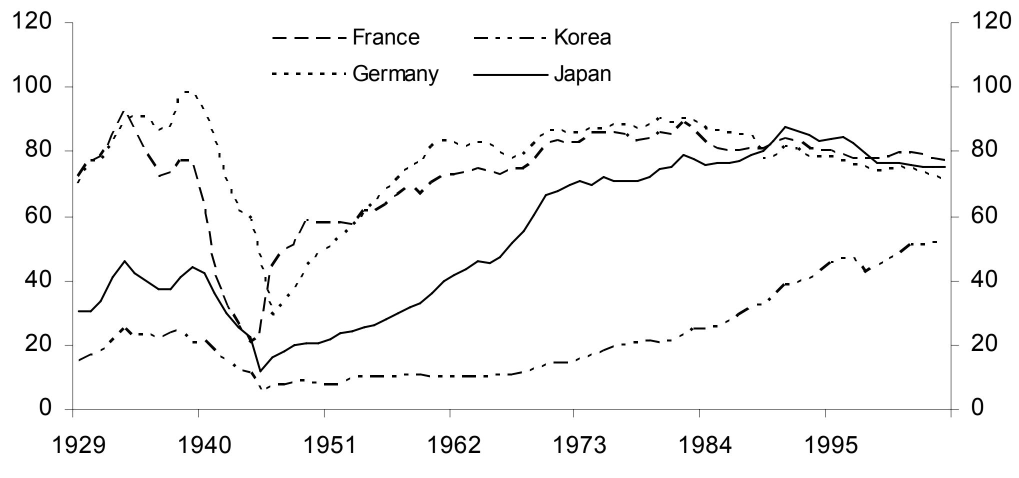
[2] Counts are based on The Conference Board and Groningen Growth and Development Centre, *Total Economy Database,* September 2006.

First, the pattern of catch-up has varied over time. Catch-up was most rapid in the period from 1950 to 1973. Differences in productivity levels among OECD countries closed by around two-thirds over this period. However, the overall rate of convergence slowed after 1973 and even further after the mid-1990s (box 3.1). The wide variation in performance during the most recent decade partly reflects differences in the production and use of information and communication technology (OECD 2003). Productivity accelerated in some countries (including the United States) that have used these technologies effectively, but not in other countries (including some European countries).

Second, the post-war catch-up does not appear as strong or inexorable from a longer-term perspective — that is looking at the whole of the 20th century. Some European economies, particularly Germany and France, had higher relativities with the US prior to WWII than they did in 1950 (figure 3.2).[3] Part of the post-war convergence was recovery from the destruction of human and physical capital. Part of it was catch-up in a technological sense, to close the large gap that had, by the completion of reconstruction in the 1950s, opened up between best-practice US technology and average-practice European technology (Phelps 2006). Japan and, later, Korea appear to be more 'pure' cases of catch-up, whereby their productivity relative to the US stepped up from pre- to post-war.

Figure 3.1 **Long-run economic growth**

GDP per person; US = 100



Data sources: From 1950 data are sourced from The Conference Board and GGDC, *(Total Economy Database*, September 2006); in earlier years these data are spliced with data from Maddison (2003).

3 Figure 3.2 shows GDP per person. These data suggest it was likely that French and German productivity relativities were higher before WWII than in 1950, however annual historical data on productivity levels are not available before 1950. Broadberry (1998) shows that German output per worker fell by 22 per cent compared to the United States between the mid-1930s and 1950, somewhat less than the illustrated fall in GDP per person.

Box 3.1 **Catch-up and convergence**

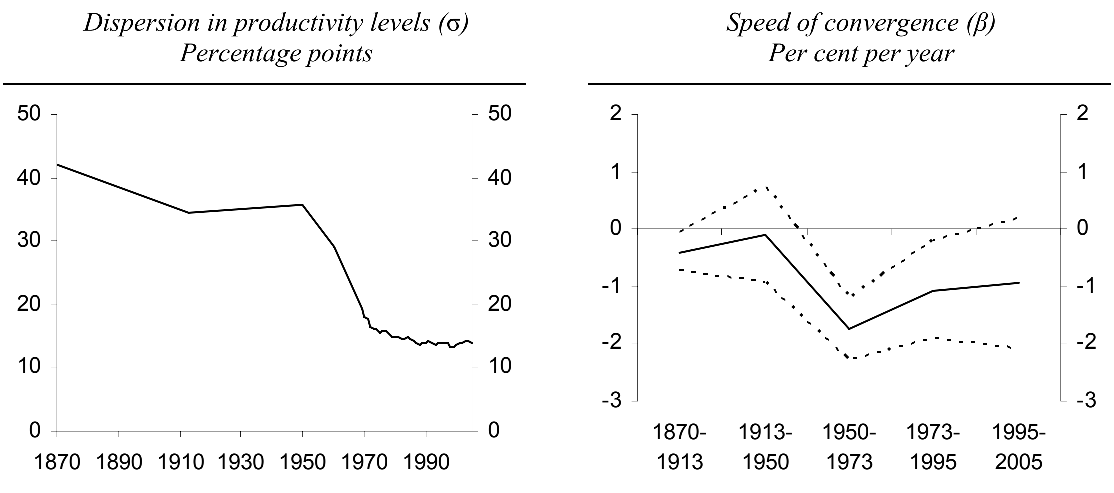
According to theory, the productivity leader is at the forefront of technology and its rate of productivity growth relies on new technological breakthroughs. Follower countries can achieve faster rates of productivity growth and catch up to the leader's productivity level as they engage in 'technological catch-up' — by adopting the leader's technologies and know-how, without undergoing the same investment, learning and adjustment costs; and by 'leapfrogging' some technologies rendered obsolete by the leader's later discoveries.

Productivity levels among a group of countries can converge, as a result of catch-up. Two useful measures are commonly referred to as sigma (σ) convergence and beta (β) convergence.

Sigma convergence refers to a decline in the dispersion of countries' productivity levels. The left-hand side of figure 3.2 shows that the productivity dispersion among 16 OECD countries fell sharply between 1950 and the early 1970s. At other times σ-convergence has been weak and no further convergence has occurred within this group of countries since the late 1980s.

Beta convergence refers to productivity growing faster in countries with initially lower productivity levels. The speed of convergence measures the rate at which these initial productivity gaps are closed. The right-hand side of figure 3.2 shows that productivity gaps between OECD countries closed at an average rate of nearly 2 per cent per year between 1950 and 1973. The speed of convergence has since slowed, and the confidence intervals are broad enough to include the possibility that there was no general tendency for convergence after 1995.

Figure 3.2 **Convergence in OECD productivity levels, 1870 to 2005**[a]



[a] Dispersion is measured as the coefficient of variation in productivity levels within a constant sample of 16 countries. Speed of convergence is derived from a regression of the annual average log change in productivity on the initial log level of productivity. Data are for 16 countries to 1950, 22 countries from 1950 to 1973 and 24 countries from 1973. Light dotted lines indicate 95 per cent confidence intervals.

Data sources: Authors' calculations based on Maddison (2001) Appendix E, Maddison (2003); The Conference Board and GGDC, (*Total Economy Database*, September 2006).

Third, the patterns of catch-up have varied between countries. While many countries have attained similar productivity levels to those in the United States, other countries have seen productivity gaps maintained over long periods. Countries fell into four groups:

- those that overtook the US productivity level in the post-war period — France, Belgium, Norway, The Netherlands and Germany — and in the process took their relativities above pre-war levels;
- those that partially caught up to the US level — Japan, Denmark, Finland, Spain and the United Kingdom;
- those that kept up with US growth rates — Canada and Australia; and
- those that fell behind — New Zealand.

These differences in labour productivity growth and levels can reflect either differences in capital intensity or differences in multifactor productivity (MFP). Currently, MFP data for international comparisons are scarce. However, the limited data that are available (Schreyer 2005) show that the large labour productivity gaps compared to the US level that remain in Australia, New Zealand and Canada result mainly from MFP, with lower capital intensity explaining one-third or less of the overall gaps.[4]

3.2 Catch-up and convergence within industries

Industry differences across countries provide a further qualification to the notion of automatic catch-up. As seen in the last chapter, a country's industry mix can affect its aggregate level of productivity — countries with a bias toward oil extraction have been able to overtake the US productivity level. Depending on a country's industry mix, it may be easier or harder for it to catch up. A country's scope for catch-up will also depend on within-industry possibilities for catch-up.

When making international comparisons at the industry level, some allowance must be made for the greater uncertainty about the accuracy of measures. A rich set of internationally comparable data is soon to become available from the EU-KLEMS project (see http://www.euklems.net). It will permit international comparisons of labour and multifactor productivity — both growth and levels — at an industry

4 Inklaar, Timmer and van Ark (2006) also show, with respect to a group of services industries, that MFP explains the majority of gaps with US labour productivity for Australia and Canada.

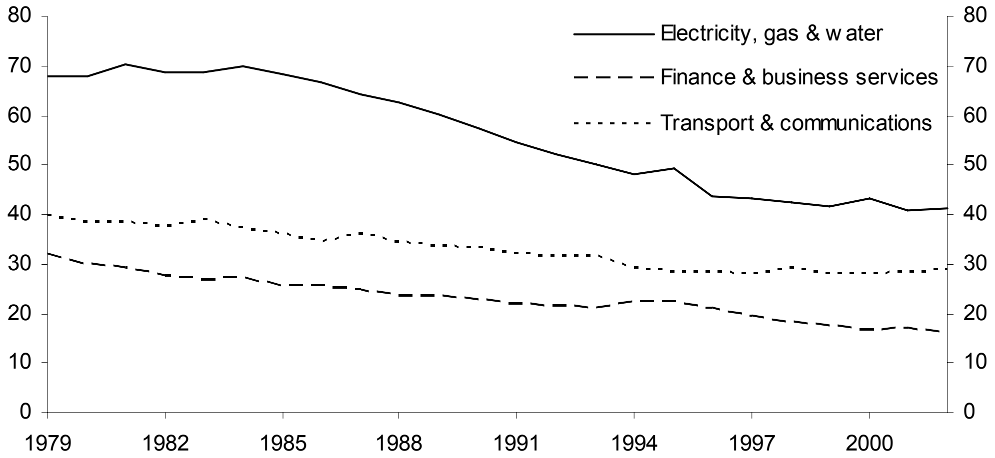
level. While Australia will not be part of the initial release in March 2007, the ABS and the Productivity Commission have been cooperating with the Groningen Growth and Development Centre to provide data that will enable the inclusion of Australia in the database, probably later in 2007. The measures constructed and used here are only rough.[5]

Even so, the historical patterns of international productivity convergence within individual industries are striking for their diversity. The dispersion in productivity levels has fallen within some industry groups — electricity, gas & water supply, finance & business services and transport & communications (figure 3.3 and table 3.1). In particular, within electricity, gas & water supply, the dispersion in productivity levels has fallen almost by half. In other industries — agriculture, manufacturing and wholesale and retail — the dispersion in productivity levels has not declined (figure 3.4). This is not because productivity in these latter industries started the period at similar levels in all countries. Broadly, the dispersion in productivity levels was just as great as within the first set of industries.

5 The analysis in this section relies on gross value added data deflated by industry gross output PPPs, as described in appendix B. Sorensen (2001) has shown that industry convergence results can vary depending upon the choice of base year when using GDP PPPs to deflate industry output, and this fragility likely carries over, to a lesser degree, to the current analysis since industry gross output PPPs do not correctly deflate industry output measured as gross value added. Data limitations mean productivity levels can be compared only across 19 OECD countries since 1979, so it is not possible to study the period of strongest convergence (1950 to 1973). However, as discussed above, that earlier period was unusual. The pattern of convergence in recent decades probably provides the more reasonable guide to likely future trends. Mining is excluded as productivity differs widely from country to country depending more on natural resource endowment than efficiency. Public administration, health and education and some other service industries are excluded because output is measured largely on the basis of inputs into production so that meaningful comparisons of productivity are impossible. The countries studied are Australia, Austria, Belgium, Canada, Denmark, Spain, Finland, France, Germany (reunified, spliced to West German data prior to 1991), Greece, Ireland, Italy, Japan, The Netherlands, Norway, Portugal, Sweden, the United Kingdom and the United States.

Figure 3.3 **Convergence within some industries**

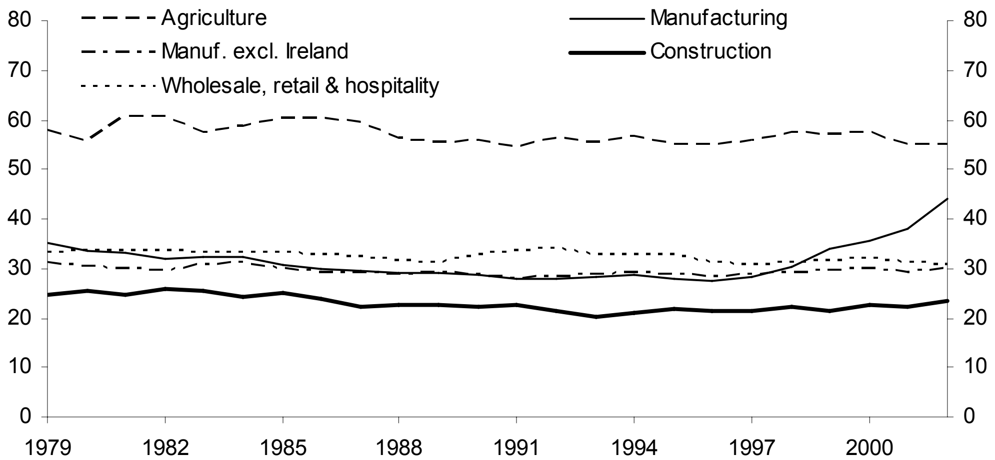
Coefficient of variation in productivity levels, percentage points



Data source: Authors' calculations based on GGDC, (*60-Industry Database*, September 2006): industry price data from Timmer, Ypma and van Ark (2006).

Figure 3.4 **No convergence within other industries**

Coefficient of variation in productivity levels, percentage points



Data source: Authors' calculations based on GGDC, (*60-Industry Database*, September 2006); industry price data from Timmer, Ypma and van Ark (2006).

The same diversity is evident in terms of the speed with which productivity gaps between countries have closed over time. In all industries productivity tended to grow faster over the period to 2002 in countries with initially lower productivity levels in 1979 (table 3.1).[6] However, the speeds with which these productivity gaps closed varied widely, from almost too slowly to notice in agriculture to very rapidly in finance and business services. The consequence of these differences in speed of catch-up (measured as β-convergence) is that average productivity gaps in finance & business services fell by half over this period, while average productivity gaps in agriculture fell by less than one-tenth.

A closer look within these industries provides some insight into what was going on. Figure 3.4 shows that, within manufacturing, there was some early convergence but this gave way to rapid divergence from the mid-1990s. The story here revolves around Ireland. Manufacturing productivity there was quite low in the late 1970s, but was boosted by an inflow of foreign direct investment concentrated on high-tech manufacturing and induced by favourable tax regimes for foreign manufacturers, educated (and initially cheap) labour and free trade with the EU, among other factors (Box 1998). By the late 1990s, Ireland had the highest recorded manufacturing productivity in the OECD. This shows that very rapid improvement in productivity is possible via international technology flows, although this occurred under a particular set of conditions (including government incentives and opportunities to service the European market), rather than with a sense of inevitability. Outside of Ireland there has been no general convergence in manufacturing productivity.

Table 3.1 **Convergence within selected industries[a]**

	Dispersion in productivity levels (percentage points)			*Speed of β convergence (per cent per year)*	
	1979	2002	Annual change	Coefficient	t-statistic
Agriculture	58	55	-0.1	-0.4	-0.8
Manufacturing	35	44	0.4	-3.4*	-2.9
Manufacturing excl. Ireland	31	30	-0.1	-1.0	-1.2
Electricity, gas & water	68	41	-1.2**	-1.8**	-5.1
Construction	25	23	-0.1	-1.6*	-2.5
Wholesale, retail & hospitality	33	31	-0.1	-0.9	-1.4
Transport & communications	40	29	-0.5*	-1.8**	-5.1
Finance & business services	32	16	-0.7**	-2.9**	-7.3

a Dispersion is measured as the coefficient of variation in productivity levels. Speed of convergence is derived from a regression of the annual average log change in productivity on the initial log level of productivity; the coefficient is approximately the per cent of the initial productivity gap that is closed each year. * indicates statistical significance at the 5 per cent level, ** indicates statistical significance at the 1 per cent level.

Source: Authors' calculations based on GGDC, (*60-Industry Database*, September 2006): industry price data from Timmer, Ypma and van Ark (2006).

6 A negative 'speed of convergence' may arise from regression towards the mean, so that a general trend decline in productivity dispersion is a more reliable indication that productivity convergence has actually occurred (Quah 1993; Friedman 1992).

In agriculture, as a second example, the dispersion of productivity levels has remained very high. The data suggest that, for example, agricultural productivity in Japan is less than one-tenth of the US level. The sustained differences between developed countries is a likely result of differences in the amount and quality of arable land (and the value of that land for other uses), farm size, differences in crop types, measurement problems and policies that support low productivity agricultural practices in some countries.

How can the notion of technological catch-up explain why productivity levels converged in electricity, gas & water, transport & communication and finance & business services, but not in agriculture or manufacturing? One possible explanation centres around the distinction between tradable and non-tradable segments of the economy (Bernard and Jones 1996). In tradable segments, such as agriculture and manufacturing, countries specialise in areas of comparative advantage. To the extent that different countries are producing different goods there is no reason to expect their productivity to converge. In non-tradable segments, similar goods and services are provided in all economies and it is more likely that technology developed in the frontier economy can be applied within follower economies. That is, it may be that where countries are behind the productivity frontier due to non-tradable segments they have greater scope for future technological catch-up.

3.3 Summary and implications

In summary, there has been historical productivity catch-up and convergence among OECD countries. A complete interpretation of the post-war productivity convergence, its strength in some countries and weakness in others, and its moderation in the 1970s remains elusive. But it is clear that both the pace of convergence and the levels of productivity that countries have converged towards have been governed by particular circumstances — time-, country- and industry-specific factors (including the policy and institutional factors mentioned in the previous chapter) — rather than by a general rule or tendency. Judging by other countries' experiences, it would not appear inevitable — nor necessarily even feasible — for Australia to catch up fully to the US productivity level in all industries.

4 Australia's historical performance

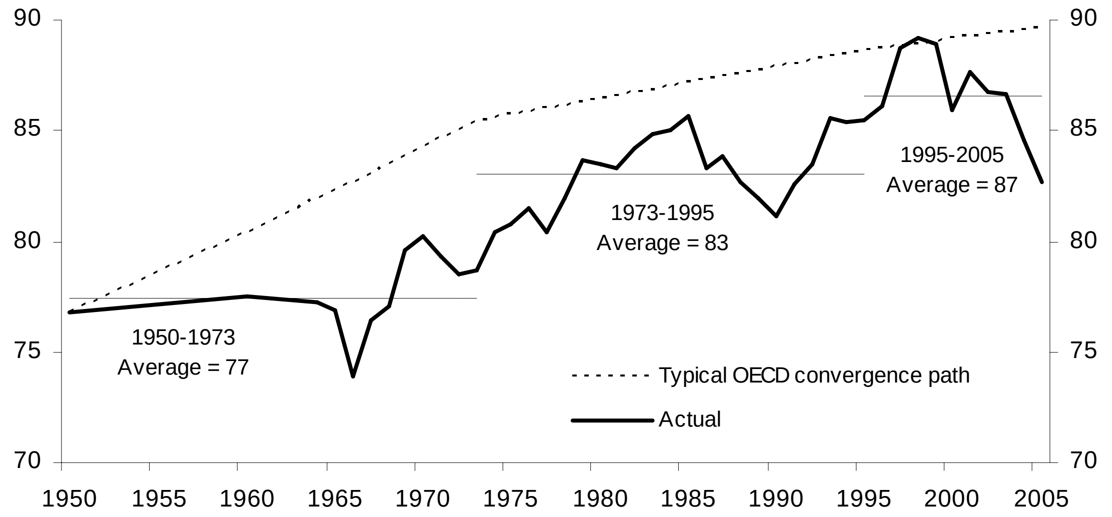
This chapter compares Australian and US productivity levels and growth rates, in the broad and across industries, with the aim of identifying patterns that might be relevant to Australia's ability to catch up in the future.

4.1 Australia's productivity performance in a convergence perspective

Over the long haul, Australia's historical catch-up has been quite weak. Australia's annual rate of productivity growth (measured as GDP per hour worked) exceeded the US rate by a bare 0.1 of a percentage point over the second half of the 20th century. Over 55 years, this raised Australia's productivity from around 77 per cent of the US level to around 87 per cent (figure 4.1)**.**

Figure 4.1 **Australia chasing the frontier**

Australian productivity, per cent of US level[a]



a The 'typical convergence path' is based on average OECD speeds of convergence for the periods 1950 to 1973, 1973 to 1995 and 1995 to 2005, as detailed in box 3.1.

Data source: Authors' calculations based on The Conference Board and GGDC, (*Total Economy Database*, September 2006).

This is below the average pace of catch-up observed elsewhere in the OECD and does not simply reflect Australia's relatively high starting position at the beginning of the post-war period. In 1950, Australia ranked five among OECD countries. But it was subsequently overtaken by many other countries, and by substantial margins, to rank 12 in 1973 and 17 in 1995.[1]

It is also clear that the pace of this slight catch-up has not been even. Australia lagged behind because of its performance through the 1950s and 1960s. The policy and institutional environment in Australia in the post-war decades reinforced the closed, inward-looking and rigid nature of the economy (PC 1999), and this may have tended to dampen productivity catch-up. While many European countries were closing on US productivity levels very rapidly over this period, Australia managed only to hold its position. Had Australia caught up toward the US productivity level at the typical pace elsewhere in the OECD, Australian productivity would have approached 85 per cent of the US level in 1973, around 7 percentage points higher than the level actually achieved (figure 4.1).

From that point on Australia's rate of productivity catch-up has been broadly in line with international norms. There was a period of catch-up beginning in the early 1970s and continuing into the early 1980s. Australia caught up 7 percentage points over 12 years and reached 86 per cent of the US mark by 1985. This catch-up coincided with the productivity slowdown in the United States (and elsewhere). However, in Australia real wage inflation through the 1970s may have held down labour utilisation (by raising unemployment) and boosted productivity.[2] Part of the apparent catch-up vanished in the late 1980s as the series of Prices and Incomes Accords in Australia unwound earlier real wage rises, employment and labour utilisation increased and Australia's relative productivity retreated.

There was a second period of catch-up beginning in the early 1990s, with a contribution from microeconomic reforms dating from the 1980s. Australia's 1990s productivity surge was stronger, and began earlier, than that in the United States. Australia's labour productivity reached a peak of 89 per cent in 1998 (a 6 percentage point increase over 6 years). But it has slipped back since, as Australian productivity slowed, while in the United States the rapid pace of the late 1990s has been maintained. The marked drop over the past couple of years may turn out to have a cyclical component.

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[1] Ranking calculated from data in The Conference Board and GGDC, *Total Economy Database*, September 2006.

[2] Of course average incomes are also affected by changes in labour utilisation. Over the long term Australian labour utilisation has been broadly the same as that in the US (see figure 2.2). However, it fell around 10 percentage points compared to the US over the decade beginning in the mid-1970s. It has mostly recovered since 1997.

4.2 Industry contributions

Aggregate productivity gaps reflect productivity differences within industries and differences in industry composition.

Industry gaps and catch-up

Again, the limitations in industry comparisons should be kept in mind. Measuring industry outputs and therefore productivity on a comparable international basis is difficult. While broad purchasing power parity exchange rates can be used for aggregate comparisons, industry comparisons ideally require industry-specific conversions. The level comparisons in table 4.1 are based on industry-specific conversions, but the quality of the conversion factors used varies across industries (appendix B). Some allowance should also be made for differences in industry definitions and measurement conventions (for an example, see box 4.1). These limitations mean that comparisons should only be used to indicate whether productivity levels in Australian and US industries are broadly similar, different or very different.

Although the available measures should not be taken literally, they nevertheless indicate that Australia’s productivity performance relative to the United States has varied widely across industries. Table 4.1 shows that Australian industry performance broadly fall into groups that have:

- matched or exceeded US levels and growth rates — that is, participated in frontier shifts;
  - mining, construction and transport;
- not attained US levels but have exceeded US growth rates in certain periods — that is, partially caught up;
  - utilities, communications, retail trade and finance & insurance; and
- not matched US levels or growth rates — that is, fallen further behind;
  - manufacturing, wholesale trade and, perhaps, agriculture.[3]

[3] Deficiencies in the PPP price deflator used for agriculture may be more severe.

Table 4.1 **Catch-up in Australian productivity levels, 1979 to 2003**

	Growth rate in the United States	*Australia's growth rate relative to the United States*	*Australian labour productivity*		
			1979	1998	2003
	per cent per year	percentage points per year	per cent of US level		
Agriculture, forestry and fishing	3.7	-0.8	94	69	78
Mining	2.7	0.3	186	203	199
Manufacturing	3.7	-1.3	83	71	60
Electricity, gas & water	3.5	1.1	41	71	53
Construction	-0.8	2.2	74	111	124
Trade	2.6	-0.1	62	60	60
Wholesale trade	4.3	-1.0	55	33	43
Retail trade	2.5	0.2	60	73	63
Accommodation, cafés & restaurants	0.3	0.1	85	84	87
Transport & communications	2.5	-0.6	98	95	85
Transport & storage[a]	2.3	-2.5	179	95	98
Communications	2.9	3.0	41	114	83
Financial & business services	0.4	-0.5	97	90	85
Finance & insurance	2.6	0.3	62	73	67
Property & business services	-0.5	-1.1	120	96	93
Public services	-0.2	0.9	100	124	124
Other services	1.4	-0.6	83	71	72
Whole economy	**1.6**	**0.1**	**84**	**89**	**87**

[a] The unusual pattern in transport and storage productivity reflects unusual patterns in the GGDC's Australian price deflators.

Source: Authors' calculations based on current price output, industry temporal price deflators and hours worked from GGDC, (*60-Industry Database*, September 2006). Productivity levels are constructed using gross output PPP data by industry grouping from Timmer, Ypma and van Ark (2006) and gross output PPP for wholesale trade and retail trade based on Timmer and Ypma (2006); productivity levels within hospitality, transport, communications, finance and insurance, and property and business services industries use the gross output PPPs for their respective industry groupings.

Box 4.1 Measurement of output in wholesale and retail trade

Measurement issues cloud the interpretation of the retail and wholesale data. First, there could be an industry attribution problem. Many of the gains from ICT use in distribution are coming from by-passing the wholesaling function. Manufacturers do not make until they have a buyer; and goods are delivered by transport companies directly to retailers. While this is happening in both Australia and the US, the impact it has on industry comparisons depends on how the gains are allocated between industries in each country. Second, measures of growth in the volume of output in US wholesaling and retailing of ICT equipment reflect both the quantity and quality of computing equipment sold. Quality improvements have been enormous (Triplett and Bosworth 2004; Gordon 2004). The Australian measure is related to the quantity of ICT equipment sold — that is, the output is related to 'shifting boxes' and not what is in them. Excluding retail of electronics and appliance stores and non-store retailers (such as Dell) lowers estimates of US retail annual productivity growth since 1990 by around 0.6 percentage points (Manser 2005).

Among the first group of industries, Australia appears to be clearly ahead of US productivity levels only in mining. This advantage has been maintained and even extended over the past couple of decades. Measurement problems play a larger, though uncertain, role within other industries where Australia has had an apparent lead. In construction the data suggest Australian productivity has caught up and then surpassed levels in the United States, but the quality of construction output is notoriously difficult to measure so that both productivity levels and growth rates are difficult to interpret (Allen 1985; Sharpe 2001). In transport, the data currently available imply Australian productivity growth rates that are implausible.

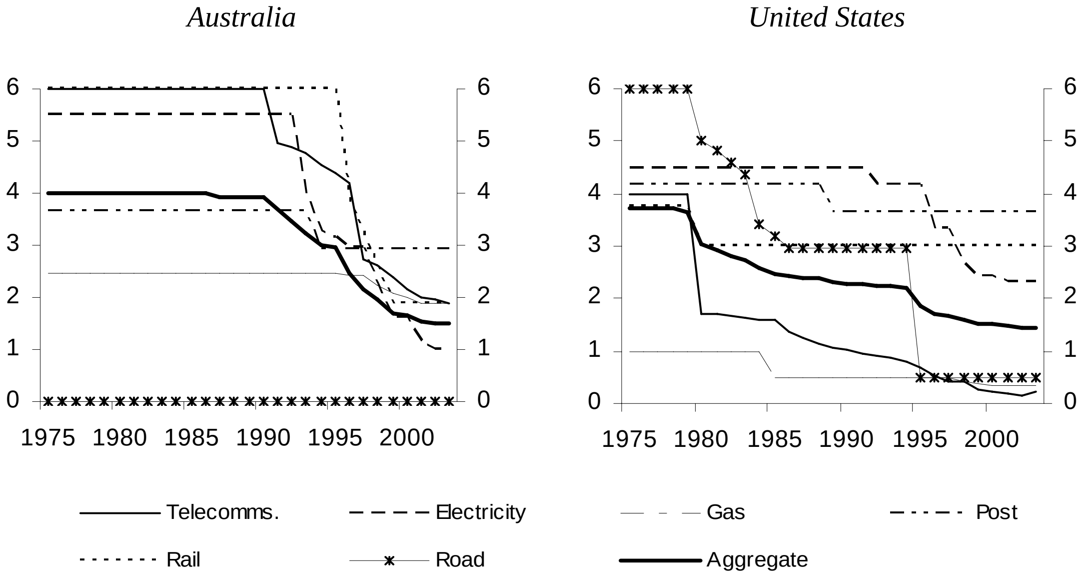
The evidence of catch-up in specific periods within the second group of industries is clearer. Starting in the late 1970s from productivity levels far below those in the United States, Australian productivity rose rapidly in utilities, communications and finance, particularly in the 1980s and 1990s.[4] This productivity surge coincided with a series of microeconomic reforms that improved the quality of regulation. For example, the OECD scores the quality of regulation in a range of industries between 0 and 6, with a lower score indicating more effectively regulated industries. Reform in many Australian industries, particularly during the early 1990s, brought overall regulatory conditions more closely into line with those in the United States, despite

4 Looking at the period from 1979 to 2003 as a whole, Australia closed around 5 per cent of the productivity gap with the US per year in communications, around 1 per cent of the gap per year in utilities and around 0.5 per cent of the gap per year in finance and insurance.

concurrent reforms in that country (figure 4.2).[5] However, Australian productivity has slowed since the end of the 1990s in each of these industries so that this pattern of catch-up has ceased and may have even temporarily reversed.

Figure 4.2 **Product market regulation indicators by industry**

0 = most effective regulation, 6 = least effective regulation



Data source: Conway and Nicoletti (2006).

Turning to those industries in which Australian productivity has lagged well behind that in the United States, two factors are likely to explain a large part of the gap in manufacturing productivity. First is the perennial issue of differences in scale. While the well integrated and large US market saw large scale manufacturing emerge early in the piece, geography and — for much of Australia's history — tariff barriers isolated Australian manufacturers from the large foreign markets needed to operate at similar scales. This partly explains why large productivity gaps are evident in most parts of the manufacturing industry (table 4.2). Second, the gap has widened since the mid-1990s largely because of ICT manufacturing. This sector of the manufacturing industry contributed strongly to the acceleration in productivity growth in US manufacturing (chapter 2), but Australia has a much

5 Taking the electricity supply industry as an example, during the 1990s Australian governments have regulated third party access, liberalised the wholesale market for electricity, allowed consumers to choose their retailer and reduced the extent of public ownership and vertical integration. Overall, the OECD rates Australian regulation in that industry more favourably than in the United States. However, the OECD continues to rate Australian regulation as inferior to that in the United States in gas supply (due to public ownership and lower competition) and telecommunications (due to public ownership).

smaller ICT manufacturing industry than the US — perhaps one-fifth as large as a share of the whole economy — reflecting different comparative advantages.[6]

Table 4.2 **Productivity gaps within manufacturing industries, 1997**
Per cent of US level

Australian productivity	*Manufacturing industries*
Below 50 per cent	Fabricated metal products; Leather & footwear; Furniture & miscellaneous; Other transport equipment.
50 to 75 per cent	Chemicals; Clothing; Instruments; Mechanical engineering; Motor vehicles; Non-metallic mineral products; Printing & publishing; Radio, television and communication equipment; Textiles.
75 to 100 per cent	Food, drink & tobacco; Pulp, paper & paper products; Rubber & plastics; Wood & wood products.
Above 100 per cent	Basic metal products; Mineral oil refining, coke & nuclear fuel; Other electrical machinery & equipment; Office machinery.

Sources: Authors' calculations based on GGDC, (*60-Industry Database*, September 2006); sub-industry gross output prices from Timmer, Ypma and van Ark (2006).

The widening gap in wholesale trade and, to a lesser extent, the maintenance of the gap in retail trade are surprising given the importance of these areas in Australia's productivity improvement from the early 1990s (Parham 2004). These are areas in which Australia has participated in frontier shifts due to the innovative use of ICT (OECD 2004a; PC 2004). Measurement differences between the two countries may have contributed to the widening of the gap over time (box 4.1), but are unlikely to explain a large part of the current large gap (Timmer, Inklaar and van Ark 2005).

Finally, output in sectors such as public services (government administration and defence, health and education), business services and other services is largely measured on the basis of the value of inputs, so that productivity comparisons are not meaningful.

Industry composition

The relative size of industries varies between countries, reflecting factors such as different comparative advantages, consumer preferences, geography and policy. Since productivity levels and typical growth rates vary across industries, differences in industry composition can also affect aggregate productivity level comparisons. If one country has relatively more resources devoted to relatively high productivity

[6] Gross value added in two key ICT industries, office equipment manufacturing and electronic valves and tubes manufacturing, accounted for around 0.65 per cent of US GDP in 2003, but only around 0.15 per cent of Australian GDP.

industries, its average level of productivity will be higher than in the other country, all other things equal.

However, in practice industry composition appears to explain little of the difference between Australian and US aggregate productivity levels (appendix C), at least at this level of industry aggregation.[7] Broadly speaking, Australia's industry composition is similar to that in the United States and, to the extent that there are differences, they tend to offset each other. For example, while Australia has a larger share of employment in some below average productivity industries such as agriculture and construction, this is offset by its larger share of employment in mining, utilities and communications.

The corollary is that practically all of the productivity gap between Australia and the US results from productivity gaps within particular industries. In this respect the largest contributors are wholesale trade, retail trade and hospitality, and manufacturing (appendix B).

4.3 Summary and implications

Australia is by no means the only developed country where productivity has not caught up with that of the United States. Nevertheless, it stands in contrast to the European experience. While some European countries fully caught up with US productivity levels, over the long haul and in the broad economy Australia has done only a little better than keep pace with US labour productivity growth.

This underlying pattern of slow catch-up reflects widely varying patterns within industries. Australia's historical catch-up has been clearest within utilities, communication and finance, consistent with the pattern of international convergence focused on the non-traded segments of the economy. Elsewhere in the economy, particularly within manufacturing and wholesale trade, very large productivity gaps have been maintained throughout the past couple of decades.

The persistence of large productivity gaps, both at the aggregate level and within some industries, suggests the need to search for deeper explanations than just industry composition. There are many layers of possible explanations (see box 4.2). From among the many factors, two possible deeper explanations are examined in this paper. These are geography and education; and they are discussed in the following two chapters.

[7] Davis and Rahman (2006) drew this same conclusion. They combined Australian productivity levels in 56 industries with US industry shares in total hours worked and found little difference with the actual Australian average.

Box 4.2 **Layers of possible explanation**

Putting aside measurement error, possible explanations abound for Australia's productivity lagging that in the United States. These can largely be grouped into four categories.

Proximate factors — In an accounting sense, labour productivity differences are due to the proximate factors of capital intensity and multifactor productivity (MFP). Schreyer (2005) estimated that Australian MFP rose from around 82 per cent of the US level in 1990 to 85 per cent in 2002. The latter figure suggests MFP differences explain three-quarters of the 20 percentage point labour productivity difference he estimated. However, in an economic sense these two factors are inevitably intermingled (multifactor productivity in part drives decisions to invest in capital), so that the decomposition is of most use in raising questions about intermediate determinants.

Intermediate factors — Intermediate factors explain where and how these differences in MFP and capital intensity arise. Potentially important intermediate factors include: technology and know-how — the extent to which technological advances, improved management practices and organisational arrangements are diffused and applied; industry composition — the allocation of resources between high- and low-productivity industries; scale effects — higher levels of MFP that accompany larger-scale production; organisational and production efficiency — the extent to which production activity is 'at the frontier'; and differences in the quality of labour and capital. Many of these intermediate factors are difficult to measure. For this reason, important inputs into these intermediate factors are often studied instead, including investment in R&D and innovation, investment in capital that embodies technological advances; and investment in education, training and skills.

Deeper factors — All the above factors are influenced by fundamental determinants such as resource endowments, geography, culture, social capital, legal systems, industrial relations systems, education systems, tax structures, regulatory burdens, other institutions and policy frameworks and settings. These affect a nation's industry mix, its productive capabilities, its flexibility and adaptiveness, the magnitude of transaction costs, infrastructure requirements and the incentives to engage in productive activity. Some of these factors are amenable to policy changes that could raise Australia's relative productivity level, but many are not.

5 Geographical constraints

Australia is a remote and sparsely settled country with a national market of 20 million people largely fragmented into capital cities separated by vast distances. Australian firms' access to foreign consumers and providers of capital equipment and intermediate goods is limited by long shipping distances. Access to domestic purchasers is either in local markets or requires a large transport component.

It has long been recognised that Australia's geography could play an important role in its economic performance (Blainey 1966; Caves 1984). Isolation from world markets and sparse settlement could reduce Australia's access to the benefits of specialisation, scale and trade and could weaken competitive pressures in some industries.

5.1 Remoteness and sparseness

How large a role do remoteness and sparse settlement play in explaining Australia's productivity gap with the United States?

Recent work at the Australian Treasury (Battersby 2006; Davis and Rahman 2006; Davis and Ewing 2005) has focused on the role played by geographic remoteness. Australia's remoteness from world economic activity may help explain why Australia's productivity gap has stubbornly persisted. It might also help to explain why productivity has lagged further behind in New Zealand, the only economy more geographically remote than Australia. But it is hard to know how large a role remoteness plays. Across the OECD as a whole remoteness does not seem to have severely constrained economic performance (box 5.1) and this suggests other factors are also important.

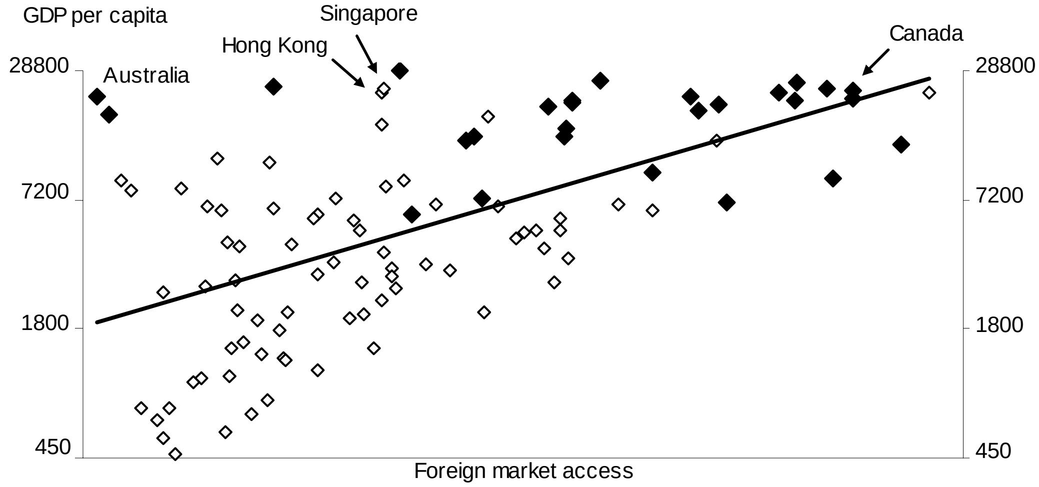
Box 5.1 Remoteness and economic performance

Around the globe, countries that are geographically close to the centres of world economic activity tend to have higher incomes and higher productivity. Two important reasons for this are that firms in these countries pay lower costs for capital equipment and face lower transportation costs in taking their products to large foreign consumer markets. Eaton and Kortum (2001) estimate that one-quarter of the difference in productivity between high-income countries and low-income countries is due to trade barriers that restrict access to capital equipment, such as distance and language differences. Redding and Venables (2004) estimate that one-third of the variation in world income levels results from differences in exporters' foreign market access (where market access is calculated based on distance between countries and contiguity of countries).

However, market access does not appear to explain differences in economic performance among OECD countries (black diamonds in figure 5.1). Australia performs well above the predicted norm, given its degree of remoteness. Australia appears to have almost entirely offset the tyranny of distance, presumably by specialising in the efficient production and delivery of agricultural and mining commodities. One interpretation of these results is that less tangible differences between countries — such as their institutions, policies and culture — may be more important than remoteness. This is illustrated by the strong economic performance of Singapore and Hong Kong despite being a long way from the centres of world economic activity.

Figure 5.1 GDP per capita and foreign market access

1996 USD PPP, logarithmic scales

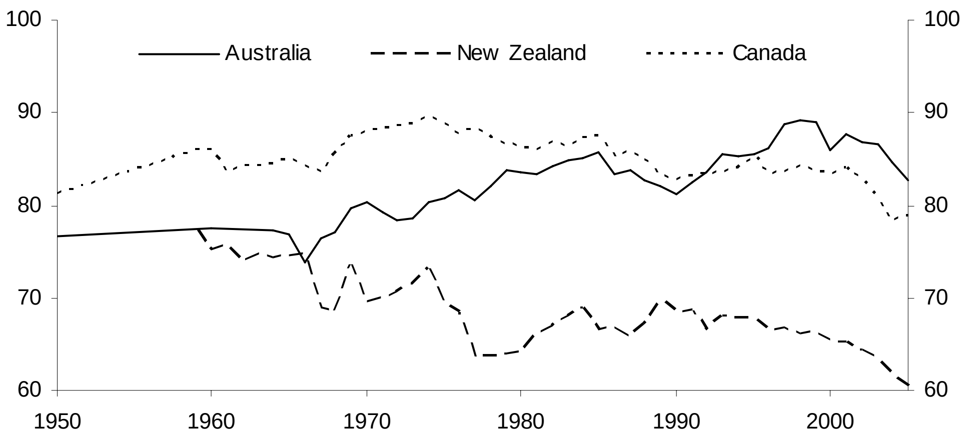


Data source: Foreign market access is an index of transport costs to world markets based on a gravity-trade equation. OECD member countries are represented by black diamonds The regression equation illustrated appears in column 1 of table 2 in Redding and Venables (2004). Across the full sample of 101 countries the relationship is highly statistically significant, with foreign market access explaining 35 per cent of the variation in GDP per capita.

Perhaps something further can be learnt by comparing Australia and Canada. In broad terms, the two countries have maintained a similar relativity with US productivity over the last half century (figure 5.2); and this may indicate similarities in underlying contributors to, and constraints on, catching up to US productivity. Yet Canada does not suffer the same remoteness from world activity as does Australia — in particular, the very large US market is next door.

Figure 5.2 **Labour productivity in Australia, Canada and New Zealand**

US = 100



Data source: The Conference Board and GGDC, (*Total Economy Database*, September 2006).

Canada and Australia are similar in that they are both unusually sparsely settled. Their average population densities are only around 10 per cent that of the United States and little more than 1 per cent that of the United Kingdom (table 5.1).

This overall sparseness of settlement in Australia and Canada is only partly offset by both countries being highly urbanised, with most of their populations and economies concentrated into a small number of cities.[1] Australians tend to live in cities and towns of similar size to Canadians. US cities are noticeably larger; Australia and Canada have no cities to rival the size of New York, Los Angeles and Chicago (figure 5.3). US cities are also greater in number and closer together. These urban patterns reinforce the similarities in settlement between Australia and Canada and their differences with the United States.

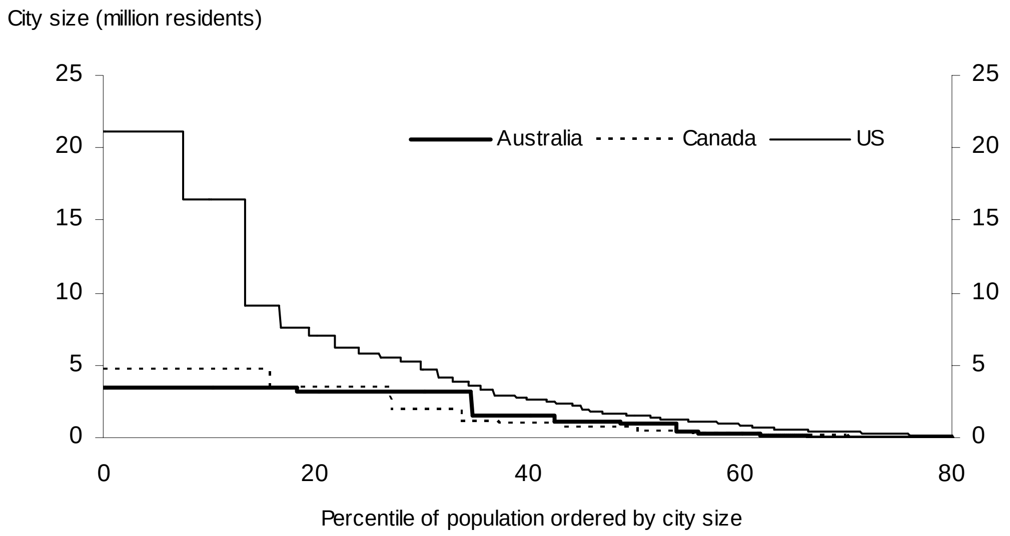
[1] Numerous improvements have been suggested to average population density as an indicator of economic sparsity. For example, Ciccone and Hall (1996) calculate population-weighted average population density based on US county data (normally average population density is implicitly weighted by land area). OECD (2005) calculates population concentration based on differences in regions' shares of a country's population and land area. However, both methods depend sensitively upon the level of aggregation of regions.

Table 5.1 **Infrastructure and population density**

	Population density (People per sq km)	Urbanisation (per cent of population in urban areas)	Roads (km per '000 people)	Rail (km per '000 people)	Gross fixed capital formation 2000 (USD PPP per person): Electricity gas & water	Transport & storage	Commun -ications
Australia	3	87	43	0.5	233	426	299
Canada	3	79	46	1.6	218	328	264
New Zealand	14	86	24	1.0	160	170	324
USA	31	79	23	0.6	248	282	484
France	107	76	15	0.5	151	268	122
Germany	236	75	3	0.4	154	338	146
UK	247	89	7	0.3	143	301	373

Sources: Population density, urbanisation, road and rail line lengths are from World Bank, (*World Development Indicators 2006);* Gross fixed capital formation data are from OECD (*STAN Database)*. All data shown are for the year closest to 2000 for which data are available.

Figure 5.3 **Population distribution by city size in Australia, Canada and the United States**



Data sources: ABS, (*Selected Characteristics for Urban Centres, 2001*, Cat. no. 2016.0); Statistics Canada, (*Population and Dwelling Counts for Census Metropolitan Areas and Census Agglomerations, 2001*, http://www12.statcan.ca/census01); US Census Bureau, (*Metropolitan Areas Ranked by Population: 2000*, http://www.census.gov/population/www/cen2000/phc-t3.html).

Three factors could limit overall productivity performance in sparsely-settled countries:

- greater infrastructure requirements per head of population;
- fewer gains from economies of scale and competitive pressure on producers; and
- less ability to access other agglomeration economies.

Australia and Canada invest in infrastructure proportionately more than other countries. This could reflect higher infrastructure requirements per head of population to connect large sparsely-populated areas outside of cities with roads, energy and communications networks. Proportionately higher costs to establish, maintain and develop infrastructure mean that proportionately more of a nation's resources are diverted from other productive activities.

The size of urban clusters and the distance between them can also affect productivity through economies of scale and its interaction with competition. Firms serving large consumer markets (for example, a single very large city or a number of nearby urban clusters separated by only relatively low transport and co-ordination requirements) may have higher productivity where they can fully exploit economies of scale and because the discipline of competition between firms drives both efficient production and allocation of resources. By contrast, large distances between population centres can fragment some industries into many small, local producers each operating below efficient scale and each insulated from competition with firms in other cities by high transport costs.

The size of urban clusters may also affect productivity through other economies of agglomeration, such as specialised labour markets and knowledge spillovers between firms.

While it is not clear which of these features is most important, in practice productivity tends to be significantly higher in regions with greater population density (Ciccone and Hall 1996), at least outside of the mining sector. Australia's sparse settlement is likely a part of the reason for its productivity being lower than that in the United States in some industries, though at this stage the size of these effects is difficult to quantify (box 5.2).

Box 5.2 Geography and the performance of Australian and US states

Recent work at the Australian Treasury has analysed the role of proximity to the world economy in determining state productivity. Focusing on states can clarify the role of geography because institutions and cultures, which might explain most of the difference in the economic performance of countries (box 5.1), are more similar across states. Battersby (2006) calculates an indicator of proximity that takes account of each state's economy and its distance from other states and countries. Economically 'proximate' states in the US tend to have higher productivity, and Australian states are more remote than most US states. Those results (column 1 of table 5.2) suggested 11 percentage points of the productivity gap between Australia and the United States is due to proximity.

The analysis is extended here to consider other aspects of a state's geography that affect its economic performance (column 2 of table 5.2). The degree of urbanisation of a state may be particularly important. Regression analysis suggests states in which 1 percentage point more of the population live in urban areas have 0.5 per cent higher labour productivity, though differences in definitions of urbanisation make it hard to estimate how much Australia's higher urbanisation adds to its productivity overall. Average population density, in itself, appears to play a less significant role. That is, it seems most of the productivity benefits from higher population density result from close interaction of firms within, and distribution networks between, urban areas.

Proximity to world economic activity still appears to play an important role in this analysis, as in Battersby (2006). However, its importance is lessened by taking into account each state's internal geography. The results in column 2 of table 5.2 suggest 7 percentage points of Australia's productivity gap with the US might be due to proximity with most of the gap remaining unexplained. More generally, this highlights that the effects of geography on productivity are difficult to quantify.

Table 5.2 Some geographic determinants of labour productivity

Regression results; dependent variable is the log of labour productivity

	(1) Using proximity only		*(2) Using all geographic variables*	
Independent variable	*Coefficient*	*Std. error*	*Coefficient*	*Std. error*
Constant	3.739 ***	(0.284)	3.120 ***	(0.280)
Log capital/labour ratio	0.030	(0.059)	0.070	(0.058)
Log human capital	0.186	(0.119)	0.095	(0.111)
Proximity	0.027 ***	(0.007)	0.016 **	(0.006)
Urbanisation			0.005 ***	(0.001)
Population density			0.062	(0.041)
Australia dummy variable	-0.034	(0.073)	-0.135 *	(0.079)
R^2	0.43		0.59	
n	59		59	

Sources: Labour productivity, physical and human capital and proximity data are from Battersby (2006). Population density (1000 people per sq km) and urbanisation (per cent of population in urban areas) are from US Bureau of the Census and Australian Bureau of Statistics. ***, ** and * indicate significance at 1, 5 and 10 per cent levels.

5.2 Mapping to industry gaps

The effects of geography on productivity differ between industries. As a general proposition, sparse settlement does not act as a constraint on agricultural and mining productivity.

The constraining effects of sparse settlement on productivity would be perhaps most clearly evident in manufacturing. Much of the manufacturing sector operates on a smaller scale in Australia than in the United States. Firms employing fewer than 10 people play little role in US manufacturing, but account for almost one-quarter of the Australian industry (table 5.3). Since small manufacturers have much lower labour productivity (less than half that of large firms on average), the smaller average firm size in Australia explains part of the difference in average manufacturing productivity between the two countries.[2]

However, size of firms is by no means the only factor. Table 5.3 also shows that among groups of similarly sized firms, US productivity levels in manufacturing are around twice the Australian productivity levels (two and a half times in the case of firms with less than 10 employees).

Table 5.3 **Size of manufacturers in Australia and the United States**

	Share of manufacturing employment (per cent)		*Labour productivity ('000 USD PPP per employed person)*	
Firm employment	*Australia*	*United States*	*Australia*	*United States*
0 to 9 persons	23.4	4.2	34	82
10 to 49 persons	22.2	15.8	44	87
50 to 499 persons	26.5	49.7	62	114
500 or more persons	27.9	30.4	87	179

Sources: ABS, (*Manufacturing Industry, 2002-03*, Cat. no. 8221.0); US Census Bureau, (*General Summary, 2002 Economic Census, Manufacturing, Subject Series)*.

2 More detailed analysis reveals that size mix is also a factor in the productivity differences within manufacturing sub-industries.

Geography is also likely to affect the efficiency of transport and distribution of goods. Integration of US manufacturing supply chains and the delivery of goods to retailers is achieved through a distribution network centred on a small number of hubs (including Los Angeles, New York, San Francisco, Dallas, Chicago and Atlanta), with each hub serving a market as large or larger than the entire Australian economy. In Australia, the long distances between major cities and the sparse settlement of the population tend to fragment distribution networks and add to transport requirements and costs.[3]

Further work is needed to understand better the constraints geography imposes — for example through lower competition, weaker knowledge flows, higher transport and communication costs or less factor mobility — and how the constraints translate specifically into industry productivity gaps.

5.3 Possible effects on future performance

Though economic remoteness and sparseness can only change gradually, some of their constraining effects on productivity may be mitigated over time. Technological advances have reduced the real costs of transport and, through the development of faster ships and cheaper air transport, the time that goods spend in transit. Improvements in communication technology have also been dramatic and are continuing. The increased flow and lower cost of information via the internet is an important example. Effective coordination over long distances is increasingly commonplace. International trade has increased dramatically.

While technology may reduce transport and communication costs in future, it is unlikely to fully eliminate the economic disadvantages of distance. These costs explain only part of the effect of distance on trade. International trade is moving towards products for which language, culture, local preferences and, perhaps, trust play a more important role.[4]

Further, while falling transport costs increase global trade flows this could improve productivity in large economies as much or more than in small, remote economies. The outcome depends upon the role of local economies of scale, resulting from the scale of domestic demand, linkages with suppliers of capital and specialised labour markets (Fujita, Krugman and Venables 1999). In some industries, lower transport

[3] That said, a higher proportion of long-haul transport on 'thick' inter-city routes may enable some efficiencies in the freight task.

[4] For example, even though the internet makes long-distance communication almost free, people disproportionately visit sites in nearby countries, particularly for cultural products (such as music) and financial transactions (Blum and Goldfarb 2006).

costs will allow firms in large countries to exploit their existing cost advantages to meet an even-larger share of world demand. The effects of globalisation on relative productivity trends will differ from industry to industry, and may not improve Australia's relative productivity in aggregate.[5]

5.4 Summary and implications

This chapter has argued that sparse settlement fragments the Australian economy, limiting the benefits available from specialisation, economies of scale and competition between producers. While these geographic disadvantages cannot be fully overcome, the consequences of market fragmentation can be ameliorated through effective freight transport policy that encourages both efficiency within freight modes — road, rail, coastal shipping, air — and appropriate choices between modes. There may be scope to improve policy in some of these areas (PC 2005b; PC 2006a).

5 The movie industry provides one example (Leamer 2006). The process of globalisation has lowered cultural 'transport costs' and is spreading common (English) language skills abroad. While this provides an opportunity for Australian film producers to reach the large US and foreign markets, it is possible that the dominant effect will be that Hollywood's existing economies of scale will drive many local film producers out of their local markets.

6 Education

Since the accumulation of human capital is a key long-term determinant of productivity, differences between countries in education and skill may help to explain their productivity gaps. This chapter compares educational attainment and skill in Australia and the United States. It explores: how education differences translate into industry productivity gaps; how education relativities between the two countries will evolve in the future; and how the differences affect productivity gaps now and in the future.

6.1 Differences in education and skill

Education and skill play a key role in economic growth. Skill contributes to productivity directly by improving the capabilities of workers. Economic theory and empirical evidence also point to an indirect link whereby the accumulation and application of knowledge underpins technological advance and innovation (Romer 1990; Benhabib and Spiegel 1994).

However, the attributes of talent, education and skill embodied in the workforce are very difficult to measure.

One way to get a handle on the direct contribution of education and skill on productivity is to use the measures of the contribution of labour composition to productivity growth constructed by the statistical agencies in both Australia and the US. These measures show, on the basis of certain assumptions, how much a shift in the skill composition of hours worked contributes to labour productivity growth. Composition is defined across groups that are delineated by workforce experience, gender and educational attainment.[1] A shift in hours worked toward groups with higher skill and productivity will make a positive contribution to labour productivity growth.

[1] The hours worked by the identified groups are then aggregated with weights based on relative wages under the assumption that wages reflect the marginal productivity of individual workers. It is also assumed that the marginal product of labour is proportional to its average product.

Trends in labour composition have been quite different in the two countries. On average, labour composition appears to have contributed around 0.1 percentage points more to annual productivity growth in the United States than in Australia (table 6.1).

Table 6.1 **Changes in labour composition**

Market sector (Australia) and private business sector (United States)[a] (percentage points per year)

	Contribution of labour composition to annual growth in labour input		*Contribution to difference in annual productivity growth*
Period	*Australia*	*United States*	*Australia less United States*
1988-89 to 1993-94	0.6	0.7	-0.1
1993-94 to 1998-99	0.3	0.4	-0.1
1998-99 to 2003-04	0.4	0.6	-0.1

[a] United States data are for 1989 to 1994, 1994 to 1999 and 1999 to 2004. Contributions to productivity growth reflect the Australian elasticity of output to labour input.

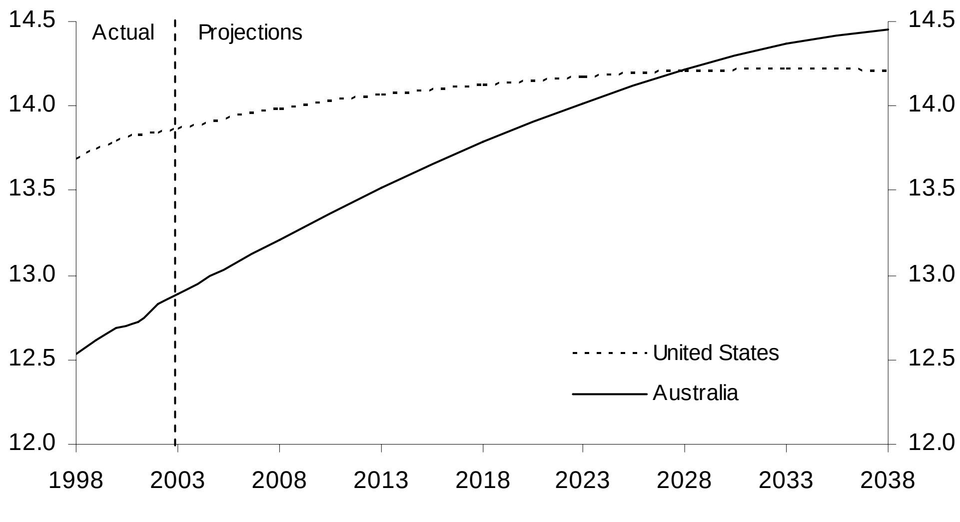
Sources: Authors' calculations based on ABS, (*Australian System of National Accounts, 2004-05*, Cat. no. 5204.0); BLS, (*Changes in the Composition of Labor for BLS Multifactor Productivity Measures*, 2004).

While this could be interpreted as revealing a more rapid accumulation of human capital and a higher contribution of skill to productivity growth in the United States, a closer examination suggests that may not necessarily be valid. For two reasons, similar improvements in educational attainment will appear to contribute more to labour productivity growth in the United States than in Australia.[2] First, Australian estimates of labour composition change reflect a narrower range of educational attainment (no post-school qualifications, vocational qualifications, diploma and bachelor's degree) than estimates in the United States (where measured attainment ranges from primary to post-graduate education). Second, the private return to skill in terms of higher wages appears to be larger in the United States. This partly reflects the role that policies — such as Australia's more centralised wage determination process and more generous unemployment benefits — have played in compressing Australia's wage distribution, rather than necessarily reflecting productivity differences.

[2] For example, for the average male an increase in education from the lowest reported education category to the highest was estimated to raise his wage by 57 per cent in Australia, but by 175 per cent in the United States in the early 1990s (Reilly, Milne and Zhao 2005; BLS 1993).

An alternative approach is to compare average years of education in school, vocational institutions and universities. To draw any conclusion on how differences in years of education might affect productivity, it is necessary to assume that the effect that time spent in education has on productivity is the same in both countries. This ignores potentially important differences in the quality of teaching, the distribution of education (for example the number of doctorates versus the number of early school leavers), the field of study and the needs of local industries. On this basis, Australia appears to have an educational attainment gap with the United States. While the average Australian of working age (taken to be 25 to 64 years for this purpose) has undertaken around 12.9 years of education, their counterpart in the United States has undertaken 13.9 years of education (figure 6.1). However, this gap has been closing rapidly in recent years. Between 1998 and 2003, average length of education rose by almost 0.4 years in Australia, but by less than 0.2 years in the United States.

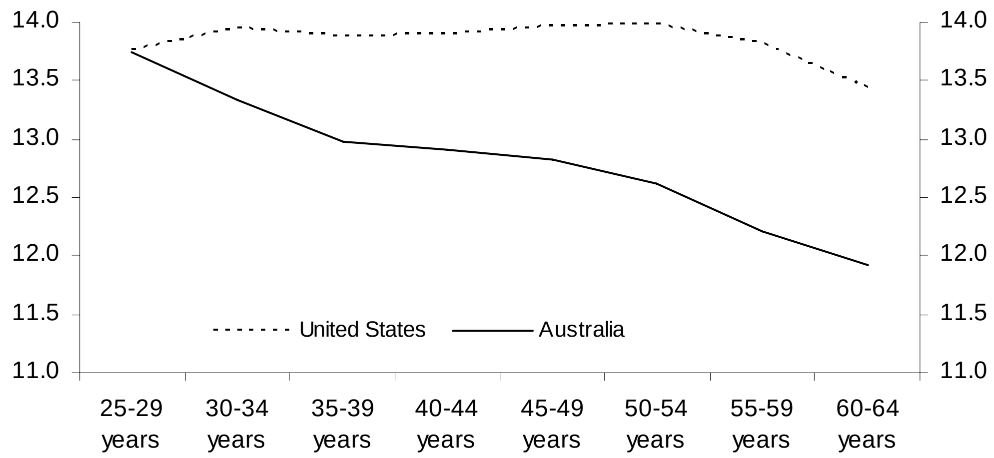
Figure 6.1 **Historical and projected average years of schooling, Australia and the United States**



Data source: Authors' calculations based on OECD (*Labour Force Statistics);* PC (2005); US Census Bureau (2004) U.S. Interim Projections by Age, Sex, Race, and Hispanic Origin, http://www.census.gov/ipc/).

This difference in education levels among working-age populations largely reflects historical experience. Higher education and completion of upper secondary education both became widespread much earlier in the United States. Whereas completion of secondary education became common in Australia through the 1970s and 1980s, as early as 1940 the majority of young Americans were high-school graduates (Goldin 1998). The duration of formal education of recent cohorts now differs little between the two countries. The estimates in this paper suggest that Australians aged 25 to 29 years have undertaken essentially the same length of education as their peers in the United States on average (figure 6.2). In fact, their lifetime education might even come to exceed that of their US counterparts. Available data suggest that Australians of that age will undertake one additional year of formal education by the time they leave the traditional working age group, compared to 0.8 of a year in the United States.

Figure 6.2 **Average years of schooling by age, Australia and the United States, 2003**



Data source: Authors' calculations based on OECD (*Labour Force Statistics*).

Maturation of the young cohorts, which have similar education levels across the two countries, will tend to reduce the difference in the average educational attainment of the working age populations. In Australia, as the less educated older cohorts retire out of the labour force and are replaced by younger and more educated cohorts, average educational attainment will rise. This effect will be much more muted in the United States. As a result, without changes in policies or preferences, education levels among the working age population in Australia are projected to match those in the United States by around 2030 (appendix C discusses the construction of these projections).[3] To the extent that the longer average schooling of the US workforce has been a source of their productivity advantage in the past, the productivity gap seems likely to narrow in the future, as discussed in the following section.

[3] This analysis, based on educational attainment to 2003, ignores the possible future effects of more recent policy changes in many Australian States to extend compulsory schooling (discussed in Lattimore 2007).

6.2 Mapping to industries

At the industry level, there is a complex relationship between increasing educational attainment and productivity growth. Some industries are better able to make use of skilled labour and are more likely to see their productivity increase. The available data make it difficult to see clearly where the current education gaps are and hence where the productivity effects may be strongest. Table 6.2 shows attainment of bachelor's degrees (or higher qualifications) among employed people in Australia and the United States. These data suggest Australian employees have, on average, significantly lower educational attainment than their peers in the US in a large number of industries, including manufacturing, wholesale and retail trade, communications, finance and insurance, property and business services and hospitality. The increase in the supply of skilled labour can also affect wage and price relativities across industries and lead to changes in industry structure.

Table 6.2 **Educational attainment of employed people by industry, 2003[a]**

US industry	*Bachelor's degree or higher*	*Australian industry*	*Bachelor's degree or higher*
	%		%
Agricultural, forestry, fishing & hunting	13	Agriculture, forestry & fishing	8
Mining	22	Mining	18
Construction	11	Construction	6
Manufacturing	22	Manufacturing	13
Wholesale & retail trade	19	Wholesale trade	13
		Retail trade	8
Transportation & utilities	16	Electricity, gas & water supply	21
		Transport & storage	9
Information	42	Communication services	16
Financial activities	40	Finance & insurance	33
Professional & business services	44	Property & business services	34
Educational & health services	46	Education	60
		Health & community services	37
Leisure & hospitality	16	Accommodation, cafes & restaurants	8
Public administration	39	Government administration & defence	34
Other services	19	Cultural & recreational services	26
		Personal & other services	15
Total	**30**	**Total**	**21**

[a] Data are for all employed persons aged 18 to 64 in the US and aged 15 to 64 in Australia.

Sources: ABS, (*Education and Work, May 2003*, Cat. no. 6227.0); US Census Bureau, (*Current Population Survey, Educational Attainment in the United States 2003, Detailed Tables)*.

The flipside of this comparison is that differences in industry structure between countries potentially imply different demand for certain types of skills. The Australian market may demand proportionately more mining engineers and truck drivers, while the US market may demand proportionately more biochemists and actors. This may explain differences in both the nature and level of educational attainment in the two countries, though exploration of these differences is outside the scope of the current paper.

6.3 Future relevance and effects

Over the coming decades the average educational attainment of Australian workers will likely approach that of US workers in the absence of changes in policy, preferences or economic structure in both countries. To the extent that education differences currently affect relative productivity performance, the narrowing of the gap can be expected to raise Australia's relative productivity.[4] Education affects productivity in two different ways. It can have an immediate effect on productivity *levels* in different countries because it affects the productivity of individual workers and therefore the average productivity of the workforce. There can also be an indirect effect on productivity *growth* rates if differences in education affect an economy's rate of innovation and adoption of foreign technologies, and this could open up a gap between countries' productivity levels over time.

Education raises the *level* of productivity because workers are more capable. Day and Dowrick (2004) suggested a rise of one year in the average educational attainment of the workforce is accompanied by an increase in the level of labour productivity of around 8 per cent.[5]

If this is correct, then the projected 1.1 year increase in schooling in Australia will raise productivity by 8.4 per cent, while the 0.3 year increase in schooling in the United States will raise productivity there by 2.0 per cent over the next 20 years. This would narrow Australia's productivity gap with the United States by around 5.3 percentage points over the 20 years to 2026 and raise Australian productivity

4 Increasing educational attainment might also raise participation rates, although these effects are likely to vary widely depending upon the groups targeted and the type of education undertaken (Lattimore 2007). Simply increasing the compulsory duration of schooling is not guaranteed to raise participation rates, nor necessarily productivity.

5 This is broadly consistent with evidence that among Australian twins a difference in education of one year results in a difference in average full-time incomes of between 4.5 and 8.3 per cent (Miller, Mulvey and Martin 1995) and that across the OECD an additional year of schooling tends to raise aggregate output by around 6 per cent (Bassanini and Scarpetta 2001).

growth above that in the United States by an average 0.3 percentage points per year, with a larger effect in the first decade.[6]

A more educated workforce may also improve an economy's long-run productivity *growth* through innovation and knowledge diffusion, though the magnitude of this effect is less clear. In the near-term the level of education will be higher in the United States than in Australia. Day and Dowrick (2004), based on a review of the limited literature, assume that an additional year of schooling raises annual economic growth by 0.3 percentage points per year. If this were correct, then the difference in levels of education would widen Australia's productivity gap with the US by around 2.1 percentage points over the 20 years to 2026. However, there is a great deal of uncertainty surrounding these estimates. The role played by education is likely very different for countries at the international technological frontier, than for countries like Australia for whom productivity improvement will result primarily from absorbing technology developed overseas. Australia historically had much lower educational attainment than the US (see for example Bassanini and Scarpetta 2001), yet its productivity has not historically fallen behind relative to the US as this assumed relationship would imply.

On balance, it seems likely that the effect that Australia's rapidly-improving education profile will have on the *level* of productivity compared to the United States will exceed any possible 'long-run growth effect' stemming from Australia's temporarily lower level of educational attainment (figure 6.3).

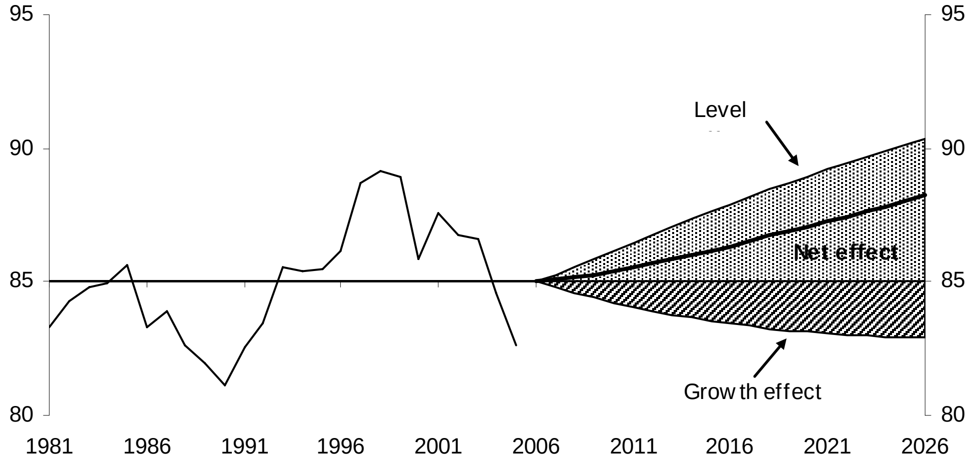
6.4 Summary and implications

Education plays a role in explaining productivity differences between countries. Australian workers currently have significantly shorter average duration of education than their peers in the United States. However, this gap in attainment is closing rapidly and, on current trends, may close completely in the next two decades or so. Standard estimates of the relationship between education and productivity suggest that the improvement in Australian education might close around 3 percentage points, and perhaps as much as 5 percentage points, of the productivity gap with the United States.

6 Projections start from the assumption that Australia's labour productivity will be around 85 per cent of the US level in 2006. After projected changes in education, Australia's productivity level would be 0.85*1.084/1.020=90.3 per cent of the US level.

Figure 6.3 **Possible effects of education on Australia's relative productivity**[a]

US = 100



[a] Projections are illustrated starting from 85 per cent of the US productivity level in 2006.

Data source: Authors' calculations.

These projections raise policy questions but do not provide policy answers. Education raises productivity but at significant expense, not least through the forgone earnings of students and the employment of additional educators. Would Australians be better off if they invested more or less of their resources in education than their peers in the United States? The current analysis considered education only at the most aggregate level — in terms of average years of schooling — and assumed the benefits from studying longer were the same in both countries. An answer to this question would need to take account of the costs of education, the nature of current differences in education profiles and the different opportunities in the two economies for educated workers to make use of their particular skills. It is likely that there remain some target groups for which improvement in the quality of education could underpin higher Australian productivity and workforce participation (PC 2006b).

7 Concluding remarks

This chapter draws on the earlier material to address the central question posed in the title of the paper. What scope is there for Australia to match US productivity growth, or to do even better, and thereby catch up to the US level of productivity?

7.1 The scope for catch-up

The paper has highlighted that international comparisons of productivity — especially productivity levels — at the aggregate level can be useful, but also need to be treated with caution. Whilst differences between countries can indeed reflect differences in 'performance', they can also reflect factors such as stage of development, distorting labour market arrangements and comparative advantage. Because of the different economic circumstances that countries face, catch-up to the leader is not inexorable or necessarily even feasible.

Three industry-level scenarios

With the complexities and ambiguities inherent in aggregate comparisons, international comparisons are more meaningfully made, and the scope for catch-up is more meaningfully considered, at an industry level.

The scope for industry catch-up is explored in regard to the six industries identified in chapter 4 as having the largest productivity gaps with the United States. If the aggregate gap is to close, most of the catch-up would have to occur within these six industries. Very large gaps remain in wholesale and retail trade and in manufacturing, with Australian labour productivity (according to the estimates in table 4.1) roughly half of US levels in each of these industries. There have been improvements in utilities, communications and finance, but sizeable gaps appear to remain.

The implications for aggregate catch-up are then evaluated in simple fashion. The exercise is designed to identify a rough order of magnitude only. Limitations in the comparative data and limitations in the method used[1] mean that projection of a specific magnitude of aggregate catch-up is neither possible nor claimed. As an example of the limitations, the assessment overlooks future changes in industry composition, which would arise with inter-industry differences in productivity growth.[2]

The implications of three illustrative scenarios are explored.

- Productivity growth in Australian and US industries is projected forward at rates observed historically.
- Australia approaches US productivity levels in individual industries at the rates exhibited in the past, on average, by high-income OECD countries.
- Australian industries approach US levels at a rate that is rapid according to both historical and international standards.

Extrapolation of US and Australian industry productivity growth

The first scenario extrapolates productivity growth rates in Australia and the United States, based on trends over the past couple of decades. The scenario therefore takes only limited account of the possibility that US productivity will continue to be on a stronger trajectory.

In the past, US productivity growth has outpaced Australian productivity growth in manufacturing and the distributive trades. Australia's productivity growth has been stronger in communications, utilities and finance.

On this basis, Australia's productivity gap with the United States is projected to *widen* over 20 years by between 3 and 4 percentage points (table 7.1). This is because Australia does better in the industries that are smaller. Manufacturing, retail and wholesale trade together account for 31 per cent of total hours worked in Australia, while the three industries in which Australia has historically been outperforming the US account for less than 7 per cent of hours worked. There is catch-up in the utilities, communications and finance, but their combined positive effect on narrowing the aggregate productivity gap does not compensate for the

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[1] Other effects, which could either assist or frustrate catch-up, are omitted from the analysis. Productivity growth in excluded industries is assumed the same in both countries and the effects of differences in the relative sizes of two excluded industries, agriculture are mining, are discussed separately below.

[2] Each industry is assumed to maintain a constant share of economy-wide output. A much more sophisticated, general equilibrium framework would be needed to allow for the effects that inter-industry differences in productivity growth would have on industry mix through relative prices and relative growth in demand.

widening effect of slippage either in manufacturing on its own or in wholesale trade on its own.

Table 7.1 **Scenario 1 — Extrapolation of past trends, 1979 to 2003**

Industry	*Trend growth rate relative to the US*[a]	*Australian productivity (per cent of US level)*			*Contribution to whole economy productivity relative to the US*
	% per year	1979	2003	2026	Percentage points
Manufacturing	-1.4	83	60	44	-2.6
Electricity, gas & water	1.8	41	53	80	0.1
Wholesale trade	-2.2	55	43	26	-1.7
Retail trade	-0.2	60	63	61	-0.3
Communications	3.9	41	82	198	0.4
Finance & insurance	1.0	62	67	84	0.5
Sum of contributions					-3.6

[a] Trend rates of growth are calculated from regression of log productivity levels on a trend. This method takes into account the pattern of growth throughout the period and so provides a better gauge of underlying trends than the average growth rates between the endpoints of the period shown in Table 4.1.

Source: As for Table 4.1

Industry catch-up at international average rates

An alternative approach is to view Australia's productivity outlook within a convergence framework. For the purpose of projection, it is assumed that US productivity growth in each industry will be the same as the historical industry trend rates since 1979, averaged across Australia and the United States.

International experience shows that the speed of productivity convergence varies between industries (chapter 3). The tendency for countries behind the international frontier to catch up is stronger in utilities, communications and finance — the same industries in which Australia has historically closed productivity gaps with the United States — than it is within manufacturing, wholesale and retail trade — the same industries in which Australian productivity gaps have historically been maintained or widened. If these historical rates of catch-up were achieved by Australian industries, the aggregate productivity gap with the United States would narrow by around 3 percentage points according to the projections (table 7.2). Despite slower rates of catch-up, the former three industries again have the largest effect on the productivity gap.

Table 7.2 **Scenario 2 — Catch-up at international historical rates, 1979 to 2003**

Industry	*Speed of convergence*	*Australian productivity (per cent of US level)*			*Contribution to whole economy productivity relative to the US*
	% per year	1979	2003	2026	Percentage points
Manufacturing[a]	-1.0	83	60	69	0.9
Electricity, gas & water	-1.8	41	53	68	0.1
Wholesale trade	-0.9	55	43	54	0.5
Retail trade	-0.9	60	63	70	0.8
Communications	-1.8	41	82	88	0.1
Finance & insurance	-2.9	62	67	83	0.4
Sum of contributions					2.8

[a] Speed of convergence based on analysis that excludes Ireland.

Source: As for table 4.1.

Fast catch-up

The third scenario involves a fast rate of catch-up. Historically, productivity convergence within industries has rarely exceeded a rate of 3 per cent per year among OECD countries. This could be considered to be an ambitious rate, in that past international experience has been boosted by some non-technological factors operating in Europe but not Australia (chapter 3).

Nevertheless, if Australian productivity were to converge towards levels in the United States in all six industries at that pace, Australia's aggregate productivity gap would close between 5 and 6 percentage points under the parameters of the projections (table 7.3).

Table 7.3 **Scenario 3 — Catch-up at fastest international and historical rate**

Industry	*Speed of convergence*	*Australian productivity (per cent of US level)*			*Contribution to whole economy productivity relative to the US*
	% per year	1979	2003	2026	Percentage points
Manufacturing	-3.0	83	60	80	1.8
Electricity, gas & water	-3.0	41	53	76	0.1
Wholesale trade	-3.0	55	43	72	1.0
Retail trade	-3.0	60	63	82	1.9
Communications	-3.0	41	82	91	0.1
Finance & insurance	-3.0	62	67	83	0.5
Sum of contributions					5.5

Source: As for table 4.1.

Is aggregate catch-up likely?

The scenarios are intended to cover the bounds of what might be possible in the future, based on what has happened in the past. They span a range: from replication of the long-run historical average rates of productivity growth in the two countries; to the fastest rate of catch-up observed among OECD countries historically.

Even with the acknowledged limitations of data and method, the rough projections provide sufficient basis to indicate that:

- even under very optimistic assumptions regarding catch-up in the six industries, Australia will not catch up fully to the US aggregate level of productivity over coming decades;
- under pessimistic assumptions, Australia could fall further behind at the aggregate level; but
- closing at least part of the aggregate productivity gap with the United States does appear feasible.

What outcome is likely or possible?

Individual industry sectors (included in the scenarios)

Australia’s manufacturing productivity growth is likely to continue to lag behind that of the United States. Productivity growth in US manufacturing has accelerated and continues to grow strongly because of technological advances in durable goods manufacture and, most specifically within that area, in ICT manufacture. Australian manufacturers' productivity will not be similarly boosted because comparative advantage does not favour Australia's engagement in this activity in any substantial way.

The issue is whether productivity growth in Australian manufacturing will deviate from its 'slow and steady' trend (table 7.1). Australian manufacturing productivity, outside of ICT manufacturing, has grown at the same pace as in the US over the past couple of decades. In the future there may be scope for some catch-up in these parts of manufacturing but history and international experience suggests this would at best be gradual and is unlikely to fully counteract the substantial ICT-based gains (of economy-wide significance) that the US generates.[3]

Historical and international evidence suggests that catch-up within wholesale and retail trade is typically weak. Gaps between Europe and the US have been attributed to policy differences, such as zoning regulations that limit exploitation of retail economies of scale through 'big-box' formats in Europe (Gordon, 2004). Australia has generated strong productivity growth in wholesale and retail over recent years, through ICT-based innovation. The gains in wholesale at least, through transformation from storage-based to logistics operations, have been stronger than in Europe. It is probable that substantial room for gains in both wholesaling and retailing remain. There may not be the same constraints of zoning regulation in Australia, but this may be an area in which the geography of sparse settlement imposes some ultimate constraints on catch-up. While it is conceivable that catch-up within these two industries could close almost 3 percentage points of the aggregate gap (table 7.3), for these reasons a contribution of a little more than 1 percentage point appears more likely (table 7.2).

It seems reasonable to speculate that further catch-up is possible in utilities, communications and finance. The dynamic effects of increased competition in these industries, facilitated by past policy reforms, should continue to deliver dividends over coming years. Further reforms in some areas could also contribute (PC 2006b). Continued productivity catch-up within these industries could close 0.6 to 0.7 percentage points of the gap (tables 7.2 and 7.3).[4]

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3 Greater competition may stimulate further productivity gains in Australia's manufacturing. Reductions in tariffs have exposed Australia's manufacturing sector to more international competition than would have otherwise been the case. However, past currency depreciations may have insulated the sector. The currency has been stronger in recent years and competition has intensified in both finished and intermediate goods, particularly from China. International competition is likely more important for Australian productivity, given the high level of domestic competition within the large US market.

4 Even in the case of fast catch-up (scenario 3), these projections envisage productivity relativities rising to levels achieved in electricity, gas and water supply in the late 1990s, and below those achieved in communications in the late 1990s.

It is worth emphasising that the scenarios cover the industries that are the source of the stronger productivity growth trajectory in the United States. The US productivity acceleration since the mid-1990s has been ICT-based, both in the manufacture of ICT and in the heavy and innovative use of ICT in services industries such as wholesale, retail and finance. Australia will not match the extent or significance of productivity growth in ICT manufacturing. However, the same services industries have had productivity accelerations in Australia based on more intensive and innovative use of ICT. The view taken is that they will at least keep up with US productivity growth and have scope for some catch-up.

Overall, the scenarios point to the potential for productivity growth within five industries — retail, wholesale, communications, utilities and finance — to close roughly 2 percentage points of Australia's productivity gap with the US. The manufacturing industry's contribution to closing the gap is less clear, but is unlikely to be positive — it conceivably may widen the aggregate productivity gap by more than 2 percentage points (table 7.1) but catch-up outside of ICT manufacturing may partly or even mostly offset this.

Other industries

Catch-up possibilities will also be affected by what happens in industries apart from the six considered. For the projections, it is implicitly assumed that the two countries will have broadly similar rates of productivity growth in these other industries. The available data suggest that this assumption is broadly reasonable.

Differences in the relative size of industries, outside of the six examined, may also help Australia to catch up. For example, agriculture and mining play a larger role in the Australian economy and, since productivity growth has typically been above-average in these industries, this difference will tend to reduce the aggregate productivity gap over time — an effect that is not accounted for in the projections. This difference in industry structure may narrow the productivity gap another couple of percentage points over the next two of decades.[5]

The effect of constraints

No additional allowance is made for the effects of the constraints of geography or education. They are taken as being reflected in the past and in the future rates of industry catch-up. The effects of these constraints are not 'additive' in relation to the industry catch-up possibilities that have been considered.

[5] Were commodity prices to remain at current high levels this may also lead to an increase in the size of Australia's mining industry, which may raise Australia's overall productivity level.

A cross-check on magnitudes is possible however, at least in regard to education Projections of average years of schooling and standard assumptions regarding the marginal effects of schooling on productivity suggest that, without changes in policies or preferences, rising average education in Australia could close around 3 percentage points — and perhaps as much as 5 percentage points — of the gap over the next couple of decades. This magnitude tends to confirm the order of the projected effects based on industry catch-up.

In conclusion

In sum, complete catch-up does not seem feasible. Some aggregate catch-up, based on stronger productivity growth in Australia than in the United States, does appear feasible. Together, the analysis of industry productivity trends and industry structure point to the potential for Australia to close 2 to 4 percentage points of the productivity gap with the US over the next two decades or so. That is not to say that this catch-up will come automatically, but it is an order of magnitude to which Australia could reasonably aspire.

7.2 Broad policy implications

It is not an objective of this paper to identify ways in which governments could facilitate Australia's productivity catch-up. Detailed assessments and policy recommendations for improving productivity have been made in numerous Productivity Commission reports. Nevertheless, a few very broad comments based on the analysis undertaken here can be made.

The US aggregate level of productivity should not be regarded as a realistic or feasible target. First, the US aggregate level is essentially an arbitrary target as far as what is sensible and feasible for Australia to achieve. An achievable level of Australian productivity, relative to the US level, may even change as fundamental economic circumstances change.

Second, any policy approach should focus on productivity performance at a micro level, recognising that productivity catch-up in the aggregate will result from production decisions taken within industries and firms. This paper has demonstrated that opportunities for frontier shifts and catch-up come at an industry level. Firm-level research has shown the importance of individual firm behaviour within industries — the fact that there is considerable heterogeneity across firms in their innovation strategies as technology 'leaders' and 'followers'. Much of the aggregate productivity improvement over time comes from new ideas, new business models, new production activities and new firms.

Broadly speaking, government policy will be most supportive of productivity catch-up by putting in place the framework that underpins sound private choices within firms and industries. This means focusing on economic incentives (such as competition), capabilities (such as skills and research and other infrastructure) and flexibility (the scope for firms to adapt, experiment and to implement new business models).[6] The scope for particular industries to compete and prosper on a world stage will ebb and flow with changing technology and global economic trends. Just as the recent development of the Chinese economy has presented Australia with opportunities to benefit from its natural resources while increasing competitive pressure on some labour intensive industries, future changes will continually shift Australia's opportunities. In the face of these uncertainties, policies that would seek to increase or maintain the size of any particular production activity today are likely to decrease overall Australian welfare tomorrow. It is better for governments to ensure that the business environment generally is conducive to innovative behaviour.[7]

The paper has pointed out that Australia's productivity gap in manufacturing is likely to widen, because of the substantial presence of ICT manufacture in the United States and its virtual absence in Australia. This does not mean that Australia would be better off if it started producing microprocessors. The issue of whether Australia has a comparative advantage to produce with market success in this area is crucial. Furthermore, if productivity continues to improve in overseas ICT manufacturing and competition between foreign producers continues to lower the prices of the electronic equipment that Australia imports, Australia will continue to benefit from terms-of-trade gains and from productivity gains in the economy generally associated with diffusion and innovative use of ICT.

The paper has also examined in greater depth two issues that may help to explain why Australia has had a persistent productivity gap with the United States — geography and education.

Geography appears to be an ongoing limiting factor for Australia. Obviously, governments cannot do much about physical geography. But they can ensure that: Australia is properly integrated nationally and internationally through its transport and communications infrastructure[8]; other infrastructure such as utilities are geared toward national as well as regional production; investment and employment decisions are not adversely distorted by regional incentives; and production

[6] See PC (2005b).

[7] For a recent study of science and innovation in Australia, see PC (2006c).

[8] See PC (2006a).

activities are not unduly fragmented around the country by unnecessary and inconsistent regulation[9].

On education, no clear policy implications come out of the analysis presented here. The comparisons presented in this paper were based on average years of schooling. Whilst Australia has been below the United States on this measure and the empirical evidence suggests that this would have contributed to Australia's productivity gap, there has been little difference between the two countries over the past couple of decades on the duration of schooling among the younger ages who predominantly populate the education system. As these younger cohorts continue to age, the average years of schooling among Australian workers will move toward the US average. This is not to say, however, that there could not be improvements in the delivery of education that would help to promote Australia's productivity catch-up.

[9] See Regulation Taskforce (2006).

A The industry dimension of US productivity

This appendix provides detail on past US productivity trends at the industry level.

A.1 Stages of productivity growth

Productivity growth in the US economy has not been even. Table A.1 identifies three main stages in long-term productivity growth since 1950.

The turning points that define the boundaries between these periods were identified as follows. First, short-term volatility in productivity was taken out of consideration by measuring underlying productivity growth as the average annual rate of growth from peak to peak in successive productivity cycles. (The ABS uses this approach to measure trends in Australian productivity growth.) Productivity peaks were identified as local maximums above a smoothed series that was formed from a 5-year moving average of the original series. The rationale for this approach is that the resulting estimates control for cycle effects because they are based on productivity growth between the same point in cycles.

With this method, the turning point for the 1990s productivity acceleration is 1992. The year commonly pinpointed as bringing the upturn is 1995. However, since 1995 was a productivity trough, productivity growth from 1995 tends to be an overstated trough-to-peak measure. Productivity growth from 1992, on the other hand, can be defended as a peak-to-peak measure that quarantines the effects of short-term volatility.

Table A.1 **Major stages of US labour productivity growth**

Average annual percentage change

	1950 to 1973	*1973 to 1992*	*1992 to 2005*
Business sector	3.0	1.6	2.4
Non-farm business sector	2.6	1.5	2.4
Manufacturing	2.6	2.6	4.2
Durable goods	2.5	2.8	5.6
Non-durable goods	2.9	2.1	2.7

Source: Authors’ calculations based on BLS data, (http://www.bls.gov/lpc/home.htm, accessed 30 July 2006).

A.2 Sectoral and industry shifts

Agriculture

The farm sector’s contribution to productivity growth was greatest in the 1950s and 1960s. Table A.1 shows that there was an additional 0.4 of a percentage point of productivity growth in the business sector, compared with the non-farm business sector, over 1950 to 1973. Agriculture made a much smaller contribution in each of the following periods, as indicated by the smaller differences between rates of growth in the business sector and the non-farm business sector. Other estimates suggest that agricultural labour productivity grew by 5.3 per cent per annum in the first period, before slowing to 3.4 per cent per year after 1973.[1]

Manufacturing

The manufacturing sector maintained labour productivity growth at an annual average of 2.6 per cent through both the first period (the 1950s and 1960s) and the ‘slowdown’ period (from 1973 to the early 1990s). Within the sector, productivity growth slowed in non-durables manufacture, as happened at the aggregate level, but productivity growth *accelerated* in durables manufacture (table A.1). Manufacturing productivity growth accelerated sharply to 4.2 per cent a year in the 1990s, principally due a doubling in durables productivity growth, compared with the previous period.

1 The BLS does not publish farm sector productivity and these data are sourced from the US Department of Agriculture, (http://www.ers.usda.gov/Data/AgProductivity/US_tfp02.XLS). The decline in agriculture’s share of the economy, which was most pronounced in the first period, would also have affected aggregate productivity growth.

Estimates of multifactor productivity (MFP) growth, which provide a more direct indicator of trends in technology and efficiency than estimates of labour productivity[2], are also available for the manufacturing sector. They show a slightly different pattern: very strong growth (1.4 per cent a year) in the first period, a marked slowdown (to 0.7 per cent a year) after 1973 and then the acceleration from the late 1980s and through the 1990s (table A.2).[3]

There was even more diversity in technology shifts, in terms of timing and extent, at a more detailed industry level (table A.2). There was strong productivity growth within chemical product and transport equipment manufacturing in the 1950s and 1960s, but this subsequently faded. Manufacturing of electronic and other electrical equipment showed strong MFP growth in all periods and especially so in the 1990s. The industrial machinery and computer equipment industry joined as a major contributor in the 1970s and 1980s and was a leading performer in the 1990s. The strength shown in the last two mentioned industries is an indication of advances in information and communications technology (ICT) in the production of microprocessors, computers and communications devices (table A.2; see also Triplett and Bosworth 2004).

Whilst MFP growth tailed off in non-durables, it increased in durables (table A.2). In the earliest period, MFP growth was reasonably strong in both durables and non-durables manufacturing. But the pace of MFP growth in durables manufacturing fell sharply after 1973 and fell further after 1988, such that the level of MFP actually declined over the last 13 years. In durables manufacturing, on the other hand, the slowdown after 1973 was slight and was overshadowed by a much larger acceleration after 1988.

[2] Technological advance in the production of a good or service will show up as an MFP gain in the producing industry. If the advance is embodied in capital equipment and is correctly measured, its purchase by a using industry will show up as capital deepening in the using industry. Whilst both capital deepening and MFP are sources of labour productivity growth, the MFP measure better indicates the industry source of technological advances.

[3] These data show a different set of productivity growth cycles than shown in aggregate labour productivity: peaks in manufacturing MFP that were also turning points in underlying productivity growth occurred in 1950, 1973 and 1988. The first two peaks are common to both series. Manufacturing MFP accelerated after 1988, whereas business sector labour productivity accelerated after 1992. The year 2001 is the endpoint of the manufacturing MFP series and not necessarily a peak

Table A.2 **Average annual multifactor productivity growth in manufacturing industries**

Percentage points

	Multifactor productivity growth			*Contributions to manufacturing MFP growth*[a]		
	1950 to 1973	*1973 to 1988*	*1988 to 2001*	*1950 to 1973*	*1973 to 1988*	*1988 to 2001*
Manufacturing	1.35	0.73	1.13	1.35	0.73	1.13
Non-durable goods	1.19	0.26	-0.33	0.64	0.14	-0.17
Food & kindred products	0.6	0.7	-0.7	0.1	0.1	-0.1
Textile mill products	2.5	2.8	1.6	0.1	0.1	0.0
Apparel & related products	0.7	1.3	1.1	0.0	0.1	0.0
Paper & allied products	1.2	-0.2	-0.2	0.1	0.0	0.0
Printing & publishing	0.6	-0.7	-1.3	0.0	0.0	-0.1
Chemicals & allied products	2.3	-0.4	-0.4	0.2	0.0	0.0
Petroleum refining	0.8	-0.2	0.3	0.1	0.0	0.0
Rubber & miscellaneous plastics products	0.7	0.1	1.1	0.0	0.0	0.1
Durable goods	1.28	1.12	2.36	0.69	0.59	1.30
Lumber & wood products	1.6	2.0	-1.3	0.0	0.1	0.0
Furniture & fixtures	0.5	0.7	0.6	0.0	0.0	0.0
Stone, clay, glass & concrete products	0.8	0.4	0.0	0.0	0.0	0.0
Primary metal industries	0.1	-0.7	0.4	0.0	-0.1	0.0
Fabricated metal products	0.5	0.2	-0.1	0.0	0.0	0.0
Industrial machinery & computer equipment	0.8	2.3	4.3	0.1	0.3	0.6
Electronic & other electrical equipment	2.0	2.3	6.1	0.2	0.2	0.6
Transportation equipment	1.1	0.2	0.5	0.2	0.0	0.1
Instruments	1.6	1.5	0.9	0.1	0.1	0.1
Miscellaneous manufacturing	1.5	0.7	0.2	0.0	0.0	0.0

[a] Contributions to aggregate manufacturing MFP growth are estimated by applying Domar weights to log changes in annual sub-industry-level MFP indexes.

Source: Authors' calculations based on BLS (*Detailed MFP Statistics*, http://www.bls.gov/mfp/home.htm, accessed 8 August 2006).

A.3 Services

A range of service sectors have also contributed to the acceleration in business sector labour productivity since 1992. The acceleration in manufacturing labour productivity growth after 1992 contributed around 0.4 of a percentage point to the aggregate productivity acceleration.[4] Applying this figure to those in table A.1

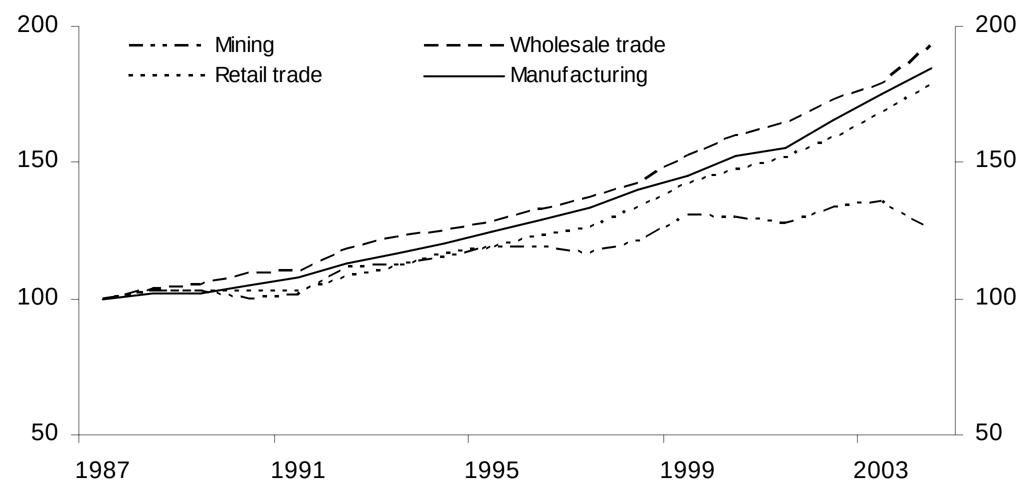
[4] Manufacturing productivity accelerated by 1.6 percentage points and represented roughly 22 per cent of business sector value added (Triplett and Bosworth 2004, table A-5).

leaves another 0.4 of a percentage point acceleration due to non-manufacturing sectors.

Identifying the role of individual service industries in this acceleration is more difficult than for manufacturing. As labour productivity data from the US Bureau of Labour Statistics (BLS) extend back to only 1987, contributions to the acceleration cannot be calculated. Nevertheless, it is clear that services sectors have been major sources of productivity growth. In particular, labour productivity in wholesale trade and in retail trade has grown at a similar pace to that in manufacturing since the late 1980s (figure A.1). Together, these two industries are as large as manufacturing (around 20 per cent of business-sector value added) and so made a large contribution to aggregate productivity growth since 1992. While productivity growth has been strongest within various electrical and electronic wholesaling and retailing industries (table A.3), productivity growth outside of these sub-industries has also been robust (Manser 2005). Table A.3 also highlights strong productivity growth in parts of the utilities, transport, information and professional and business services sectors. The strong productivity growth in services industries was broadly spread.

Figure A.1 **Labour productivity in major sectors, United States**

Index, 1987 = 100



Data source: BLS.

Table A.3 **Labour productivity growth in various United States industries, 1992 to 2004**

Average annual growth rate, per cent

NAICS code	*Industry*	
21	Mining	1.0
31-33	Manufacturing	4.2
334	Computer and electronic product manufacturing	15.5
3341	Computer and peripheral equipment manufacturing	28.5
3344	Semiconductor and other electronic component manufacturing	23.1
3342	Communications equipment manufacturing	7.5
22	Utilities	
2211	Electric power generation, transmission and distribution	3.1
2212	Natural gas distribution	3.8
42	Wholesale trade	4.2
4234	Professional and commercial equipment and supplies wholesalers	16.2
4236	Electrical and electronic goods merchant wholesalers	11.7
44,45	Retail trade	4.3
443	Electronics and appliance stores	15.3
4541	Electronic shopping and mail-order houses	15.4
48-49	Transport and warehousing	
481	Air transportation	3.7
482111	Line-haul railroads	4.9
48412	General freight trucking, long-distance	1.0
51	Information	
5112	Software publishers	11.7
5171	Wired telecommunications carriers	5.1
5172	Wireless telecommunications carriers	12.0
52	Finance and insurance	
52211	Commercial banking	2.2

Source: BLS

Strong labour productivity growth reflected an improvement in efficiency, and not just an increase in capital intensity due to investment in ICT (though the latter is also clearly apparent). Triplett and Bosworth (2004) developed MFP estimates for over 50 industries for the period from 1987 and found significant accelerations in wholesale trade, retail trade, finance & insurance and health services. Individually, each of these service industries accounted for more of the acceleration in aggregate MFP growth pre- and post-1995 than did manufacturing.

This broad acceleration in service industry MFP was initially a surprise. The long-standing presumption was that MFP gains in service industries were less likely than in goods producing industries (Baumol 1967). The innovative use of ICT has played a strong part. Much like electrification in the early 20th century, ICT enables users to raise MFP by introducing their own innovations in products (for example, new information-hungry financial derivates) and processes (for example, just-in-time supply chains). The discipline of competition, both from domestic and, increasingly, foreign peers, was the key motivating force behind these productivity-enhancing innovations (McKinsey Global Institute 2001). The flexibility to introduce new organisational arrangements has also been found to be important (OECD 2004a).

B Comparisons of industry productivity levels

This appendix outlines the technical construction and interpretation of comparable industry labour productivity data in Australia and the United States.

B.1 Labour productivity levels

International aggregate productivity comparisons provide an indication of the relative economic wellbeing of different countries. Closer examination at the industry level provides an indication of the areas in which an economy is behind the productivity frontier and so, in some cases, it may have room to catch up.

Analysis of productivity *growth* rates across countries is relatively straightforward. Statistical offices in each country publish data on industry output growth. These reflect the value of output (gross value added) and estimates of price changes over time within each industry. The methodology used to collect these price data can vary between countries (for example, the United States changed to measuring the price of ICT goods using hedonic price indexes before most other countries) and, at times, these differences can create problems for comparisons. But on the whole the quality of data on price changes is quite good.

Analysis of industry productivity *levels* is not nearly so simple. The highest hurdle is the shortage of international price level data. Spatial differences in prices are inherently difficult to measure because precisely the same goods and services are rarely available in two countries. Errors in international price data may contribute to differences between countries in measured productivity levels and the smaller baskets of comparable goods and services at the industry level make industry price data even less reliable.

Data reliability issues aside, data availability is also a problem. The ideal comparison would use industry-level price data to adjust output in different countries for differences in prices within that industry in every year. However, these data are not available in every year but, at best, in a single year. Consistent estimates of productivity levels in other years are then obtained using the relatively-accurate productivity growth rate data for the two countries. Measurement problems mean that the resulting estimates of relative productivity levels will always vary somewhat depending upon the base year used for deflation. This is a problem known as spatial-temporal inconsistency.

The accuracy of productivity level estimates hinges on the accuracy of the international price level data. In the absence of price level data for particular industries, some early work used GDP PPP data to deflate industry-level productivity (for example, Dollar and Wolff 1988, Bernard and Jones 1996). These are clearly preferred to market exchange rate data which are very volatile in the short term and ignore the prices of non-traded goods and services. The problem with this method, however, is that relative prices vary markedly between industries. This means that estimates of industry relative productivity levels constructed using GDP PPPs will be incorrect. The spatial-temporal inconsistency problem also means that in some industries estimates of relative productivity levels will vary so widely depending upon the choice of base year as to be uninformative (box B.1).

The way around this problem is to use price level data for each industry. However, historically industry PPP data have been available only for a small number of industries. The current paper applies new industry PPPs for gross output developed by Timmer, Ypma and van Ark (2006) and Timmer and Ypma (2006).

Using gross output PPPs to deflate gross value added is the 'single deflation' method for estimating real gross value added.[1] Implicitly this assumes that intermediate input prices vary between industries in line with industry output prices. This will generally produce incorrect measures of real gross value added and the error will be larger in industries where intermediate inputs are a larger share of costs or where relative intermediate input and output measures differ widely. For example, if an industry's gross output PPP was above the economy-wide average PPP, but the prices of intermediate inputs into an industry were close to the economy-wide average PPP, then an appropriate gross value added PPP would be larger than the gross output PPP. That is, in this particular example, using a gross output PPP to deflate gross value added would be incorrect, but preferable to using a whole economy PPP. Double deflation would be preferable were input and output prices able to be measured with reasonable certainty. More accurate analysis may be possible with the release of the EU KLEMS database in March 2007.

[1] This is, for example, the method used to compare productivity levels in retail and wholesale trade in Timmer and Ypma (2006).

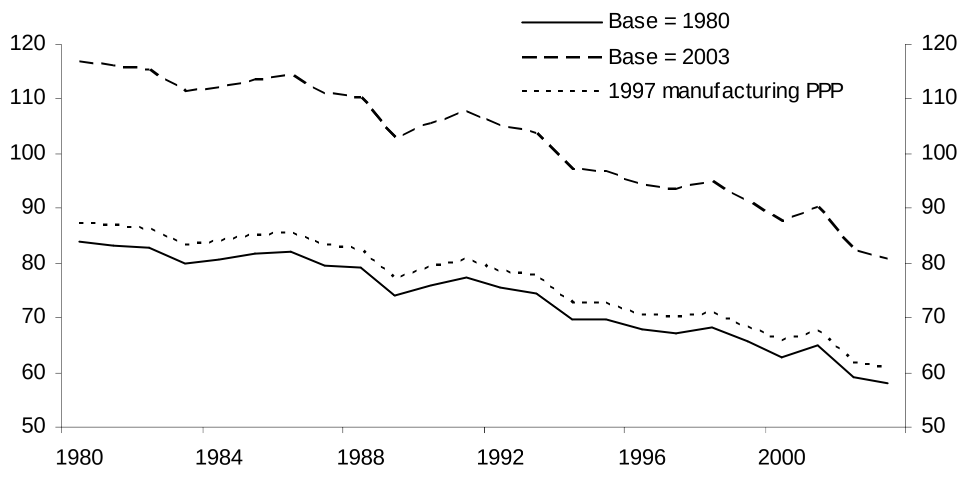
Box B.1 **Problems with prices**

The manufacturing industry provides an example of the difficulty in calculating industry productivity levels using economy-wide price data. An approximate way to compare productivity levels is to use GDP PPP data to deflate manufacturing productivity for a particular 'base' year. This assumes that relative prices in manufacturing are the same as relative prices elsewhere in the economies in that year, which is unlikely to be true. These relative productivity levels can then be extrapolated to other years by comparing productivity growth rates within manufacturing.

When using GDP PPP data, the spatial-temporal inconsistency in the productivity level estimates is severe. Manufacturing prices evolve very differently in different countries and in particular have grown much more rapidly in Australia than in the United States. In part this is due to compositional differences. A much larger share of the manufacturing industry in the US produces ICT-based products than in Australia, and their prices have trended downwards. These trends mean that estimates of productivity levels depend upon an arbitrary choice of base years. Choosing an earlier base year results in higher estimates of Australia's relative manufacturing prices in each year and so lower estimates of Australia's relative manufacturing productivity.

These problems are illustrated in figure B.1. Choosing 1980 as the base year produces an estimate of Australian manufacturing productivity of around 67 per cent of the US level in 1997, while choosing 2003 as the base year produces an estimate of 93 per cent. Without industry-level price data there would be no reason to prefer one of these estimates. However, the best estimates available of manufacturing prices suggest that actual productivity levels are closer to the smaller of these estimates.

Figure B.1 **Estimates of Australian manufacturing labour productivity**
Per cent of US level



Data source: Authors' calculations based on GGDC, (*60-Industry Database*, September 2006); OECD (*PPPs for GDP*), and manufacturing gross output PPPs from Timmer, Ypma and van Ark (2006)).

Table B.1 **Estimates of Australian industry productivity levels, 1997**

Per cent of US level

	Using gross output PPP data	*Using 1997 GDP PPP data*
Agriculture	61	65
Mining	217	188
Manufacturing	70	80
Electricity, gas & water	75	75
Construction	105	94
Wholesale trade		55
Retail trade	61	79
Accommodation, cafes & restaurants		99
Transport & storage	91	94
Communications		98
Personal and other services	72	74
Finance & insurance	89	79
Property & business services		105
Public administration, defence, education & health	122	86

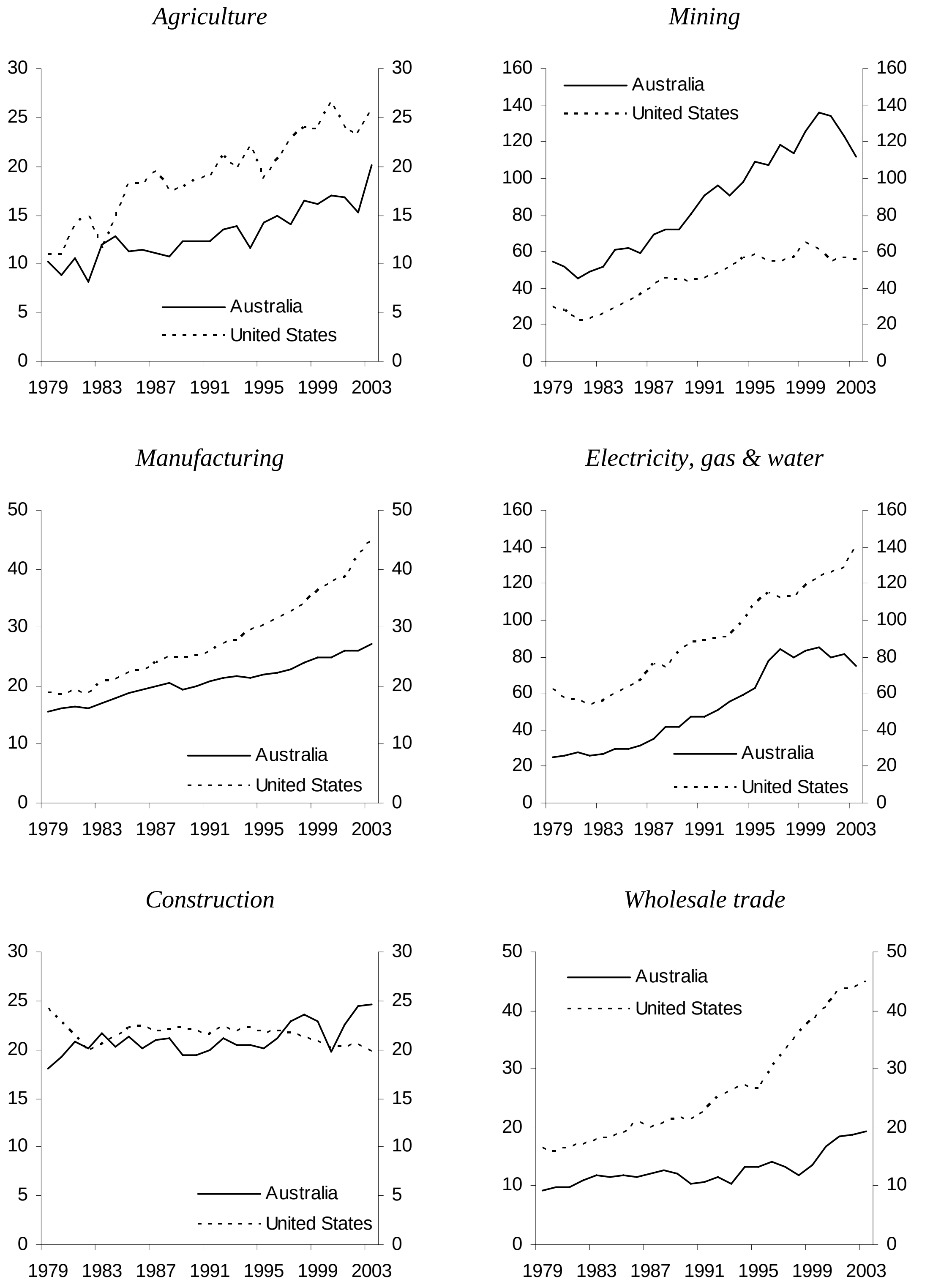
Source: Authors' calculations based on current price output, industry temporal price deflators and hours worked from GGDC, (*60-Industry Database*, September 2006). The 1997 GDP PPP is as published by the OECD. Gross output PPP data for 1997 are from Timmer, Ypma and van Ark (2006).

Table B.1 summarises the estimates of Australian labour productivity levels compared to the US for 1997 obtained from using GDP PPP data and industry gross output PPP data. In the main, the same stories are supported by the two methods. Australian productivity in that year appears to be well below levels in the US in manufacturing, electricity, gas & water, wholesale trade, retail trade, agriculture and, perhaps, finance & insurance. On the other hand, Australian productivity in that year appeared to be much higher in mining than in the United States, and broadly similar in construction, transport and storage, communications, and public services.

Figure B.2 illustrates productivity trends in selected industries in Australia and the United States. These are calculated using the industry-grouping gross output PPP data (and more detailed industry gross output PPP data for wholesale and retail trade). These trends are discussed in chapter 4.

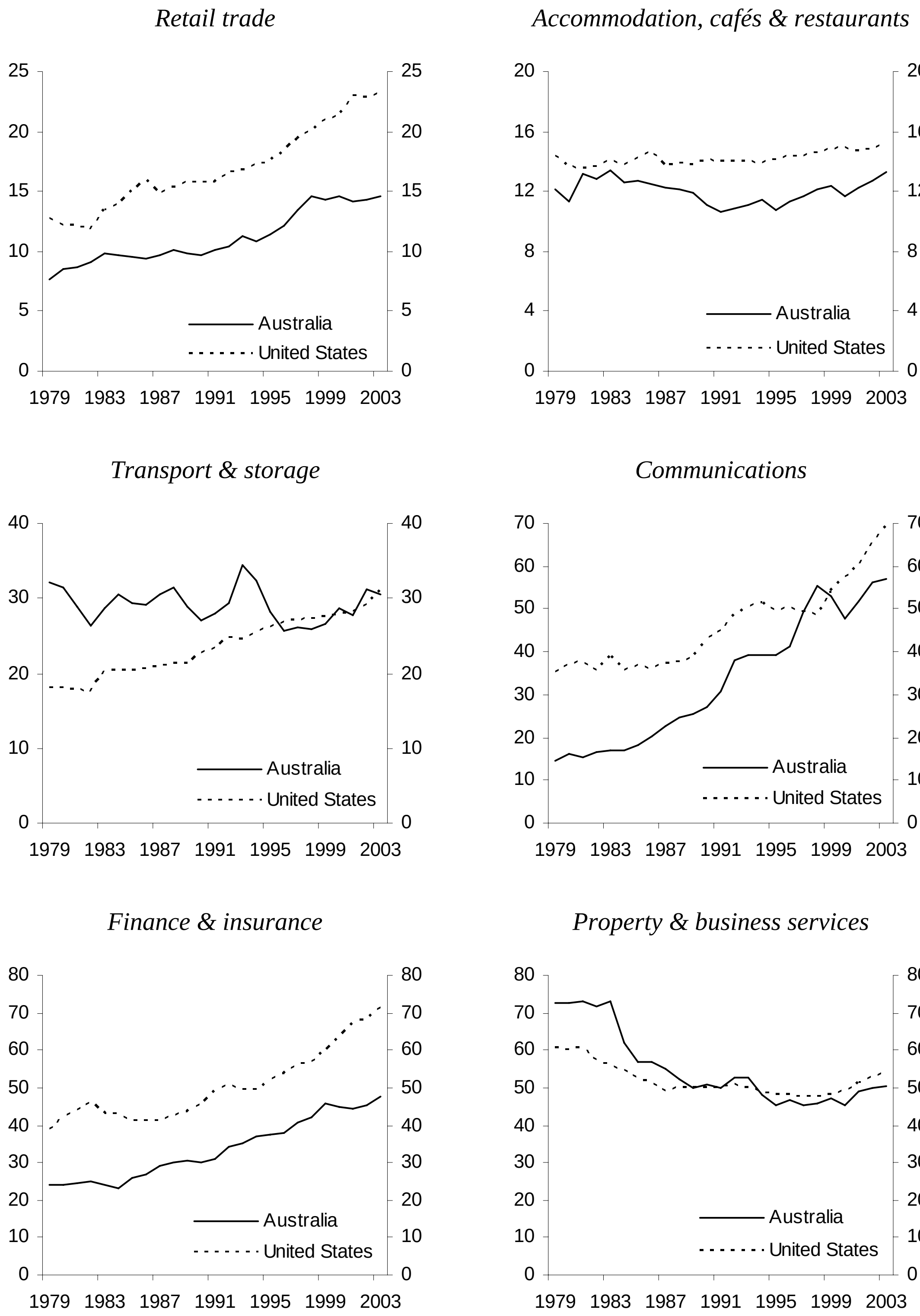
Figure B.2 **Labour productivity in Australia and the United States**

1997 USD PPP per hour worked



(Continued on next page)

Figure B.2 **(continued)**



Data source: As for table B.1.

B.2 Industry contributions to whole economy productivity differences

Productivity differences within industries are of most interest because they help to explain differences in aggregate productivity levels between countries. Differences in aggregate productivity arise for two reasons. First, some countries have higher productivity within some industries. For example, Australia's mining productivity is higher than that in the US and so this industry adds to Australia's productivity relative to the US. Second, industry structure may play a role. Industries with typically much higher (or much lower) productivity than the economy-wide average play a larger part in some economies than in others. Mining is one industry where productivity is much higher than the economy-wide average and the mining industry plays a larger part in the local economy than in the US, which adds to Australia's productivity relative to the US.

It is possible to decompose differences in productivity levels into contributions from differences in productivity levels within industries and differences in industry structure. This decomposition uses the same index number formulae as is used for calculating the contributions to growth in productivity over time within a country. In particular, the Tornqvist index for aggregating growth in the volume of industry output, given output in current price terms in each industry and industry price deflators is as follows

$$\ln\left(\frac{Y^t}{Y^{t-1}}\right) = \sum_i \bar{s}_i^{PY} \ln\left(\frac{PY_i^t}{PY_i^{t-1}}\right) - \bar{s}_i^{PY} \ln\left(\frac{P_i^t}{P_i^{t-1}}\right)$$

where PY_i is current price value added in industry i, P_i is the temporal industry price deflator, and $\bar{s}_i^{PY}$ is the two-period average of that industry's share in total value added.

The bilateral comparison of output follows by replacing the time indicators t and $t-1$ with country indicators A and U, which are used to indicate Australia and the United States.

$$\ln\left(\frac{Y^A}{Y^U}\right) = \sum_i \bar{s}_i^{PY} \ln\left(\frac{PY_i^A}{PY_i^U}\right) - \bar{s}_i^{PY} \ln\left(\frac{P_i^A}{P_i^U}\right)$$

Here PY_i is current price local currency value added in industry i, P_i is the spatial industry price deflator (including currency conversion), and $\bar{s}_i^{PY}$ is the two-country average of that industry's share in total value added. It is convenient to use the same bilateral Tornqvist index to aggregate labour input,

$$\ln\left(\frac{L^A}{L^U}\right) = \sum_i \bar{s}_i^L \ln\left(\frac{L_i^A}{L_i^U}\right)$$

where L denotes hours worked, $\bar{s}_i^L$ represents the two-country average of industry i's share in total hours worked.

Total economy relative labour productivity can then be defined as relative output divided by relative hours worked. It is straightforward to obtain an expression for total economy relative labour productivity in terms of relative labour productivity within each industry.

$$\ln\left(\frac{LP^A}{LP^U}\right) = \sum_i \bar{s}_i^{PY} \ln\left(\frac{LP_i^A}{LP_i^U}\right) + \sum_i \left(\bar{s}_i^{PY} - \bar{s}_i^L\right)\ln\left(\frac{L_i^A}{L_i^U}\right)$$

This decomposition shows that the aggregate productivity gap between country A and U is a combination of two terms. The first term is a weighted sum of the industry-specific productivity gaps, with the weights being the industry's share in total output averaged over the two countries. Interpretation of the second term requires further manipulation. It is useful first to notice that when aggregated over all industries the value-added shares and the hours worked shares both sum to one. One result of this is that

$$\sum_i (\bar{s}_i^{PY} - \bar{s}_i^L)\ln\left(\frac{L^A}{L^U}\right) = 0$$

This leads to an alternative decomposition given below.

$$\ln\left(\frac{LP^A}{LP^U}\right) = \sum_i \bar{s}_i^{PY} \ln\left(\frac{LP_i^A}{LP_i^U}\right) + \sum_i (\bar{s}_i^{PY} - \bar{s}_i^L)\ln\left(\frac{L_i^A / L^A}{L_i^U / L^U}\right)$$

The second term can now be interpreted as the effect that differences between the two economies in industry structure have on the productivity gap. If an industry typically has high labour productivity (for example, mining) then the average share of output in that industry will exceed the average share of hours worked. Hence, the second term shows that if country A has a larger share of its labour in industries with higher than average productivity then it will have higher economy-wide productivity as a result.

This decomposition of the productivity gap between Australia and the US is shown in table B.2. Some care is required in interpreting the table. The productivity gap is measured as 100 times the log of the relative productivity level between Australia and the US. For small gaps this approximates the percentage difference in productivity levels. For example, the table shows an aggregate productivity gap across all industries of -15.5, implying that Australian productivity is 14.4 per cent lower than in the United States.

Table B.2 **Industry contributions to the aggregate productivity gap between Australia and the United States, 1997**

	Output share	*Industry productivity gap*	*Weighted industry-productivity gap*	*Difference between output and labour shares*	*Relative labour shares*	*Weighted relative labour shares*	*Industry's overall contribution to the aggregate productivity gap*
	$\bar{s}_i^{PY}$	$100*\ln\left(\frac{LP_i^A}{LP_i^U}\right)$		$\bar{s}_i^{PY} - \bar{s}_i^{L}$	$100*\ln\left(\frac{L_i^A / L^A}{L_i^U / L^U}\right)$		
	(1)	(2)	(3)=(1)*(2)	(4)	(5)	(6)=(4)*(5)	(7)=(3)+(6)
Agriculture	0.02	-49	-1.2	-0.02	113	-1.7	-2.9
Mining	0.03	77	2.3	0.02	66	1.3	3.6
Manufacturing	0.16	-36	-5.7	0.01	-14	-0.1	-5.8
EGW	0.02	-29	-0.7	0.02	41	0.7	0.0
Construction	0.05	5	0.3	-0.02	24	-0.4	-0.1
Wholesale, retail & hospitality	0.15	-49	-7.2	-0.08	10	-0.8	-7.9
Transport & communications	0.07	-9	-0.7	0.01	29	0.4	-0.3
Financial & business services	0.28	-12	-3.3	0.12	-18	-2.1	-5.4
Public services	0.18	20	3.5	-0.04	-30	1.3	4.7
Other services	0.03	-33	-1.1	-0.02	13	-0.3	-1.4
Total			-13.7			-1.8	-15.5

Source: Productivity levels within broad industry groups are deflated using gross output PPP data. See the data sources for table B.1.

The main message from this decomposition is that differences in industry structure (column 6 in table B.2) explain only a small fraction of the overall productivity differences between Australia and the United States. Australia has a larger share of employment in some lower-than-average productivity industries such as agriculture and construction, but also has a larger share of employment in some higher-than-average industries such as mining and electricity, gas & water supply.

Rather, almost the entire aggregate productivity gap is a result of productivity gaps within particular industries (column 3 in table B.2). In this respect the largest contributors are wholesale trade, retail trade and hospitality, and manufacturing.

C Projections of educational attainment

This appendix outlines the basis for the projections of educational attainment presented in the text. The projections were constructed to illustrate likely future levels of educational attainment among the working age population (aged 25 to 64 years) if current trends continue without any changes in government policies or student preferences.

Educational attainment data by broad class were converted to average years of schooling in Australia and the United States using the theoretical duration of schooling data in table C.1. For these comparisons to be economically meaningful requires that a year of schooling provides the same human capital development in both countries. It could be argued that this is unlikely to be true, however adjusting schooling duration for education quality is intractable. While international standardised tests suggests that Australian 15 year old students are significantly more literate and numerate than their peers in the United States (OECD 2004b), this may reflect duration of schooling (Australian students start school younger) or sample selection (most Australian students had the option to leave school at age 15, while the compulsory schooling age ranged from 16 to 18 years in the United States) rather than differences in education quality.

Table C.1 **Assumed duration to complete attained levels of education, 2003**

	Australia		*United States*	
	Cumulative duration	*Share of population aged 25-64 years*	*Cumulative duration*	*Share of population aged 25-64 years*
	years	per cent	years	per cent
Primary and lower secondary	10	38	9	13
Upper secondary (vocational)	12	11	13 (both upper secondary)	49 (both upper secondary)
Upper secondary (general)	13.5	20		
Tertiary (non-university)	15	11	15	9
Tertiary (university)	17	20	17	29
All levels	12.9	100	13.9	100

Sources: Population shares are from OECD (*Labour Market Statistics by Educational Attainment, http://www1.oecd.org/scripts/cde/*). Australian theoretical cumulative durations are from unpublished OECD data, while United States durations reflect the authors' adjustments to improve consistency with Australian data.

The projections assume that future cohorts reach age 25 to 29 years with the same educational attainment as the 2003 cohort of that age. Below this age, a large proportion of the population is still completing full-time education and educational attainment data are difficult to interpret.

However, schooling does not stop at this age. Changes in educational attainment of cohorts between 1998 and 2003 were used to estimate the likely future schooling undertaken by older cohorts. For example, table C.2 shows that in 1998 the Australian cohort aged 25 to 29 years had 13.1 years of schooling. By 2003, this cohort, now aged 30 to 34 years, had 13.3 years of schooling, suggesting they had undertaken around 0.3 years of further schooling during this period. The projections assume that the same level of education will be undertaken by future cohorts between those ages, and this produces a plausible projection profile in the near-term. However, these projections may overstate the growth in Australian education levels in the long-term if the current enrolment of older Australians is in part to make up for the lower level of education they received while young.

Table C.2 **Educational attainment and apparent education undertaken between 1998 and 2003**

	Australia			*United States*		
Cohort age in 1998	*Years of schooling in 1998*	*Years of schooling in 2003*	*Apparent education undertaken*	*Years of schooling in 1998*	*Years of schooling in 2003*	*Apparent education undertaken*
			years			years
25-29	13.1	13.3	0.3	13.8	13.9	0.2
30-34	12.7	13.0	0.3	13.8	13.9	0.1
35-39	12.7	12.9	0.3	13.7	13.9	0.2
40-44	12.7	12.8	0.2	13.8	14.0	0.1
45-49	12.5	12.6	0.1	13.9	14.0	0.1
50-54	12.3	12.2	-0.1	13.7	13.8	0.1
55-59	12.0	11.9	0.0	13.4	13.4	0.1

Source: As for table C.1.

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