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Australia's 1990s Productivity Surge and its Determinants

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Abstract:

Australia's annual rate of productivity growth surged by over 1 percentage point in the 1990s. Three major possible explanations have been put forward: the use of more advanced information and communications technologies (ICTs), increases in workforce skills, and policy reforms designed in large part to drive and enable productivity improvement. The paper examines the contribution of ICTs in a productivity growth accounting framework. The USA is used as a comparator, given the similarities between the two countries in ICT uptake in the 1990s. Particular attention is paid to removing cyclical influences in the growth accounting, a factor overlooked in most other studies. The use of ICTs is found to have only small effect at the aggregate level, accounting for 1 or 2 tenths of percentage point of productivity acceleration. This aggregate view, however, masks larger productivity linkages at the industry and firm level, depending on the extent to which ICTs enable complementary product and process innovations. The contributions of skills and policy reforms are also briefly assessed from evidence provided by other studies. The most plausible explanation is that the bulk of Australia's productivity acceleration is due to much-delayed catch-up that has been facilitated by policy reforms focusing on competition, openness and flexibility.

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Productivity Commission website: www.pc.gov.au

Productivity page: www.pc.gov.au/work/productivity/index.html

1. Introduction

Australia's growth performance since the early 1990s has been exceptional. Over the last 10 years, annual GDP growth averaged just under 4 per cent — a performance not seen since the 1960s and early 1970s. Strong growth even persisted in the midst of the 1997 Asian financial crisis and the 2001 global downturn.

A surge in productivity growth has underpinned Australia's good performance. After showing its weakest rate in the 1980s, Australia's productivity growth accelerated by a little over 1 percentage point to new highs in the 1990s — labour productivity growth at an average 3.2 per cent a year and multifactor productivity (MFP) growth at 1.8 per cent a year.

The much improved performance has stimulated a search for reasons. A few commentators have disputed the significance of the evidence of a productivity surge by speculating about the influence of recovery from the early 1990s recession and measurement error.[1] But the length and strength of the productivity resurgence — controlling for cyclical influences — demand some 'structural' explanations. Most attention has focused on three candidates:

- a shift in the production frontier due to the introduction of new technology — specifically information and communications technologies (ICTs);
- a shift toward the frontier through efficiency improvements stimulated by a set of microeconomic policy reforms — 'catch-up' gains from firms moving toward best practice and from resources shifting to where they can be used more productively; and
- an increase in average education attainment and skills that would increase human capital deepening and promote innovation through the absorption and development of technologies and efficient business practices.

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[1] To account for an acceleration in productivity growth any measurement error would have to have worsened (if an over-estimation) or diminished (if an underestimation). The latter is more possible in that estimation of productivity in some service industries may have improved. On the other hand, many OECD countries have similarly improved and harmonised aspects of estimation, without generating estimates of productivity acceleration anywhere near the strength of Australia's.

This paper concentrates on the first possible explanation, particularly since there has been worldwide interest in ICTs as a source of productivity growth. A comparison with US experience, using a growth accounting framework, provides the basis for assessing the contribution of ICTs to Australia's aggregate productivity acceleration. Productivity growth and the ICT contributions to it are sensitive to cyclical effects. This study is distinguished from others by the attention paid to selection of periods that minimise cyclical effects. The paper also draws on other empirical work to briefly assess other possible explanations.

2. An overview of Australia's productivity performance

Australia's recent productivity performance needs to be set in a broad historical and international context to highlight some of the developments that should be covered in a comprehensive explanation of the 1990s surge.

2.1 A broad sweep across countries and the decades

Australia's rate of productivity growth was comparatively low over most of the 20th century. At the beginning of the century, Australia had one of the highest levels of labour productivity in the world (Maddison 2001), reflecting the combination of a relative abundance of natural resources and a relatively small population. Governments subsequently traded this high productivity position for nation building as, with widespread popular support, they encouraged population growth, diversification of the economic base and redistribution of income through a set of policies that (perhaps unintentionally) held growth in productivity in check.

Nevertheless, Australia still enjoyed a relatively high ranking at the start of the post-war era. In 1950, Australia's GDP per hour was 81 per cent of the productivity leader — the USA — and it ranked 4 among a group of 22 developed or high-income countries (figure 1[2] and table 1).

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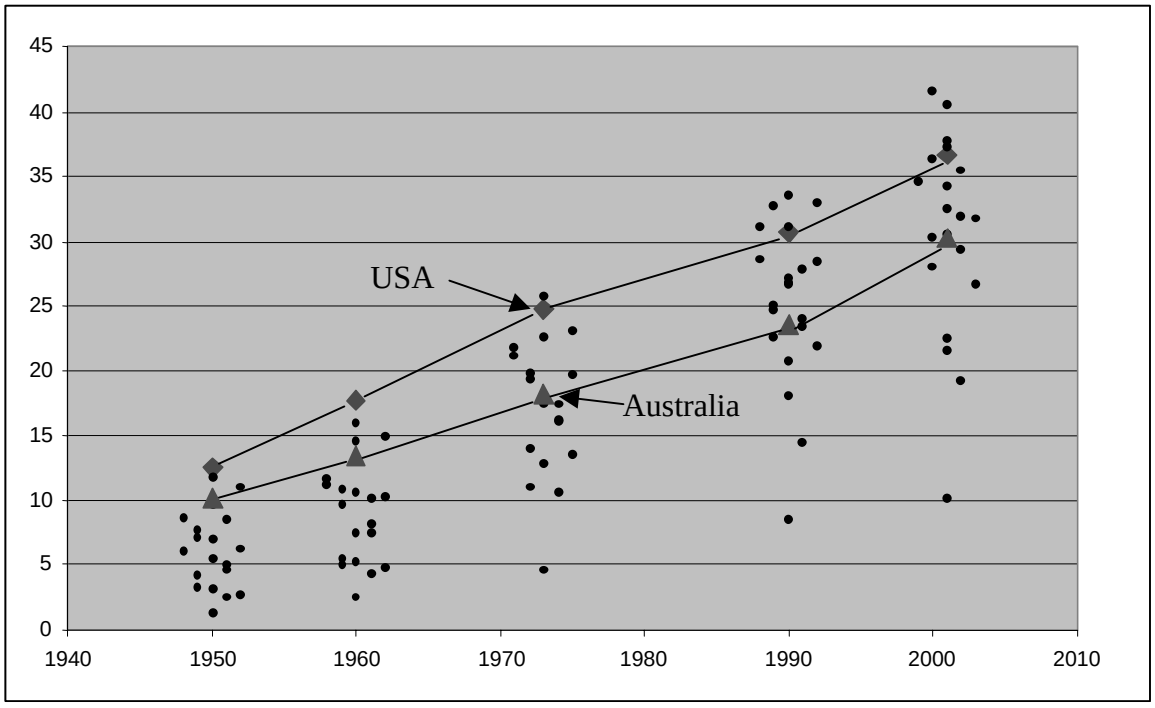
[2] Figure 1 shows productivity levels in 22 OECD countries in 1950, 1960, 1973, 1990 and 2001. Some observations are offset from the reference year on the chart to avoid over-writing.

The next four decades were a period of catch-up to the leader and convergence in productivity levels. European countries, in particular, started to catch up and in some cases overtook the USA (figure 1).

Australia did not participate in this 'convergence club'. Many countries also overtook Australia as it slipped further behind the USA in the 1950s and then merely maintained its position relative to the USA until 1990. Australia's ranking slipped to 15 by 1990.

Figure 1 Labour productivity in OECD countries, 1950, 1960, 1973, 1990 and 2001

GDP per hour (US$ at purchasing power parity)



Source: Data sourced from University of Groningen and The Conference Board, GGDC Total Economy Database, 2002; http://www.eco.rug.nl/ggdc, accessed 7 March 2002.

A string of policy reviews in the 1960s, 1970s and 1980s attributed this relatively poor performance to highly regulated product, capital and labour markets and the inefficient provision of economic infrastructure (energy, water, transport, communications), which was dominated by government-owned enterprises operating without clear commercial imperative or performance regulation.

As a consequence of relatively poor productivity growth, Australia's ranking on the international league table of GDP per capita also dropped — from 5 in 1950 to 15 in 1990 (table 1).

Table 1 Australia's rankings on productivity, average income and labour utilisation[a] levels among 22 OECD countries

	1950	1960	1973	1990	2001
GDP per hour					
Australia's rank	4	5	10	15	14
% of US level	81	75	74	77	83
GDP per capita					
Australia's rank	5	7	9	15	7
% of US level	78	78	77	74	78
Labour utilisation[a]					
Australia's rank	16	17	7	7	5
% of US level	96	104	104	96	94

[a] Labour utilisation is the number of hours worked per head of total population. It explains the difference between GDP per hour and GDP per capita.

Source: As for Figure 1.

2.2 The productivity surge in the 1990s

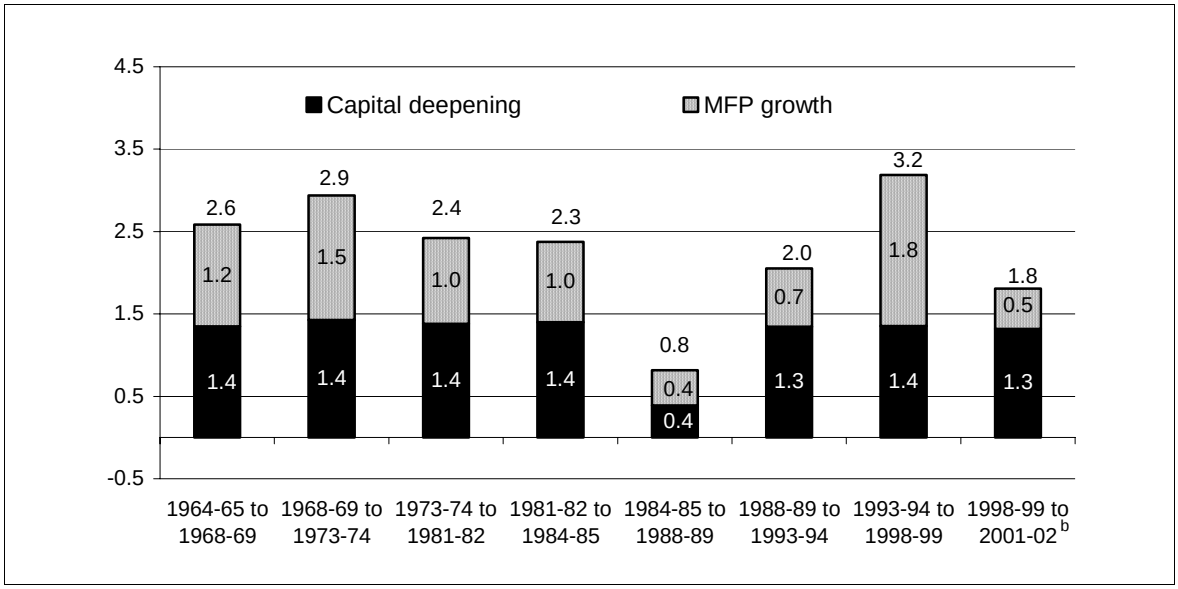
Figure 2 shows the rates of labour productivity growth over productivity cycles in the market sector of the Australian economy. Measurement over productivity cycles — from productivity peak to productivity peak — neutralises the spurious influence of the business cycle. The latest period, 1998-99 to 2001-02, is not a complete cycle. Since productivity growth over this period cannot be taken confidently to be an underlying rate, attention is focused on the most recent completed cycle, 1993-94 to 1998-99.

The figure shows that Australia's productivity growth rebounded in the 1990s, with underlying rates reaching record highs. The record 3.2 per cent annual average labour

productivity growth in the 1993-94 to 1998-99 cycle compares with an average of 2.0 per cent in the previous cycle and 1.7 per cent over the cycles from 1981-82 to 1993-94.

Figure 2 Growth in labour productivity over productivity cycles[a] and contributions from capital deepening and multifactor productivity, 1964-65 to 2001-02

Average annual rates of growth (per cent)



[a] Productivity cycles are the intervals between productivity peaks, as identified by the Australian Bureau of Statistics (ABS).

[b] Incomplete cycle.

Source: ABS 5204.0 and Productivity Commission estimates.

MFP growth was the major contributor to improved labour productivity growth. With the rate of capital deepening stable at around 1.4 per cent a year, better MFP growth has accounted for all of the acceleration in Australia's underlying labour productivity growth (figure 2). Record MFP growth of 1.8 per cent a year accounted for around two-thirds of labour productivity growth in the 1990s cycle. MFP accelerated from 0.7 per cent a year — the average over both the previous cycle and the three cycles between 1981-82 and 1993-94.

The start of the surge cannot be pin-pointed with precision because of recession-related effects. Figure 3 suggests that the Australian economy took a new growth path, based on

higher MFP growth, in the early 1990s, around 1993.[3] Even without precision, it would appear that Australia's productivity surge pre-dated the uplift in US productivity growth from 1995.

Strong productivity growth in the 1990s fuelled relatively strong growth in average incomes and raised Australia's GDP per capita ranking to 7 by 2001 (table 1). Australia's level of GDP per head had recovered from 74 per cent of the US level in 1990, to regain its very long-term position at around 78 per cent by 2001.

In summary, Australia's productivity and average income growth were relatively poor when there was a world-wide productivity boom in the catch-up and convergence era of the post-war period. Australia only started to catch up on the USA during the 1990s — a period of mixed performance across countries. The USA itself accelerated, contributing to a breakdown in convergence.[4] Australia not only kept pace with, but exceeded, the US acceleration to record one of the highest accelerations in the OECD area (OECD 2001a).

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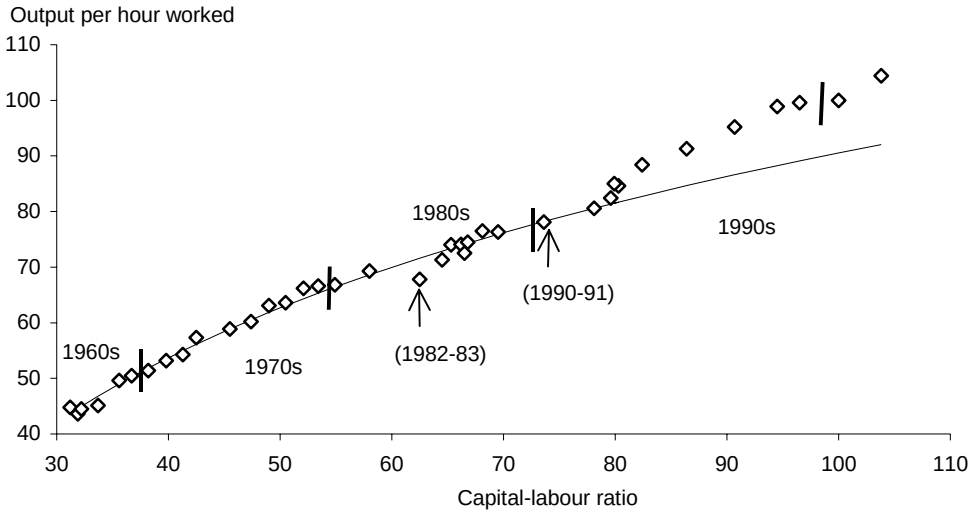
[3] Figure 3 plots paired observations of the capital to labour ratio and labour productivity levels. Because of the general tendency of capital deepening, the observations line up in chronological order. Shifts from one observation to another occur can be attributed to combinations of capital deepening and MFP growth. If the relative importance of MFP growth increases, as happened in the 1990s, the observations follow a steeper gradient. See Parham (1999) for more details on growth path analysis.

[4] Catch-up and convergence stalled in the 1990s as US productivity accelerated relative to most other countries (Australia being one notable exception). Convergence actually broke down in the second half of the 1990s, when the US productivity acceleration was strongest (OECD 2001a, McGuckin and van Ark 2002).

Figure 3 Australia's growth path, 1964-65 to 2001-02[a]

Indexes 2000-01 = 100



[a] The years in brackets correspond to troughs in the business cycle.

Source: ABS 5204.0.

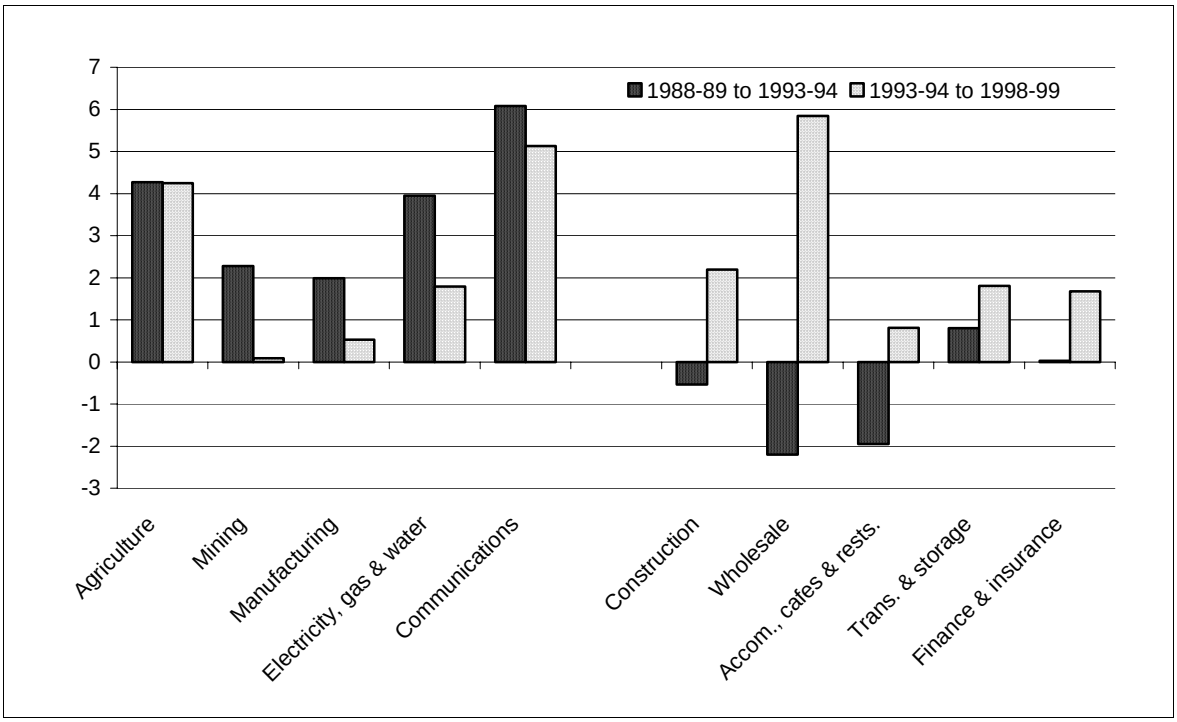
The 1990s brought an important change in the industry sources of aggregate productivity growth. Figure 4 presents MFP growth rates in industry sectors over the past two aggregate productivity cycles. Some caution about the precision of industry estimates is appropriate, particularly in view of the value-added method of estimation, which has been used in the absence of data to support a KLEMS approach.[5]

In the 1988-89 to 1993-94 cycle, there was relatively strong productivity growth in the 'traditional' contributors to aggregate productivity growth — Agriculture, Mining, and Manufacturing (left-hand side of Figure 4). Two other strong performers — Communication services and Electricity, gas & water — joined these traditional sectors in this cycle. Their improved performance stemmed from the major efficiencies (eg better investment decisions and reductions in excess manning) achieved in government enterprises, as well as technological advances in some activities.

[5] The differences in value added and KLEMS approaches are discussed by, for example, Gullickson and Harper 1999.

Figure 4 MFP growth in selected industries over the last two aggregate productivity cycles

Average annual rates of growth (per cent)



Source: Productivity Commission estimates based on unpublished ABS data.

Whilst productivity growth remained relatively strong in this most of these industries in the 1990s cycle (Mining and Manufacturing being exceptions), all these industries experienced a deceleration compared with the previous cycle. On these estimates, none made a contribution to the productivity surge from 1993-94.

A new set of service industries emerged in the 1990s. The stand-out performer was Wholesale trade. Other service industries — for example, Construction and Finance & insurance — also increased their rate of productivity growth significantly. Because of their relative size, Wholesale trade, Construction and Finance & insurance made the most substantial contributions to the aggregate acceleration (table 2).

Table 2 Industry contributions to the acceleration in market sector MFP

Percentage points and per cent

	MFP acceleration[a]	Output share[b]	Contribution
	(% pa)	(%)	(% pt)
Agriculture	0.0	6	0.0
Mining	-2.2	8	-0.3
Manufacturing	-1.5	22	-0.5
Electricity, gas & water	-2.2	5	-0.2
Construction	2.7	9	0.4
Wholesale trade	8.0	9	1.1
Retail trade	0.7	9	0.1
Accom., cafes & restaurants	2.8	3	0.1
Transport & storage	1.0	9	0.1
Communications	-1.0	5	-0.1
Finance & insurance	1.7	11	0.3
Cultural & Recreational services	-1.7	3	-0.1
Market Sector	**1.1**	**100**	**1.1**

[a] Acceleration is the change in growth from the period 1988-89 to 1993-94 to the period 1993-94 to 1998-99.

[b] Output shares are calculated from estimates of current price value added for 1993-94.

Source: Productivity Commission estimates based on ABS data.

2.3 Key features of the productivity surge

This sketch of Australia's productivity performance has highlighted the following key developments that need to be explained:

- From an international perspective, Australia's productivity growth switched from being relatively slow over at least four decades to become relatively fast in the 1990s.

- The acceleration in labour productivity growth came through improved efficiency (MFP growth) rather than increased capital deepening.
- The 1990s surge in MFP growth originated in a new set of service industries, in particular Wholesale trade, Construction and Finance & insurance.

The absence of a worldwide productivity boom, the relative strength of Australia's productivity acceleration and its starting point in the early 1990s suggest that some specifically Australian factors must form at least an important part of the explanation.

The contribution of ICTs is now assessed. There was an ICT boom in the 1990s in a number of countries, including Australia.

3 The role of ICTs in Australia's productivity surge

ICTs are widely considered to be the major productivity-enhancing technological advance of the 1990s. Advances in ICTs have brought widespread and, in some cases, quite fundamental changes to businesses and households. ICTs have been linked to labour productivity growth through three avenues.

Increases in capital deepening. Labour productivity can rise as a result of higher capital use per unit of labour, as firms invest in more ICTs (where measurement of ICT volumes takes into account increases in quality). Many analysts have noted this mechanism affords ICTs no special qualities. As they have become cheaper, firms have substituted ICTs for labour and other forms of capital — as could happen for many other inputs.

Productivity gains in ICT production. Producers' ability to manufacture much more powerful ICT equipment, with relatively little increase in inputs, generates substantial MFP gains. If the gains are of sufficient magnitude and production is on sufficient scale, they can show up as contributions to aggregate MFP growth.

Productivity gains in ICT-using industries. This is the more controversial source of ICT-related productivity gains. It requires that use of ICTs generates MFP gains. On the one hand, 'new economy' enthusiasts have pointed to MFP gains from such sources as increasing returns from ICT use and spillovers from network economies. On the other hand, sceptics have either denied or found little evidence to support the existence of MFP gains from use.

Australia cannot access productivity gains from ICT production. The ICT equipment production sector is not of sufficient size to generate productivity gains of national significance.

However, Australia has become a high ICT user. In 2000, Australia ranked 3 (behind the USA and Finland) among OECD countries on expenditure on ICTs as a proportion of non-residential investment — a marked step up from its 1980 ranking (OECD 2002). Investment in ICTs became a sizeable proportion of total investment in Australia from the mid-1980s. Since then, the growth of investment has been very strong, especially in the second half of the 1990s, when investment in hardware grew by 35 per cent a year and software investment by 20 per cent a year in real terms.

As an importer of ICTs, Australia has benefited from a sizeable terms of trade gain through the rapidly declining prices of ICTs. Strong international competition has meant that MFP gains in production have been passed on to purchasers. The Australian Treasury (2002) stated that ICT prices have fallen in domestic currency terms by 9.5 per cent a year and raised the terms of trade by 0.3 per cent a year between 1985 and 2001. Since 1995, ICT prices have fallen by nearly 15 per cent a year and raised the terms of trade by 0.75 per cent a year.

3.1 Aggregate growth accounting[6]

A conventional productivity growth accounting exercise is now used to assess the influence of ICTs on Australia's productivity performance. A comparison with the USA is used to infer the likely contribution of ICTs to Australia's aggregate productivity growth.

The estimates of Australian labour productivity growth and the growth accounting contribution to it are based on national accounts data constructed by the Australian Bureau of Statistics (ABS). In keeping with modern practice, the ABS uses hedonic (or constant-quality) price deflators to estimate real volumes of ICTs produced and purchased. Hedonic prices have not been specifically generated for Australia. The ABS uses the US price deflator for hardware, adjusted for exchange rate movements and a time lag, and a price

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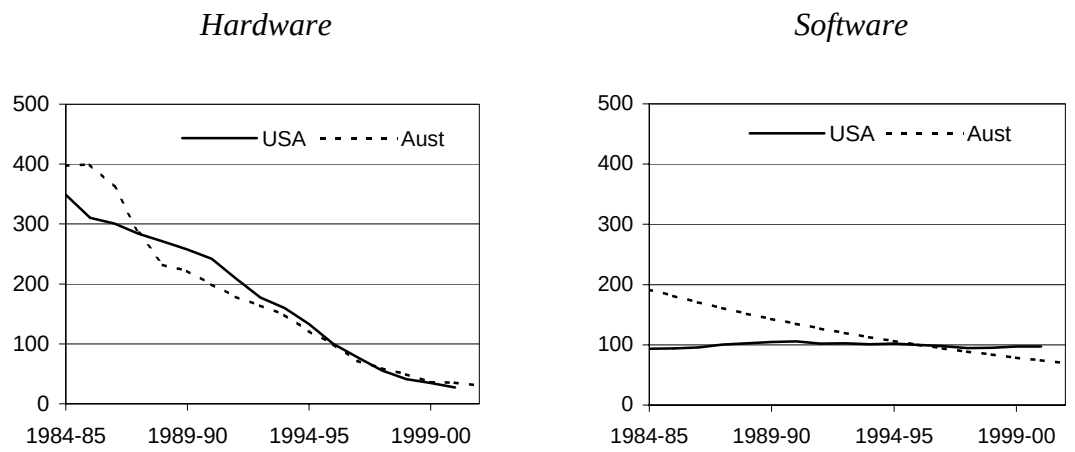
6 The growth accounting presented in this section is updated from Parham, Roberts and Sun (2001).

deflator for software that shows a nominal 6 per cent a year decline. The US and Australian deflators are shown in figure 5.

Figure 5 ICT hardware and software price indexes, USA and Australia

Index 1995-96 = 100



Source: Unpublished ABS data, and BLS data.

There has been a string of US studies of ICT contributions to productivity growth. For brevity, however, this paper focuses on comparisons with the USA, based on Bureau of Labor Statistics (BLS) data. Using BLS data brings two advantages:

- the ABS models its methods closely on BLS methods, and this enhances comparability[7]; and
- access to the BLS dataset assists flexibility in choosing periods for comparison.

A capital services measure of capital input is used and labour input is measured by hours worked. US studies also include a labour composition or 'quality' component, but this component cannot be estimated on a comparable basis or for the entire period for Australia.

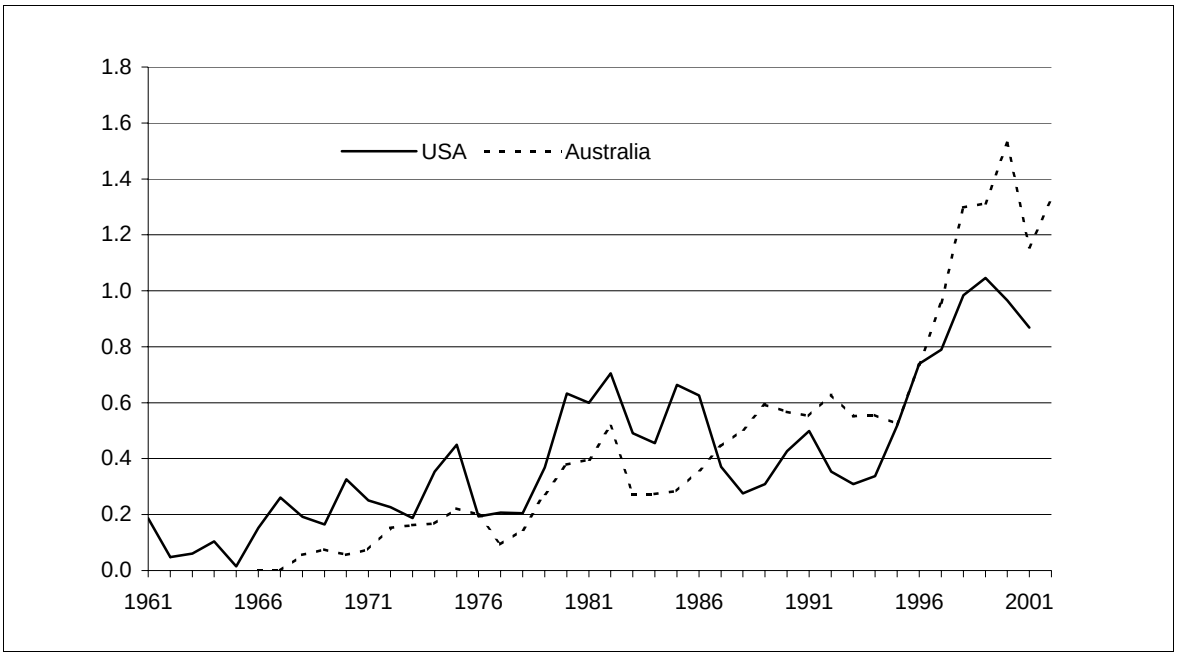
[7] Nevertheless, there are a few differences of note. Australian data cover IT, without communications equipment, whereas US data cover ICTs. The US estimates used here cover the private business sector, whereas Australian estimates cover the market sector. The main difference between the two is that the ABS-defined market sector excludes Property & business services.

Consequently, this component is added back into the US MFP growth estimates presented below to assist comparability with Australian estimates.[8]

There was a big step up in contributions from ICT capital deepening from 1995 in the USA and Australia (figure 6). The timing and strength of the ICT capital deepening contributions in the two countries are remarkably close. This suggests that there have been similar rates of increase in ICT use in the two countries and supports the validity of using the USA as a comparator for the assessment of the impacts of ICT use in Australia.

Figure 6 Contributions of ICT capital deepening to labour productivity growth in the USA and Australia[a], 1961 to 2002

(Percentage points)



[a] Years refer to 12 months ended 30 June.

Source: Productivity Commission estimates based on unpublished ABS data (to 2001-02), and BLS data (to 2001).

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[8] This does, of course, assist comparability, but in a conceptually inferior way. It would be preferable to factor out labour composition effects in Australia in order to draw comparisons with the USA. The practical significance of this issue rests on whether compositional effects would have been greatly different in the two countries. Unpublished ABS work (see section 4.1) suggests that compositional effects in Australia over the 1980s and 1990s would not be greatly dissimilar to those in the USA.

Our work at the Productivity Commission has paid particular attention to selection of periods that identify underlying rates of productivity growth. Focus on underlying trends, rather than pre- and post-1995 rates of growth, presents a departure from nearly all other previous Australian and US studies.

It is not surprising that most studies have used 1995 as the dividing year between periods for comparison of productivity growth and ICT contributions to it — for example, accounting for productivity growth in the second half of the 1990s (1995-99) compared with the first half (1990-95).[9] The 1995 year corresponds to the take-off point in more rapid advances in ICT technology, declines in ICT prices, growth in investment in ICTs and, as just seen, growth in ICT capital deepening. Using 1995 as a break point between periods therefore highlights the ICT takeoff and its effects.

But using 1995 as the break point creates problems in identifying and accounting for underlying rates of productivity growth. US labour productivity was in a trough in 1995, at a point below trend (figure 7).[10] Estimates of average growth from 1995 to the end of the 1990s are from a trough to a peak and therefore overstate the underlying rate of labour productivity growth. Moreover, the size of the estimated labour productivity acceleration is quite sensitive to minor variations in period selection around 1995 (Parham, Roberts and Sun 2001).

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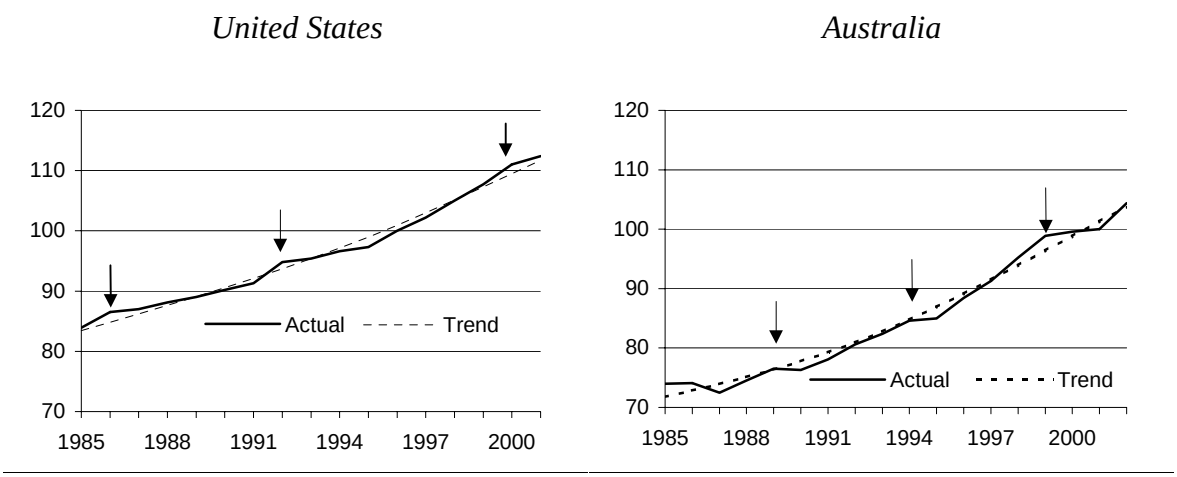
[9] Major examples of studies using pre- and post-1995 periods are Oliner and Sichel (2000), Gordon (2000), Jorgenson and Stiroh (2000) and CEA (2001). Gordon, however, does make a cyclical adjustment. Simon and Wardrop (2001) is an Australian example.

[10] A Hodrick-Prescott filter is used to form the trend series presented in figure 7. This does not clearly identify the Australian peaks as being above trend. However, the ABS uses an 11-period Henderson moving average to identify a trend series and (the same) productivity peaks in official productivity estimates.

Figure 7 Identifying peaks in US and Australian[a] labour productivity

Index 1996=100



[a] Years refer to 12 months ended 30 June.

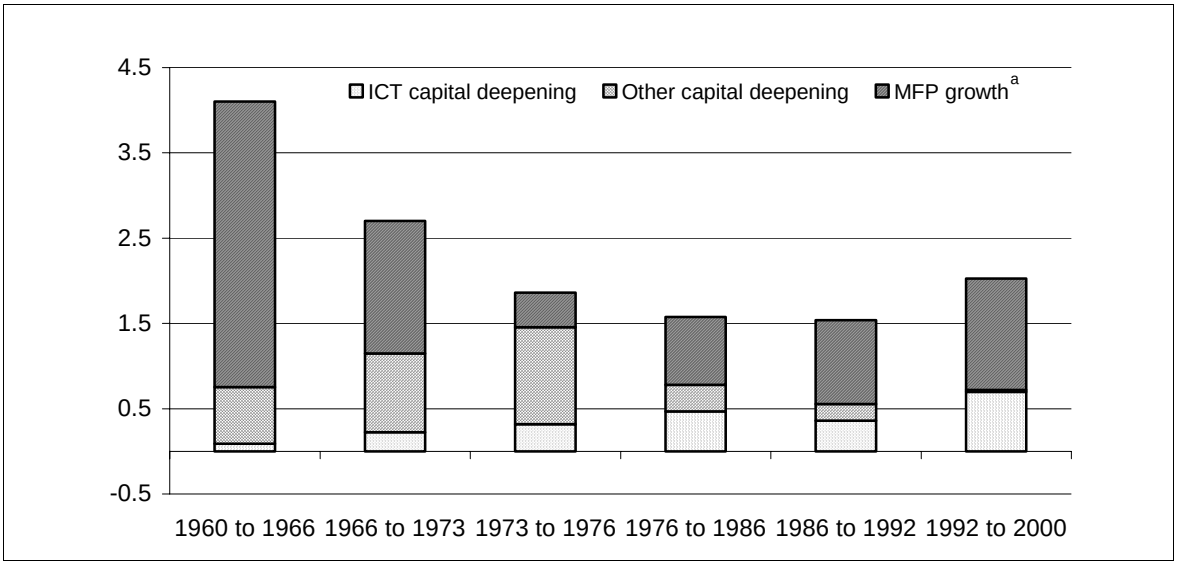
Source: Unpublished ABS data (to 2001-02), and BLS data (to 2001).

Issues with the break point and sensitivity can be set aside by analysing contributions to *trend* rates of productivity growth. The ABS method of estimating productivity growth over productivity cycles — from productivity peak to productivity peak — is one way of measuring underlying rates of growth. Adopting this method puts the prime focus on accelerations in underlying rates of productivity growth.

The contributions to labour productivity growth over productivity cycles are shown for the USA in figure 8 and for Australia in figure 9. The 1990s cycle for the USA is from 1992 to 2000 and for Australia from 1993-94 to 1998-99. Contributions to the labour productivity *accelerations* in the 1990s cycle (compared with the previous cycle) in both countries are presented in table 3. Contributions to the labour productivity accelerations from the first to the second half of the 1990s are shown for purely comparative purpose in table 4. The estimated labour productivity acceleration is lower according to the productivity cycle method, compared with the pre- and post-1995 method. In particular, the US acceleration is still significant but a much less spectacular 0.5 of a percentage point (table 3), compared with 1.1 percentage points (table 4).

Figure 8 Contributions to US labour productivity growth over productivity cycles, 1960 to 2000

Per cent per year

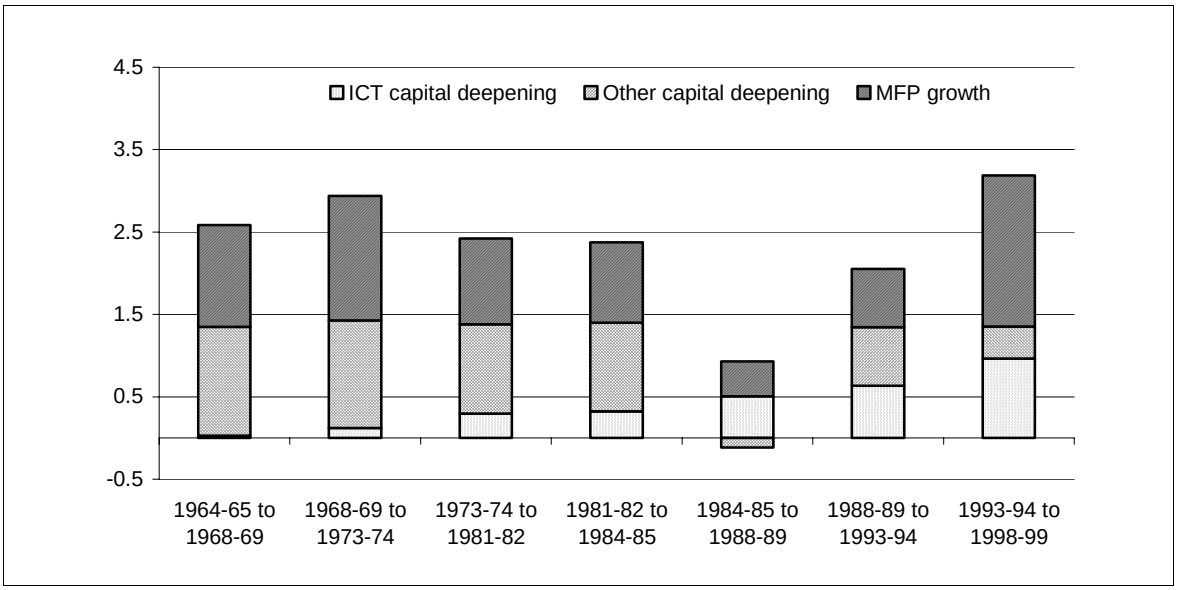


[a] Includes the labour composition (quality) contribution.

Source: Productivity Commission estimates based on BLS data.

Figure 9 Contributions to Australian labour productivity growth over productivity cycles, 1964-65 to 1998-99

Per cent per year



[a] Includes the labour composition (quality) contribution.

Source: Productivity Commission estimates based on unpublished ABS data.

There are several important similarities in the US and Australian results:

- ICTs have made strong capital deepening contributions. The ICT capital deepening contribution has increased steadily from the 1960s in both countries (figures 8 and 9). ICT capital deepening accounted for around a third of labour productivity growth in both countries in their respective 1990s cycles. ICT capital deepening made the same contribution (0.3 of a percentage point) to the 1990s labour productivity *accelerations* in both countries (table 3).[11]

- However, there has been little or no increase in the overall rate of capital deepening in either country, especially in Australia (table 3). Much or all of the increased use of ICTs (per hour worked) in the 1990s has been offset by slower growth in use of other forms of capital (per hour worked). This result contrasts with that found in most other studies of the USA (exemplified by the results in table 4) which have found that ICTs have contributed to a marked increase in the rate of substitution of capital for labour.

- MFP growth accounted for over half the labour productivity growth in the 1990s cycle in both countries. Faster MFP growth accounts for most of the 1990s labour productivity *accelerations* in both countries — entirely so in Australia's case.

[11] The slightly lower contribution in the US was due to stronger labour input growth rather than weaker ICT capital growth.

Table 3 Contributions to labour productivity accelerations in the 1990s productivity cycle in the USA and Australia

Percentage points

	US[a]	Australia[b]
Labour productivity acceleration	0.5	1.2
Capital deepening	0.2	0.0
- ICT capital	0.3	0.3
* Hardware	0.3	0.4
* Software	0.1	-0.1
* Other	0.0	
- Other capital	-0.2	-0.3
MFP contribution	0.3	1.1

[a] Growth in 1992 to 2000 less growth in 1986 to 1992. [b] Growth in 1993-94 to 1998-99 less growth in 1988-89 to 1993-94.

Table 4 Contributions to productivity accelerations from 1990-95 to 1995-2000 in the USA and Australia[a]

Percentage points

	United States	Australia
Labour productivity acceleration	1.1	1.1
Capital deepening contribution	0.6	0.4
- ICT	0.5	0.5
- Other	0.1	-0.1
MFP contribution	0.5	0.6

[a] Years refer to 12 months ending 30 June.

The main difference between the US and Australian results lies in the strength of the productivity accelerations. The acceleration in underlying labour productivity growth in Australia, at 1.2 percentage points, is more than twice that in the USA (table 2). With similar capital deepening contributions, the chief explanation for the difference lies in the

much stronger MFP acceleration in Australia (1.1 percentage point) than in the US (0.3 of a percentage point).

The stronger productivity acceleration in Australia suggests that the Australian economy benefited from one or both of two factors: bigger gains from the use of ICTs and/or more gains from non-ICT factors. In either case, it does not necessarily mean — and generally it is highly unlikely — that productivity levels in Australia have moved ahead of US levels. Rather, as the background in section 2 suggests, it is likely that Australia had more scope to improve from a lower base and has caught up on at least some of the superior US levels.

It seems reasonable to assume, consistent with the US leadership in productivity and ICTs, that the US estimates establish the upper limit of 0.3 of a percentage point on the productivity acceleration that can be associated specifically with ICT production and use.[12] Studies, such Oliner and Sichel (2000), have attributed around 0.3 of a percentage point of aggregate MFP growth acceleration to ICT production, although the acceleration was calculated pre- and post-1995 and may therefore overstate the contribution to the acceleration in trend productivity growth.[13] The acceleration over productivity cycles would be less — perhaps half or 1 or 2 tenths of a percentage point.

Even if the more favourable view of the importance of ICTs is taken from the comparison between the first and second halves of the 1990s, table 3 suggests that the maximum acceleration due to production and use of ICTs is 0.6 of a percentage point (the MFP acceleration in the USA). Taking the contribution of ICT production to be around 0.3 of a

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[12] This implicitly assumes that no other contributors to productivity growth, such as technological change unrelated to ICTs, have accelerated in the USA. Using the USA as a benchmark for Australia also implicitly assumes that there are no important differences in industry composition between the two economies.

[13] There has been some overstatement of the productivity acceleration apportioned to ICT production. Productivity improvements have been calculated by the dual method of measuring price declines and attributing them entirely to productivity improvements. However, some of the price declines have been due to declining profit margins (see, for example, Aizcorbe 2002).

percentage point, as calculated by Oliner and Sichel, means that the ICT use component is a maximum of 0.3 of a percentage point.

The estimate of 1 or 2 tenths of percentage point from ICT use in the USA is devoid of any catch-up effects, since the USA is at the frontier. This estimate therefore indicates the extent of productivity gains associated with ICT use in Australia that do not stem from catch-up effects.

The estimated magnitude fits well with other econometrically-based evidence. Bean (2000) used a cross-country regression as a basis to calculate that Australia's rate of ICT uptake would have contributed 0.12 percentage points to annual productivity growth. Gretton, Gali and Parham (2002) constructed an aggregate contribution of 0.14 percentage points from the formal analysis of firm-level data.

3.2 An industry perspective

Whilst the evidence to date suggests that MFP gains associated with ICTs at the aggregate level are significant, but not spectacular, there is evidence of stronger links in some industries. In some countries, including the USA, Japan, Korea, Finland and Ireland, there are opportunities for very substantial productivity gains in the manufacture of ICTs.

There also appear to be stronger links associated with the *use* of ICTs in certain industries. Several studies of the USA have found evidence of productivity acceleration in the 1990s in Wholesale trade, Retail trade, Finance insurance & real estate (especially in financial intermediation) and Business services. These have also been characterised as intensive users of ICTs (Stiroh 2001, Nordhaus 2001, CSLS 2000, CEA 2001, Pilat and Lee 2001).

As noted in section 2, a similar set of industries emerged in the 1990s as major contributors to Australia's productivity surge. The pattern of increased ICT usage and MFP acceleration across Australian industries is displayed in figure 10.[14] Finance & insurance, Wholesale trade, Retail trade and Construction had above-average increases in ICT use and had above-

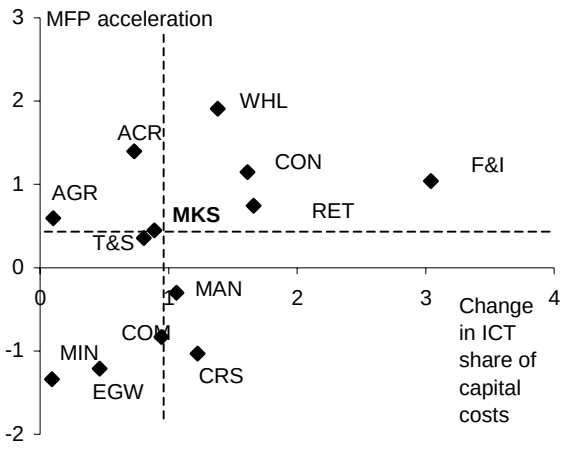
[14] The use of *trend* rates of productivity growth and different periods explains the differences in industry productivity accelerations show in Figures 4 and 10.

average MFP accelerations. Unfortunately, the equivalent industry data are not available from BLS sources to replicate this chart for the USA.

The coincidence of industries with increases in ICT use and productivity accelerations in the USA and Australia provides some circumstantial evidence for a link between ICT use and productivity growth at an industry level — concentrated in distribution, financial intermediation and business services (although Australian productivity data on the last industry are not available). There may also be ICT-productivity links at the firm level in other industries that, because of inter-firm differences in these and other factors, do not translate as readily into industry or aggregate trends (see Brynjolfsson and Hitt 2000). But figure 10 also suggests that the productivity accelerations in some Australian industries were unrelated to ICT use (and equally that increases in ICT use in some industries were not associated with MFP accelerations).

Figure 10 Change in industry ICT use and productivity growth in Australian industries over the 1990s[a]

Percentage points



ACR	Accommodation, cafes & restaurants
AGR	Agriculture
COM	Communication services
CON	Construction
CRS	Cultural & recreational services
EGW	Electricity, gas & water
F&I	Finance & insurance
MAN	Manufacturing
MIN	Mining
MKS	Market sector
RET	Retail trade
T&S	Transport & storage
WHL	Wholesale trade

[a] The productivity acceleration is calculated as the change in *trend* MFP growth between financial years 1990-95 and 1995-2000.

Source: Productivity Commission estimates based on unpublished ABS data.

The relationship between ICT use and productivity growth is complex rather than immediate and direct. ICTs are often viewed as general-purpose technologies that require time to bring to their full potential and enable productivity gains by providing a platform for other innovations in products and processes (see for example, Brynjolfsson and Hitt (2000) and Bresnahan, Brynjolfsson and Hitt (2002)).

The Australian evidence supports the view that it is changes in products and processes, enabled at least in part by ICTs, that generate productivity gains.[15] The Finance & insurance industry has been restructured to operate much more through ICTs (for example, ATMs, Internet and phone banking) than through traditional face-to-face contacts, leading to a restructuring of branch operations. Many new products (for example, financial derivatives) are now on offer.

An earlier study by Productivity Commission staff (Johnston et al 2000) also found that ICTs played a part in the restructuring of wholesaling activities. Wholesalers were able to use bar-code and scanning technology and inventory management systems as part of the process of transforming wholesaling from a storage-based to a fast flow-through operation.

The complexity of the relationships between ICT use and productivity performance reinforces the importance of taking an industry or firm point of view. Productivity gains depend on the different actions that different firms take. A firm focus helps to identify the importance of lags between uptake of ICTs and productivity gain and the significance of complementary innovations in products and processes. The significance of ICTs and complementarities has been confirmed in Productivity Commission work for an international project, coordinated by the OECD, to explore the links between ICT use and performance at the firm level (Gretton, Gali and Parham 2002). Productivity-enhancing complementarities between ICTs, skills and business restructuring were found in an analysis of a longitudinal micro dataset.

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[15] If the ICT hedonic price deflators are measured correctly, advances in ICTs are measured as embodied improvements. The MFP gains associated with ICT use, for example through firm reorganisation, can then be considered as disembodied improvements that are nevertheless internalised by the users. In some cases, lower transactions costs in business exchanges could be a spillover benefit of expanding ICT networks.

The main conclusion from the above growth accounting is that the rapid uptake of ICTs has had important but comparatively small influence on aggregate productivity growth in Australia. It appears to account for, at most, 1 or 2 tenths of a percentage point of Australia's 1.1 percentage point MFP acceleration. On the other hand, ICTs have had more marked productivity effects in individual firms and industries. ICTs would appear to provide at least partial explanation for the acceleration in the new set of service industries — particularly Finance & insurance, Construction and Wholesale trade.

However, the mere availability of new ICT technologies does not explain why Australian businesses adopted them with such vigour from the mid-1980s and put them to such productive use in the 1990s. After all, Australia's prior history was generally one of relatively slow adoption of advanced technologies. And whilst new ICTs have been available worldwide, many other advanced countries have not been as quick or productive on the uptake. A probable explanation for this conundrum is provided later.

4 Other explanations

The conclusion that ICTs have only contributed a relatively small part of the acceleration leaves the vast bulk of Australia's improved performance unexplained — an unsatisfactory point on which to finish this paper. This section briefly draws on other work to at least consider other possible explanations.

4.1 Education and skills

Steve Dowrick has reminded us of the importance of skills in the workforce as a source of growth, both directly as an 'embodied' labour input and indirectly in fostering absorption and further development of technology (see Dowrick 2002a,b and the Dowrick paper in this volume). He has highlighted the increase in school retention rates and labour force participation of females over the past 10-15 years. Based on a review of the empirical literature, Dowrick finds that raising Australia's average years of schooling by 0.8 could raise Australia's annual rate productivity growth by a third of a percentage point through direct and indirect means.

Whilst Dowrick casts his analysis in a long-term framework (given the time required for the flow of educational attainments to affect the average across the stock of employment), it is nevertheless of considerable interest to see if higher skills could have played a part in

Australia's 1990s productivity surge. The information presented in Dowrick's papers shows that Australia (along with New Zealand) had the highest average schooling across countries in 1960, but average attainment grew faster in comparator countries over the next four decades, so that Australia slipped significantly in position by 2000. Nevertheless, the increase in average schooling in Australia was higher in the 1990s than in the 1980s.

Productivity Commission colleagues, Barnes and Kennard (2002), have added more information. They examined preliminary ABS research that takes account of changes in workforce composition in the construction of a 'quality-adjusted' labour input series. This series reflects changes in the labour inputs of groups identified by gender, educational attainment and potential workforce experience. Taking into account workforce experience, the growth in skills was faster in the 1980s than in 1990s.

Barnes and Kennard's work suggests that increased education and skills has not had a direct effect on 1990s MFP growth through human capital deepening. The relative increase in skills in the 1980s, accounted for the order of 0.3 of a percentage point of average annual MFP growth. But, the skill contribution *decelerated* to around 0.05 of a percentage point from 1993-94. The direct contribution of skills to the 1990s productivity acceleration is *negative* on these numbers.

However, indirect effects, where education and skills assist the absorption of technology, could still be important. Links to the absorption of ICTs is a particular case in point and, as noted above, complementarities between skills and ICT use have been empirically confirmed. On the other hand, there is a gap in the ability of education and skill levels to explain the broad sweep of Australia's productivity performance. When Australia's average years of schooling was above other countries around the 1960s and early 1970s, the rate of productivity catch-up was relatively poor. After a period of relatively slow growth in attainment and when Australia's average schooling had fallen below other countries, the rate of productivity catch-up was relatively high. Without undermining the general importance of education and skills, this suggests that other factors were acting as the main constraint on productivity growth in earlier decades and as the main facilitators of productivity growth in the 1990s. It is also difficult to explain the industry sources of the productivity acceleration in terms of education and skills — perhaps not so much in financial intermediation, but certainly in Wholesale trade.

4.2 Policy reforms

By the 1980s, Australia's continued slippage on the international league table of average income, combined with pessimism about the future, galvanised community support for governments to take policy action to address structural weaknesses in the Australian economy. Key objectives were to raise growth in productivity and living standards.

Policy reforms, which have been introduced progressively since the mid-1980s, have included: deregulation of access to finance; floating the currency; marked reductions in barriers to trade and foreign direct investment; commercialisation (and some privatisation) of government business enterprises; strengthening domestic competition; and increasing labour market flexibility.

Policy reforms were designed to improve productivity performance by:

- sharpening incentives to be more productive, chiefly by strengthening competition from domestic and overseas sources;
- opening the economy to trade, investment, technologies and know-how developed overseas; and
- providing greater flexibility (for example, less regulatory restriction, more flexible labour markets) to adjust production processes and firm organisation to improve productivity.

It may be a matter of logic that, if previous policy frameworks were holding productivity growth in check, reform of those frameworks would allow productivity to accelerate. But empirical evidence is needed to confirm the importance of reforms.

A number of analysts, calling on a range of empirical and other evidence, have found that microeconomic policy reforms have played a major role in Australia's productivity surge (see, for example, PC 1999, Bean 2000, Dowrick 2000, Forsyth 2000, OECD 2001b). Macroeconomic policies have also been framed in ways that have helped to maintain stability in output growth.

However, it is difficult to put a particular order of magnitude on the influence of policy reforms on productivity growth. Formal analysis is not straightforward, particularly since it

is difficult to construct a measure of policy reform at the aggregate level that accurately quantifies the timing, breadth and intensity of reforms. By definition, reforms have operated at the micro level through a mixture of industry measures (eg deregulation, commercialisation of government enterprises), sectoral measures (eg phased reductions in tariffs on manufactures) and general measures (eg deregulation of access to finance and the introduction of enterprise flexibility into workplace bargaining). Furthermore, it is difficult to specify a structure of lags between implementation of reforms (which was often graduated) and production response.

Despite these difficulties, Salgado (2000) found a positive link between structural reforms and aggregate productivity growth. On his estimates, reforms contributed between 0.5 and 0.9 of a percentage point at the aggregate level. Empirical support is also found in detailed industry and firm case studies (see, for example, PC 1999). For example, the links between policy reforms and strong productivity responses in government business enterprises (see section 2) can be firmly established. And there are evident links between reforms and trends in proximate determinants of productivity growth, such as openness to trade and investment, industry specialisation (including intra-industry trade), uptake of advanced technologies, business R&D and rates of innovation (PC 1999).

The influence of policy reforms can explain the developments in the Australian economy outlined in section 2. It can explain improvements in efficiency (MFP growth rather than capital deepening). Reforms were intended to realise catch-up gains by forcing and enabling businesses to improve technical efficiency (moving towards best practice), reduce or close inefficient operations and adopt a more innovative, market-driven culture. Delayed success in catch-up, facilitated by policy reforms, can explain Australia's transition from an international laggard to a frontrunner in productivity growth. It would also provide a 'home-grown' or Australian-specific explanation for the productivity success in the 1990s.

Reforms could also help to explain the emergence of rapid and innovative use of ICTs in the 1990s. With stronger competitive incentive, businesses became more alert to the opportunities that new technologies provide and, with greater flexibility, became better able to put them to productive use.

But can the introduction of policy reforms explain the industry sources of the productivity acceleration? The incidence of reforms is clear in areas such as Electricity, gas & water, and

parts of Communications services and Transport & storage, following reforms to the operations of government enterprises. Financial intermediation has also been subject to far-reaching reforms over many years. But what about the stand-out performer, Wholesale trade?

Johnston et al (2002) found that reforms were acting as underlying drivers and facilitators of productivity gains in wholesaling. It was not so much that wholesaling became much more ICT intensive or that new 'breakthrough' technologies became available. It was more that the competitive incentives to be productive became stronger and that new flexibilities became open to businesses to use ICTs as part of a more general process of restructuring and transformation. For example, the motor vehicle industry was looking for efficiencies all along the 'value chain', including in distribution, to meet the increased competition from cheaper imports entering under lower border protection. Distribution has increasingly involved streamlined delivery of imported products and more customised products from local producers building fewer models at fewer production plants. Another contributor in some areas of wholesaling was the reform of industrial relations processes that allowed greater labour flexibility through the introduction of split shifts and reduced the rigidity of job demarcations.

A plausible explanation for the productivity gains in wholesaling is that, under increased competitive pressure, businesses rationalised production facilitates and took advantage of more efficient transport and information systems to reconfigure their distribution processes. They greatly reduced costs of storage and handling in the process. The large productivity gains in wholesaling were passed on, with profit margins declining in the 1990s (Parham, Barnes, Roberts and Kennett 2000).

5 Conclusions

Australia's labour productivity and MFP growth reached record highs in the 1990s. An acceleration of over 1 percentage point shifted Australia from being a laggard to being a frontrunner on productivity growth among OECD countries. Higher labour productivity growth in the 1990s came from improved efficiency rather than capital deepening. A new set of service industries, particularly Wholesale trade, Construction and Finance & insurance, appear to be at the heart of the productivity acceleration.

Taking into account the historical and international trends, it seems clear that the Australian economy has embarked on a process of catch-up, much-delayed in comparison with many other high-income countries. Australia has not been favoured in comparison to other countries by some new technology, a change in the structure of industries, a leap forward in the skills of the workforce or any other obvious structural factor. It seems that there has been a general improvement in efficiency of resource use that has narrowed, but not eliminated, the productivity gap with many other advanced economies.[16]

This paper has concentrated on the role that ICTs may have played in Australia's productivity surge. Australia is a high user but low producer of ICTs. As an importer of ICTs it has benefited from terms of trade effects as ICT prices have declined. Australian businesses have also used ICTs in 'smart' ways — taking advantage of the product and process innovations that ICTs enable. These have been a source of productivity gain for firms. And ICTs have played a role in the service industries contributing to the acceleration in aggregate productivity.

However, the overall contribution of ICTs to higher aggregate productivity growth in terms of frontier shifts has been relatively small. Comparison with the USA suggests that use of ICTs could only account for 1 or 2 tenths of a percentage point of the underlying productivity acceleration. This result is lower than that found in previous US and Australian studies, which have overstated the contribution of ICTs to productivity growth by failing to control for cyclical influences.

An increase in educational attainment and skills may also have contributed in some small measure to Australia's productivity surge. The timing of increased skills — faster in the 1980s than the 1990s — and the extent of the increase — slower in Australia than in other

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[16] A remaining productivity gap at the aggregate level is evident in the data presented in section 2. Research at the Groningen Growth and Development Centre on sectoral comparisons (van Ark and Timmer 2002) suggests that Australia has slipped further behind US labour productivity levels in two areas of strong US growth — manufacturing (where Australia remains at around 40 per cent of US levels) and wholesale and retail trade (around 50 per cent of US levels). In transport and communications, however, Australia has moved further ahead of the USA since 1980 and is now about 150 per cent of the US level.

countries — do not sit well with Australia's historically and internationally strong productivity surge in the 1990s. There would appear to be only a weak link between skills and the industry sources of productivity growth — particularly in wholesaling.

Nevertheless, education and skills could still have some indirect influence through absorption of technology. The uptake and productive use of ICTs is a particular case in point. (The productivity impacts of skills and ICTs would therefore not be additive.)

There is theoretical and empirical support for policy reforms playing a substantial role in Australia's productivity surge through catch-up gains in efficiency. Nevertheless, further empirical evidence would help to bolster this conclusion. Policy reforms also provide plausible explanation for Australia's shift from laggard to frontrunner and the industry sources of the productivity acceleration.

Rather than being 'alternative' explanations, reforms ICTs and skills can be seen as complementary. In a more competitive open and flexible business environment, Australian businesses were forced and enabled to restructure in order to catch up. They also became more alert to opportunities that new technologies, such as ICTs, could provide and either incorporated them in their restructuring moves or new firms emerged to take the new opportunities. That is, reforms played a part in driving the uptake of ICTs and in enabling them to be used productively. The right amount and mix of education and skills also assisted the use of ICTs and the identification and implementation of ways to take advantage of what the new technologies could offer.

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