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Sources of Australia's Productivity Revival

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I. Introduction

After languishing in the late 1970s and 1980s, Australia's productivity growth surged in the 1990s. Labour and multifactor productivity growth reached record highs, surpassing the 'golden age' rates in the 1950s to early 1970s. The productivity revival was significant. It shifted the economy away from its traditional reliance on factor accumulation as a source of growth (Parham 2000). It underpinned strong growth in GDP at an average of nearly 4 per cent a year. And it fully accounted for an uplift in per capita income growth from 1.6 to 2.6 per cent a year (Parham *et al* 2000).

The objective of this survey is to identify the key sources of Australia's productivity revival. First, the survey establishes a set of 'stylised facts' about Australia's productivity performance. Second, the survey draws on available evidence — as far as possible from formal analytical studies — to explain the stylised facts.

Since the survey focuses on the 1990s productivity revival, it does not attempt to do justice to contributions in the broader field of theoretical and applied productivity and growth analysis. Readers with a broader interest are referred to Rogers (2003b) for a survey of economic growth and to Dawkins and Rogers (1998) for a survey of Australian productivity analyses.

Before proceeding, a clarification of productivity variables of interest is in order. Most interest usually lies in labour productivity (LP) and multifactor productivity (MFP). Growth in LP (output per hour worked) holds interest because, at the aggregate level, it is highly correlated with average income growth. It also affects growth in unit labour costs. LP growth is influenced by capital deepening (increases in the capital-labour ratio) and MFP growth. MFP growth is of interest because it reflects improvements in efficiency, broadly defined. It is sometimes thought of as the unexplained growth

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residual or (inappropriately) as 'manna from heaven'. But it occurs for a reason — investments in R&D, improved management techniques, improved skills and so on. In principle, where such influences are embodied in inputs, their effects can be factored out from the growth residual by specifying and allowing for growth in the relevant input. Some studies have factored out a few of these influences, in which case they continue to be reflected in LP growth, but not MFP growth. Consequently, the interpretation of MFP growth depends on the input specification.

II. What is different about the 1990s productivity experience?

This section puts Australia's recent productivity trends in historical and international perspective and identifies stylised facts that distinguish the 1990s from earlier decades.

The principal source of productivity estimates is the official Australian Bureau of Statistics (ABS) series of labour, capital and multifactor productivity for the market sector — the part of the economy for which output and therefore productivity can be relatively well measured.[1] In 1999, the ABS introduced changes to its methodology that included a switch in the capital measure from the traditional wealth-based measure of net capital stock to a capital services measure.[2] The capital services measure takes account of the loss of economic efficiency of assets over time and the relative marginal products of different asset types.[3] Changes in the composition of capital, for example a switch to short-lived assets with high marginal products, means that growth in capital services departs from growth in the traditional capital stock measure. Use of the capital services measure factors out efficiency–related composition effects from MFP growth. To illustrate its practical significance, the switch to a capital services measure has reduced estimated MFP growth by probably half a percentage point or so in the 1990s.[4]

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[1] Aspden (1990) set out the basic ABS methodology.

[2] The changes (outlined in the 1997-98 issue of ABS Cat. no. 5204.0) were part of international moves to standardise methods of productivity estimation through the national accounting conventions of the UN's SNA93.

[3] The ABS draws on age-efficiency profiles for different asset classes to derive productive capital stocks, and these determine the flows of capital services. The service flows for individual assets are then weighted by their marginal products, as proxied by their user costs or rental prices. Capital services therefore represent efficiency units of different assets, weighted according to their marginal products.

[4] Estimates according to both methods are available for the period 1988-89 to 1993-94. The growth in the traditional capital stock measure was 1.9 per cent a year (ABS Cat. no. 5234.0, 1995-96 issue), whereas the latest estimate of the growth in capital services over the same period is 3.1 per cent a year — 1.2 percentage points greater. With a capital income share around 40 per cent, the shift to the capital services measure (and some other changes) has reduced measured annual MFP growth by around half a percentage point and increased the measured contribution of capital to output growth by the same amount.

i) Around one percentage point more productivity growth

The ABS estimates indicate that productivity accelerated by just over one percentage point during the 1990s. Table 1 shows the underlying rates of LP growth and their decomposition into a capital deepening contribution and an MFP growth contribution. The ABS determines these underlying rates by calculating average growth between the same point in successive productivity cycles — from productivity peak to productivity peak. Comparison of the mid-1990s cycle and the previous cycle reveals an acceleration of around 1.1 percentage points in both LP and MFP growth.

Estimates for the most recent years (up to 2002-03) do not form a complete cycle and therefore have not been included in Table 1. The ABS has not determined a productivity peak beyond 1998-99. The average rate of productivity growth has slowed since 1998-99, but it is not yet clear whether, or to what extent, this represents a slowing in the underlying rate rather than a number of short-term factors such the post-GST pause in housing construction in 2000-01, the drought and the global downturn.

Table 1 **Growth in productivity and contributing factors (% per year)**

	LP	MFP	Capital deepening	Output	Capital services	Hours worked
1964-65 to 1968-69	2.5	1.2	1.3	5.1	6.0	2.5
1968-69 to 1973-74	2.9	1.6	1.3	4.6	5.1	1.6
1973-74 to 1981-82	2.4	1.1	1.4	2.1	3.6	-0.3
1981-82 to 1984-85	2.2	0.8	1.4	1.8	3.6	-0.4
1984-85 to 1988-89	0.8	0.4	0.4	4.1	4.3	3.2
1988-89 to 1993-94	2.0	0.7	1.3	1.8	3.1	-0.2
1993-94 to 1998-99	3.2	1.8	1.3	4.6	4.7	1.3
1964-65 to 1998-99	2.4	1.1	1.2	3.4	4.3	1.0

Source: ABS Cat. no. 5204.0, except the capital deepening column, which contains Productivity Commission estimates.

A number of studies have used other methods to determine the existence and magnitude of an MFP acceleration (Appendix 1). They suggest an acceleration in the range of 0.5 to 1.4 percentage points, although the low end estimate is likely to be biased downward. Overall, the studies provide strong support for an acceleration of around 1 percentage point or so.

ii) Improved efficiency rather than additional capital deepening

Table 1 also shows that the LP acceleration was due to stronger MFP growth or improved efficiency, rather than additional capital deepening. It is of interest to note that the rate of capital deepening has been stable over nearly all productivity cycles so that, historically, variations in LP growth have been due to variations in MFP growth.

iii) The productivity shift commenced in the early 1990s

The ABS estimates imply that the productivity revival got underway from 1993-94. It is difficult to disentangle the start of the structural shift from the effects of recovery from the 1990-91 recession. Some studies suggest that the shift may have started earlier, but the general view is that it was established by 1993-94 (Appendix 1).

iv) From international productivity growth laggard to frontrunner

The 1990s also brought a change in a long-term pattern in which Australia performed poorly compared with other high-income countries (Thimann 1998). Australia's international productivity ranking slipped markedly over the 20th century. It actuallyslipped most during the 'golden age' of the 1950s to early 1970s, when productivity growth was historically strong in Australia, but not as strong as it was in other countries.[5] Australia's ranking among OECD countries on GDP per hour worked slipped from 4 in 1950 to 12 in 1973, and to 16 by 1990.[6] In the 1990s, however, Australia posted strong growth in the midst of mixed performance among OECD countries (OECD 2001b; Gust and Marquez 2001). Productivity growth accelerated in the US, Canada and a number of smaller economies including Australia, but slowed in France, Germany and Japan. Although Australia did not improve its productivity ranking, it did outperform the resurgent US to lift GDP per hour worked from 76 per cent of the US level in 1990 to 83 per cent in 2002. Finland and Australia had the strongest acceleration in trend MFP in the 1990s in the OECD area (OECD 2001b).

v) New service industry contributors

Industry productivity trends provide some insight into the sources of the aggregate productivity surge. However, the ABS publishes estimates of industry LP but not MFP.[7] The Productivity Commission has published industry MFP estimates according to a commonly-used method, in which industry value added is related to inputs of labour and

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[5] The post-war era was a 'golden age' of growth, catch-up and convergence (see Abramovitz 1986 and Baumol 1986), in which strong productivity growth was fuelled by strong capital flows, growth in trade and easier international transfer of technology (Maddison 1994). Australia, however, went in the opposite direction in restricting its exposure to trade (Athukorala 1995). Many economies (particularly in Europe, as well as Japan and South Korea) caught up toward the productivity leader (the US) during the golden age and also during the post-1973 slowdown.

[6] The rankings are based on estimates of GDP per hour worked at purchasing power parity drawn from University of Groningen and The Conference Board (2003).

[7] The Bureau judges that it has not had the data foundation to publish estimates according to its preferred MFP methodology, in which industry gross output is related to inputs of capital, labour, energy, and intermediate purchases of materials and services. For outlines of this approach, see for example, Jorgensen, Gallop and Fraumeni (1987), Gullickson and Harper (1999) and OECD (2001a). See Cobbold (2003) for a discussion and comparison of gross output and value added approaches.

capital.[8] These estimates may be subject to some error, but can be relied upon for broad trends.

The industry estimates indicate that the productivity surge has been broadly based. Table 2 shows the underlying growth rates in industry MFP. The raw series have been smoothed to circumvent industry-specific differences in productivity cycles. A new set of service industries — wholesale trade and finance & insurance in particular, but also retail trade, construction and transport & storage — contributed to the acceleration. Agriculture also contributed. But other traditional contributors — mining and manufacturing — did not.

Table 2 **Growth in trend MFP[a], by industry, over aggregate productivity cycles[b]**

Per cent per year

	1974-1975 to 1981-1982	1981-1982 to 1984-1985	1984-1985 to 1988-1989	1988-1989 to 1993-1994	1993-1994 to 1998-1999
Agriculture	1.6	1.1	1.4	2.6	4.3
Mining	-1.7	0.5	2.6	2.5	1.2
Manufacturing	2.1	1.8	1.7	1.6	1.3
Electricity, gas & water	2.0	3.2	4.2	3.7	1.8
Construction	1.4	0.4	-0.3	-0.2	0.4
Wholesale trade	-0.7	-0.9	-0.5	1.2	3.2
Retail trade	1.0	0.6	-0.2	0.1	1.0
Accom. cafes & restaurants	-0.9	-1.3	-1.9	-1.6	-0.3
Transport & storage	2.2	1.2	1.0	1.4	1.9
Communication services	6.5	4.9	4.8	4.9	3.7
Finance & insurance	-2.0	-1.0	0.2	0.7	0.8
Commun. Rec. services	-1.4	-2.2	-2.9	-3.1	-3.3

a Trend MFP is formed with use of a Hodrick-Prescott filter. **b** Because of lack of industry data for 1973-74, the 1970s cycle in this table commences in 1974-75.

vi) Contemporaneous growth in inputs and productivity

The strong productivity growth did not come from holding back growth in inputs. Table 1 shows that Australia's record productivity growth in the mid-1990s cycle was accompanied by growth in output, capital services and hours worked above their long-term averages. This contrasts with the 1990s experience in a number of European countries where LP growth was partly achieved by dismissing or not employing low-skill workers (OECD 2003b).

[8] The data used are supplied by the ABS and are derived on the same conceptual basis as the data used in the aggregate estimates. Estimates are maintained on the Productivity Commission website and can be downloaded along with output and input data. See http://www.pc.gov.au/work/productivity.

III. Explaining the productivity surge

The review of trends suggests that 'homegrown' factors must have played a large part in Australia's productivity revival. There was not a worldwide productivity boom in the 1990s. Moreover, in the absence of some major technological advance that specifically favoured Australia, the change in Australia's position from productivity growth laggard to frontrunner suggests that there was a constraint on productivity growth in earlier decades and that it was eased by or during the 1990s.

Insights into the sources of Australia's productivity revival can be drawn from three sources: studies of Australia's aggregate productivity performance; cross-country growth models; and studies that focus on particular sources of productivity growth or sectors of the Australian economy. Since there are few formal studies of Australia's productivity performance in total, let alone ones that specifically address the 1990s revival, the insights from cross-country and more specific studies help to fill in gaps.

But five cautionary points arise in drawing on this range of evidence. The first concerns parameter homogeneity — the applicability of parameter estimates from cross-country studies to Australian circumstances, especially if the dataset includes developing countries. Second, many studies do not explicitly allow for important institutional and policy influences. As will be seen, policies and institutions mattered in explaining differences in productivity growth in the 1990s, even within the OECD set of countries. Omitting them from the analysis not only misses a relevant part of the story but fails to control for relevant influences when enumerating productivity responses to other variables of interest. Third, there is the issue of how well theoretical concepts are captured in measured variables. In some instances, important dimensions (eg quality and type of education) are unavailable across the range of countries, forcing the use of broad aggregates (eg years of schooling in cross-country studies). Fourth, some studies adopt hybrid or ad hoc specifications of theoretical relationships. Amongst other things, they provide limited insight into whether productivity effects represent a change in levels or higher ongoing growth. Fifth, some studies use data bases that include economy-wide GDP and/or a traditional capital stock measure. Estimated productivity effects can therefore relate to concepts and measures of LP and MFP growth that differ from those generated by the ABS.

There is also a need to distinguish between proximate and underlying factors. Proximate contributors to productivity growth are capital deepening (with respect to LP), technical progress, reductions in slack and inefficiency, economies of scale and changes in the mix of industries, firms and activities that have different productivity levels. But, to

understand what actually promotes these changes, it is necessary to explore the underlying drivers and enablers.[9]

i) The OECD Growth Project

The OECD Growth Project (OECD 2001b, 2003b) provides a good starting point, even though its focus was obviously much broader than Australia's productivity performance. The project set out to explain why some OECD economies performed better than others in the 1990s. It provided an international perspective on and comprehensive analysis of recent trends in productivity and growth. The Project employed growth accounting, cross-country aggregate growth models, cross-country industry productivity models and comparative analysis of firm-level longitudinal datasets.

The growth accounting revealed that a number of the countries that raised their average income growth — Australia, Canada, Ireland, Norway and the US — were able to combine LP and MFP growth with high and mostly rising rates of employment of labour. Higher LP growth was attributed in large part to capital deepening and MFP growth associated with information and communications technologies (ICTs). The part played by ICTs in Australia's productivity revival is examined further below. The OECD attributed favourable employment outcomes to the efficiency of labour market mechanisms.

A cross-country analysis of growth in 21 OECD countries over 1971-1998 found that physical and human capital accumulation were important underlying economic determinants. A number of policy and institutional variables were found to have direct efficiency effects on growth and indirect effects through the accumulation of capital: lower inflation (indirect); the size of government, measured by taxes and expenditures (direct and indirect); business R&D (direct); financial market development (direct and indirect); and trade exposure (direct). A number of these influences, particularly those with direct efficiency effects, are examined in relation to Australia's recent experience below.

Empirical analysis of 23 industries in 18 OECD countries found further evidence of the importance of policy-related influences. Anti-competitive product market regulations were found to inhibit industry productivity, especially in countries further behind the leader, by retarding the uptake of existing technologies and further innovation (as proxied by R&D expenditure). Employment protection legislation could also retard productivity growth, depending on how it affects investment in skills and training. The OECD concluded that countries with a decentralised bargaining system and less restrictive employment protection legislation are better equipped to innovate in

[9] See PC (1999) for a review of productivity determinants that organises them into three layers of immediate causes, underlying factors and fundamental influences.

industries characterised by multiple and rapidly-evolving technologies, including most of the ICT industry. Some of these factors are examined from an Australian perspective below.

Analysis of firm-based longitudinal datasets for 10 OECD countries (not including Australia) found that whilst most productivity improvement came from existing firms in an industry, entry and exit rates varied across countries. Start-up costs and the strictness of regulations on labour adjustments were found to stifle market experimentation. This in turn could affect the rate of innovation and technology adoption.[10]

In sum, the OECD Growth Project confirmed the underlying importance of physical and human capital accumulation, but found there were particular policy and institutional features that set the good performers in the 1990s apart from the poor performers. The identified factors that affected efficiency were competition, trade exposure and flexibility in product and labour markets. ICTs and innovation have featured in the better performing countries, in part because of the flexibility allowed by their policy and institutional environments. Favourable employment outcomes were attributed to the efficiency of labour market mechanisms.

ii) Studies of Australia's productivity revival

Studies of the productivity revival have included a focus on the role of structural policy reforms, which were introduced over the past two decades largely with the aim of raising Australia's productivity performance. Reforms have included liberalisation of trade and investment; deregulation of capital markets; more flexible institutional arrangements for labour markets; more active domestic competition policy; and restructuring of public utilities, which dominated infrastructure provision. These reforms addressed policy and institutional factors that were commonly viewed to have put constraints on Australia's productivity growth through the 1960s, 1970s and 1980s.[11] The implementation of reforms was gradual, but increased in breadth and intensity from the late 1980s.

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[10] Australia was not included in the firm-level study. Australia is not well served by data to study firm demography and dynamics. Nevertheless, Bland and Will (2001) also found in panel data from the Business Longitudinal Survey that within-firm effects dominated entry and exit effects on mid-1990s productivity growth.

[11] Border protection and domestic regulation insulated much of the economy from competition and the need to adapt to change. Manufacturing was domestically-oriented, diversified but inefficient. Large areas of infrastructure (including electricity, gas and water, communications, transport) were dominated by inefficient public utilities. Factor markets were inflexible with foreign exchange controls, capital rationing and highly centralised industrial relations processes. Rates of diffusion of new technology and innovation were low. See PC (1999) for details, including reference to the findings of a string of government sponsored reports. See also Singh *et al* (1998) for an external view.

However, formal analysis of the effects of these policy reforms on aggregate productivity is not straight forward. One formidable challenge is to accurately specify variables that capture the nature, breadth and timing of reforms, some of which took effect at an industry-specific level. Another challenge is to specify an appropriate structure for lagged responses.

Valadkhani (2003) appears to provide the only formal model of Australia's aggregate productivity growth that specifically addresses the reasons for the 1990s revival or covers at least the majority of the 1990s period.[12] He investigated Australia's economy-wide GDP per hour worked over 1970 to 2001 and found positive effects from physical and human capital accumulation. He also found that increased trade and declining union membership had significant effects on labour productivity. He attributed these effects to policy reforms, although it is most probable that declining union membership also reflects other influences. The real wage and the real exchange rate also had positive effects, but the rationale for inclusion of these variables and the direction of causality could be further explained. Overall, Valadkhani's results provide support for the presence of some standard economic determinants, plus some support for policy reforms in the areas of trade and labour markets. The effects of other major reforms were not investigated.

The IMF has undertaken a number of studies of Australia's productivity performance in recent years. Salgado (2000) found from a cross-country analysis that structural policy reforms (trade liberalisation, labour market reform and increased competition) had lifted Australia's trend MFP growth in the 1990s by between 0.5 and 0.9 of a percentage point, which at least fits with the order of magnitude of the observed acceleration. Effects were weak or even negative in the short run, but positive in the long run (10 years), which suggests that the adjustment period is quite long. However, the selection of indicators of reforms[13] and perhaps the omission of other possible determinants raises some questions about the strength of the results.

An earlier IMF study (Singh *et al* 1998) examined in detail a range of macro and micro factors affecting Australia's performance. It pinned disappointing long-term economic performance up until the 1990s on low productivity growth (due to government interventions that shielded large sectors of the economy from competition), low national saving, inflation and the centralised labour market. Based on a CES production

[12] Otto and Voss (1994, 1996), IC (1995) and Madden and Savage (1998) have modelled Australia's aggregate productivity performance and provide relevant insights that are mentioned later. The few other aggregate models that relate to pre-1990s Australia are covered in Dawkins and Rogers (1998).

[13] Limitations on the availability of other data for all countries constrained the specification of variables. In particular, the average unemployment benefit replacement rate was used as the indicator of labour market reform.

function, the study found much improved productivity performance in the 1990s, which it attributed in large part to structural policy reforms that opened the economy, made product and factor markets more flexible and input use more efficient.

The Productivity Commission (PC 1999) explored the links between policy reforms and Australia's productivity performance from a theoretical and empirical point of view. It noted a string of studies that had pointed out the policy and institutional constraints on productivity growth prior to the 1990s. The Commission reviewed evidence on trends in an extensive range of determinants of productivity growth and undertook a number of case studies, which related changes in policy arrangements to productivity trends in manufacturing industries (automotive, textiles clothing & footwear and whitegoods) and government provision of infrastructure (rail and water). It also called on other industry studies. The Commission concluded that restructuring of the economy and greater emphasis on new technology and innovation, encouraged and facilitated by policy reforms, had contributed to improved productivity. However, the lack of formal analysis in the study means that the evidence was suggestive, rather than definitive.

Based on a cross-country regression of MFP growth from 1992-97 for OECD countries, Bean (2000) attributed a small part (about 0.12 of a percentage point) of Australia's productivity surge to spillovers from unusually high ICT spending. He attributed the bulk of the surge to structural reforms, although this was inferred from industry productivity trends and other information, rather than formal analysis. Parham (2002b, 2003) came to similar conclusions on the respective roles of ICTs and policy reforms. Forsyth (2000) also linked the productivity surge to structural policy reforms.

Quiggin (2000, 2001), on the other hand, has been sceptical about the influence of policy reforms. His principal argument is that microeconomic policy reforms have increased work intensity — longer hours, unmeasured increases in hours worked and increased pace of work — and, whilst this may be reflected in measured productivity, the effect does not signal any structural improvement in productivity performance. In particular, he claimed that policy reforms gave employers greater bargaining power to require unmeasured increases in working hours. He contended that the increased work intensity is equivalent to an unmeasured increase in working hours that is 'more than enough to wipe out the productivity 'miracle' apparent in the official statistics' (Quiggin 2000, p. 269). However, Quiggin has not presented formal analysis or empirical support for his case.

Nevertheless, the work intensity explanation warrants some examination in view of the attention it has received. There are four main issues. First, has there been an increase in work intensity? Despite the lack of clear evidence, the answer is probably 'yes'. Second, are policy reforms responsible? Probably yes, but only in part. Reforms are likely to have contributed to reduced 'slack' or downtime in work arrangements. However, on

longer work hours, there could be other reasons. Wooden (2003) presents evidence that the increases in hours worked occurred between 1983 and 1994, which he attributes to a supply-side response by employees to increase their incomes in the presence of wage stickiness under the Prices and Incomes Accords. Longer hours and increased complexity, if not pace, of work could also be associated with a more educated workforce and changes in occupational mix. Third, does increased work intensity mean that the productivity trends are mismeasured? No. Increases in work intensity through reductions in slack on work time or increases in pace of work would be genuine sources of productivity improvement. Moreover, in principle, the hours worked estimates used in the productivity calculations are not mismeasured. They come from surveys of households (employees), not employers, and reflect actual hours worked. Fourth, has increased work intensity led to unsustainable increases in productivity? The answer is not clear but, in my view, is probably 'no'. Unsustainability would hinge on the presence of excessively long hours, combined with fast pace of work. Quiggin relies on 1995 survey evidence of increases in worker stress, although this does not establish that the stress has in general reached unsustainable levels. As noted above, average hours worked rose between 1983 and 1994, after which they remained stable. That is, much of the productivity surge came after the trend toward longer hours had petered out.

A number of studies in a volume edited by Williams, Draca and Smith (2003) have examined differences in productivity performance across states within Australia. In a sense, they provide a cross-sectional view on factors that have contributed to recent productivity improvement in Australia. However, the volume presents analysis of different contributors in separate rather than comprehensive fashion and does not focus directly on the role of policy reforms. The studies suggest that differences in R&D effort, human capital and physical capital intensity have been important in explaining interstate differences in productivity levels and growth.

Overall, the evidence points to a similar conclusion to the more general one found in the OECD Growth Project — the importance of accumulation of physical and human capital, combined with a policy and institutional environment that promotes competition, openness and flexibility. The proposition that policy reforms had an important influence on Australia's productivity revival is strong on both *a priori* and empirical grounds, although the empirics fall short of conclusive proof. The formal analyses are supportive, but are few in number and have some weaknesses in specification. Other evidence appears strongly supportive, but lacks formal rigour. The main counter argument — that policy reforms generated a mismeasured or unsustainable effect on productivity through increased work intensity — is not well supported.

The studies considered above suggest that trade liberalisation, use of ICTs, R&D, labour market reform, increased competition, and human capital accumulation contributed to

the productivity surge. But the relative size of the contributions is not clear, given limitations in the specification of models and variables. Further evidence on these and other factors is now examined for confirmation of their importance and to attempt to put some orders of magnitude on their contributions.

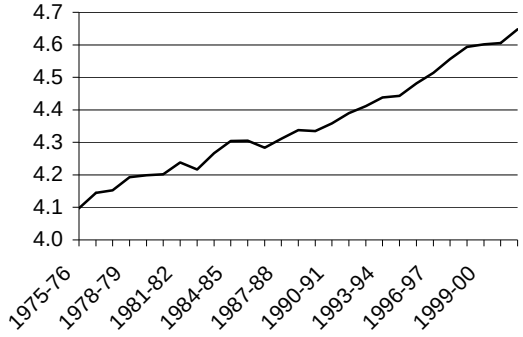
iii) Openness, trade liberalisation and manufacturing productivity

Openness to trade is thought to promote output and productivity growth in three ways: it allows countries to specialise in activities in which they have some comparative advantage or can access scale economies; it can bring stronger import competition which can stimulate innovation and weed out inefficiencies or poorer performing firms or activities; and more trade can promote accumulation and transmission of knowledge as a foundation for imitation and innovation. Some gains — especially in transfer of knowledge — can also come through direct foreign investment.

These sources of gain are a mixture of the theoretically 'old' and 'new'. The traditional, neo-classical theory draws attention to the static (reallocative) gains from trade — improvements in levels of output and productivity — although free-trade advocates have also called on the possibility of dynamic (ongoing) gains. In endogenous growth models, trade is seen as one means of assisting the accumulation and transmission of knowledge. However, openness is not sufficient for an individual country to experience output and productivity growth. A local capacity built on skills and R&D effort is also considered necessary to absorb technology and avoid specialisation in low-skill, low-productivity-growth activities. Hence, whether greater openness promotes a country's growth is an empirical matter. Edwards (1998) is one who has found strong empirical support for a positive relationship between aggregate MFP growth and openness across countries. Rodriguez and Rodrik (2001), for example, have argued the sceptical case.

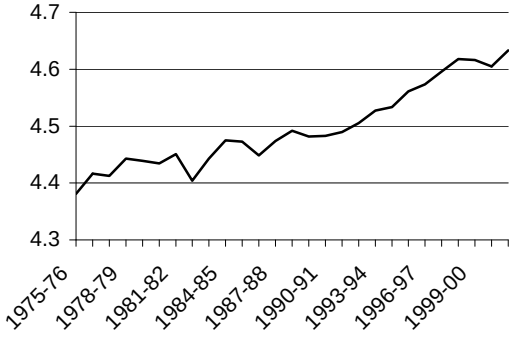
The Australian economy has become much more open over the past two decades. The trade intensity ratio (the ratio of exports plus imports to GDP) increased quite rapidly from the mid-1980s — from around 27 per cent to around 45 per cent in the early 2000s. (The trade intensity ratio in Figure 3 is juxtaposed with LP in Figure 1 and MFP in Figure 2.) The stock of direct foreign investment has also increased from around 17 per cent in proportion to GDP in the mid-1980s to around 30 per cent in recent years (ABS Cat nos 5302.0, 5206.0). Progressive relaxation of trade and investment barriers have been a major contributor. For example, effective rates of assistance for manufacturing have declined steadily from the mid-1980s, from about 20 per cent to about 5 per cent (PC 2002b).

Figure 1: ***Labour productivity (ln)***



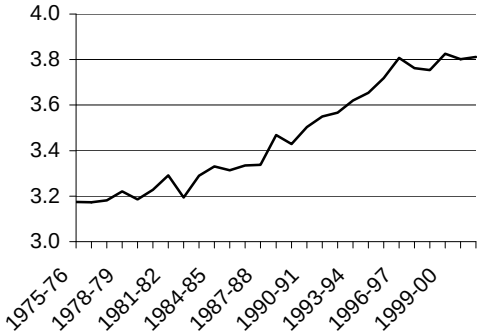
Source: ABS Cat. no. 5204.0.

Figure 2: ***Multifactor productivity (ln)***



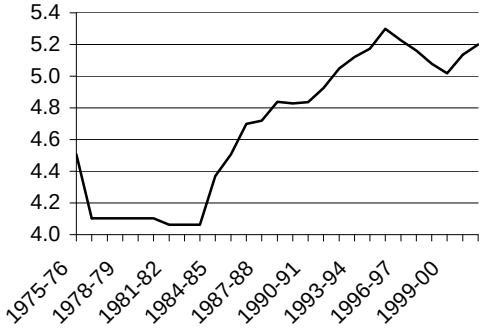
Source: ABS Cat. no. 5204.0.

Figure 3: ***Trade intensity ratio (ln)***



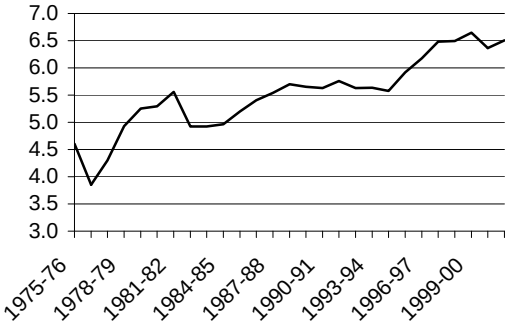
Source: ABS Cat. nos 5302.0, 5206.0

Figure 4: ***Business R&D intensity)***



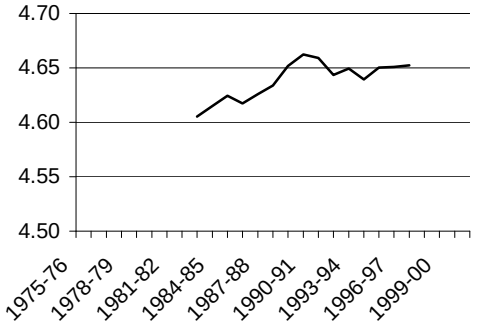
Source: IC (1995), ABS Cat. nos 8112.0, 8104.0.

Figure 5: ***ICT capital deepening (ln)***



Source: Parham, Roberts and Sun (2001).

Figure 6: ***Labour skill composition component (ln)***



Source: Barnes and Kennard (2002).

The possible growth effects of opening the Australian economy have been analysed in two main ways.[14] First, elasticities have been generated from cross-country empirical models. Dowrick (1994) estimated an elasticity of productivity growth with respect to changes in the trade ratio in a model of growth that allowed for capital accumulation, employment growth and technology catch-up, as well as openness to trade. The

[14] There are several studies of trade liberalisation based on general equilibrium models. These have tended to focus on resource reallocation effects, rather than improvements in technical efficiency and innovation.

combination of Dowrick's elasticity on openness and the change in trade intensity observed since the mid-1980s implies additional ongoing productivity growth of a little over a half a percentage point a year. The OECD (2003b) also undertook a cross-country study and their elasticity implies that increased openness of the magnitude witnessed in the Australian economy would raise productivity levels on average by just over 7 per cent.[15]

Second, a stream of studies has focussed more narrowly on the effects of trade liberalisation on productivity growth in Australia's manufacturing sector. However, manufacturing presents a puzzle, if a productivity response to trade liberalisation was expected. As shown in section II, there has been no acceleration in manufacturing productivity growth — at least in MFP terms. A Productivity Commission study (PC 2003) found that while manufacturing showed stronger LP growth in the 1990s, its MFP growth slumped in the mid-1990s (around 0.7 of a percentage point below long-term trend) at the very time market sector productivity growth was at its peak. However, intra-industry trade (exports plus imports) in manufacturing has risen quite sharply from the late 1980s indicating that the local industry has become more specialized in differentiated products, with strong growth in exports, particularly in elaborately-transformed manufactures (PC 2003). This is consistent with the presence of stronger competitive pressure, driving out less profitable activities. But it has not had much influence on productivity in manufacturing generally. The evidence on strong export growth, but weak productivity growth, tends to fit with the findings of Bodman (1996) that export growth leads labour productivity growth in Australian manufacturing, but that the magnitude of the relationship has been small.[16]

There is more temporal and cross-industry variation in productivity growth within the manufacturing sector (PC 2003). This suggests that a lack of productivity uplift in manufacturing is due to aggregation and opens the possibility that trade liberalisation has raised productivity in certain industries. Chand, McCalman and Gretton (1998), Chand (1999), Mahadevan (2002a,b), Oczkowski and Sharma (2001) and Karunaratne (2001) all used a database developed by Gretton and Fisher (1997) and all found positive productivity impacts from liberalisation in manufacturing industries. The strength of the impacts varied across industries within the sector. However, overall, the evidence is perhaps more supportive of a productivity effect than clear-cut or strong.[17]

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[15] The OECD constructed a variable to adjust trade exposure for population size. It evaluated elasticities for the impact on output per working age person from changes in trade as a proportion of GDP. Using this elasticity implies a 7.2 percentage point increase in output per person.

[16] Karunaratne (1996) also found that trade operated as an engine of growth.

[17] All bar the Oczkowski and Sharma study have transformed the output variable by multiplying value added by the effective rate of assistance, with the rationale that this procedure values output at world prices. The effect of this transformation on the empirical finding of

It is possible that the lack of a clear and general productivity response in manufacturing also reflects slow adjustment; has been delayed by lingering protection in some quarters or offsetting currency depreciation; or there could be errors in measurement in a transitional response to liberalisation.[18] Fare, Grosskopf and Margaritis (2001) compared productivity trends in Australia and New Zealand manufacturing in an assessment of the influence of different intensities of implementation of reforms. They found stronger MFP growth in New Zealand manufacturing, where the intensity of trade liberalisation and other reforms was stronger. The Productivity Commission (PC 1999) also observed a strong productivity response in whitegoods manufacture to reductions in high trade protection in the 1980s, in contrast to slower productivity growth in automotive and textile, footwear & clothing industries for which high government assistance was maintained.[19]

Nevertheless, the Australian manufacturing story could be consistent with findings from the OECD study of industry productivity across countries (OECD 2003b) that international catch-up has been faster in service industries than in manufacturing. The OECD attributed this pattern to the fact that technologies are more standardised in some service industries.

In summary, it is clear that the Australian economy has become much more open over the past two decades and that this can reasonably be attributed to policies of liberalisation. Cross-country estimates raise expectations of a positive productivity response — up to about half a percentage point in growth. But, at least on the evidence so far, manufacturing does not appear to have been a general conduit for a productivity acceleration. Increased competitive pressure from trade liberalisation has had more effect on product specialisation than productivity in manufacturing as a whole. If increased openness has had an effect on aggregate productivity growth, either better information on the productivity effects on manufacturing is needed or indirect links with productivity acceleration in other industries need to be found. As will be seen, there is evidence of the latter.

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productivity links to liberalisation is not transparent. Oczkowski and Sharma also see an inconsistency in not valuing all inputs at world prices.

[18] The productivity response to trade liberalisation could be underestimated due to changes in cost-price margins and scale economies (Harrison 1994). More rapid structural change within industries could also see premature scrapping of capital that is not reflected in the ABS capital input measures, which are based on the assumption that assets see out their expected effective lives.

[19] Productivity has improved more recently in automotive production after many years of relatively high industry assistance (PC 2002a).

iv) Technology, R&D and ICTs

Technological advance is a prime source of productivity growth. If properly handled by the statisticians, technological advances that are embodied in capital equipment raise LP growth through capital deepening, whereas disembodied advances raise MFP. In the endogenous view of growth, R&D is a means by which businesses accumulate knowledge and ideas and thereby influence the absorption and development of technology.

The empirical models confirm that R&D boosts productivity growth, although there is some doubt about the magnitudes of effects from domestic and especially international R&D. Dowrick (2003) points to evidence of spillovers from both domestic and foreign R&D, the latter being transmitted through trade (Coe and Helpman 1995). He figures from the empirical estimates of others that a 0.2 percentage point increase in foreign and domestic research intensity (R&D expenditure as a proportion of business sector GDP) would each increase Australia's MFP growth by around one-tenth of a percentage point.[20] The Industry Commission (IC 1995) estimated the elasticity of MFP with respect to domestic R&D capital to be between 0.024 and 0.081 and the elasticity with respect to foreign R&D capital to be between 0.028 and 0.8 — a range reported to be lower than for other countries. Madden, Savage and Bloxham (2001) studied a group of countries in Asia and the OECD over the 1980 to 1995 period and found a 0.06 MFP elasticity with respect to domestic R&D capital in OECD countries outside the G7. However, they found the foreign R&D elasticity to be negative in Australia's case. Engelbrecht (1997) also found a negative elasticity in a study of OECD countries over 1971 to 1990, and attributed it to insufficient domestic R&D to absorb foreign R&D. Lack of competitive incentive may also have played a part. Rogers (2002) found a negative relation in Australia between R&D intensity and industry concentration and, for manufacturing firms, between R&D intensity and trade protection.[21]

Australia's measured R&D effort has increased since the mid-1980s (see Figure 4 which shows the ratio of business R&D to GDP). Total R&D expenditure has increased from 1.12 to 1.53 per cent of GDP, and business R&D as a proportion of business output has increased from around 0.53 to 1.11 per cent.[22] Applying the latter increase to Dowrick's computations implies an increase in MFP growth of around three-tenths of a percentage

[20] The OECD (2003b) considered their finding of a 0.2 percentage point growth effect from a 0.1 percentage point (or about 10 per cent) increase in R&D intensity to be 'perhaps unreasonably' large.

[21] The OECD (2003b) found that R&D intensity in manufacturing across 18 OECD countries increases with import penetration. There was, however, an ambiguous positive effect of tariff barriers and negative effect of non-tariff barriers.

[22] Estimates of business R&D as a proportion of business output were formed from business R&D as a proportion of GDP (ABS Cat. no. 8104.0), multiplied by the ratio of GDP to business output (value added in the market sector plus property and business services).

point. The increase in the R&D capital stock has been of the order of 6 per cent a year. With an elasticity of around 0.05 (midpoint of the Industry Commission estimates and slightly under the Madden, Savage and Bloxham estimate), this also suggests an increase in MFP growth of around three-tenths of a percentage point.

It is of interest that the industry mix of R&D effort shifted in the 1990s, including toward service industries that have shown productivity acceleration. The strongest growth in R&D effort has been in mining, property & business services and finance & insurance (ABS Cat. no. 8104.0). There is also a sizeable R&D effort in wholesale and retail trade, up from its 1980s levels. Most of the R&D effort and the highest R&D intensity remains in manufacturing, but there has been little growth in the 1990s, especially since 1995-96 (PC 2003). Much of the increase in R&D in services is thought to be ICT related (PC 2003).

ICTs provide a particular example of productivity benefits to Australia from overseas development of technology. ICTs can have three effects on productivity.[23] First, rapid technological advances in hardware and software raise MFP growth in countries involved in production.[24] However, Australia imports rather than manufactures most of its ICT requirements. Second, from a user's point of view, rapid technological advances in ICTs are treated as embodied changes in capital inputs[25], so that increases in demand for numbers and power of ICTs have their principal effect on capital deepening and LP growth (Figure 5). The US, Canada, the Netherlands and Australia received the largest boost to capital service inputs from ICTs in the 1990s (OECD 2003a). Third, use of ICTs can bring disembodied MFP gains from network spillovers and complementary product and process innovations. Although the significance of this aspect is more controversial[26], the supporting evidence from firm-based longitudinal analysis and other micro studies is mounting (OECD 2003a).

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[23] See OECD (2003a) and Pilat, Lee and van Ark (2002) for surveys of the evidence on the effects of ICTs on productivity and growth. Collechia and Schreyer 2002 and Jorgenson 2003 also provide international comparisons.

[24] Close to 1 percentage point of labour productivity growth over 1995-2001 was due to ICT manufacture in Finland, Ireland and Korea. There were also gains in the US, Japan and Sweden (OECD 2003a).

[25] The advances are treated as an improvement in quality of equipment. Hedonic or constant-quality price deflators ensure that the quality improvements are reflected in volumes of ICTs purchased. The ABS currently uses hedonic price deflators developed by the US Bureau of Economic Analysis, but introduces a lag and an adjustment for exchange rate movements. Comparisons with a number of countries are affected by different treatment of quality effects (and whether software is treated as an asset). Some international comparisons, including those from the OECD, have standardised the treatment (Collechia and Schreyer 2002, Jorgenson 2003).

[26] Gordon (2000) was a prime skeptic on spillover gains, but now accepts that use of ICTs can enable complementary innovations (Gordon 2003).

Evidence that Australia has benefited from ICT spillovers does exist, but the magnitude is not large at the aggregate level. Simon and Wardrop (2001) found a strong ICT capital contribution to output growth, which also translates into a strong contribution to LP growth. In another IMF study, Cardarelli (2001) found that the ICT capital deepening contribution to LP growth has been as large as in the US and well above the European average. Parham, Roberts and Sun (2001), ABS (2001) and Parham (2002) controlled for cyclical effects, by analysing growth over productivity cycles. On that basis, they found a smaller LP effect because the increase in capital deepening due to ICT investment had been offset by slower growth in use of other forms of capital over productivity cycles. All these studies (apart from the ABS exercise) find some weak evidence for a link between ICT use and MFP growth at the industry level, but it is more obvious in high-using service industries than across all industries. Parham, Roberts and Sun (2001) and Parham (2002a) infer that, given the similarities in uptake in the two countries, Australia could benefit from ICT-related MFP spillovers up to the limit of those evident in the US.[27] Their interpretation of the US evidence suggests the presence of ICT-related MFP gains of one or two tenths of a percentage point.

Whilst this exercise does not prove the existence of ICT spillovers in Australia, support for their existence and the order of magnitude comes from other studies. Based on a cross-country regression, Bean (2000) attributed 0.12 of a percentage point of the MFP acceleration to an increase in Australia's expenditure on ICTs. Further support comes from a firm-level panel study (Gretton, Gali and Parham 2002), which found ICT-related productivity gains in the mid-1990s across a range of industries, whilst controlling for other influences. The aggregate effect across industries was between about 0.15 and 0.2 of a percentage point of MFP growth.

The last-mentioned study also gives some insight into the linkages between ICTs and productivity growth. The firm-level analysis supported the general-purpose or enabling technology view of ICTs in which they provide a platform for product and process innovation (Bresnahan, Brynjolfson and Hitt 2002). It is not just having ICTs that matters, but how firms use them as a foundation to develop new products and change work and organisation arrangements, distribution systems and so on. The study also found support for complementarities between skills and ICT use. The findings underline the importance of firm and management based innovation, in addition to traditional technology-based innovation.

It is worth emphasising that Australia's 1990s experience in the uptake and productive use of ICTs stands out in both historical and international terms. Whilst Australia was near the forefront of ICT uptake in the 1990s, this was not true of the early 1980s (OECD 2003a). And Australia is one of a very few countries to show evidence of ICT-

[27] This inference also rests on the assumption that there are no relevant differences in industry mix between the two countries.

MFP gains based on ICT use at the aggregate level (OECD 2003a). The international evidence suggests that regulatory and institutional practices have had influence in this regard. Gust and Marquez (2002) found that restrictive regulatory practices have inhibited the adoption of ICTs and productivity growth in many countries, particularly in Europe. Australia ranked low or middling on the measures of regulatory restriction they used.[28] Together with the OECD Growth Project studies, this work suggests that increased competition and flexibility have influenced the uptake of ICTs and the ability of businesses to innovate, with new or changed production arrangements. See also Feldstein (2003).

As noted above, there is an overlap between ICT use and industry productivity acceleration. Finance & insurance has been the largest investor in ICTs. Manufacturing, wholesale trade, retail trade, transport & storage and communication services have also been prominent in the uptake (Gretton, Gali and Parham 2002).[29] As in the US (Pilat, Lee and van Ark 2002), there is a correlation between increased ICT use and productivity acceleration in financial intermediation and distributive trades (especially wholesale trade). This could also extend to property & business services in Australia, although our knowledge of productivity trends in that industry is thinner.

Johnston *et al* (1999) found that competition and flexibility were influential in the strong productivity acceleration in Australia's wholesale trade. There was strong competition within the sector as well as indirect competitive pressure coming via manufacturers (eg auto makers) looking to save costs by restructuring their distribution processes. The gains have come from transforming wholesaling from a storage-based system to a 'fast-flow-through' system, based on transport logistics. Greater flexibility in work arrangements has assisted this transformation. Competitive pressure plus the flexibility to restructure has also presumably been important in the finance & insurance industry's uptake and productive use of ICTs.

In summary, there is evidence that Australia has increased its R&D effort and that this has had a productivity payoff. The empirical models suggest that the gains in MFP growth from domestic R&D could be around three tenths of a percentage point. The general evidence on international spillovers is mixed, but there is specific evidence of international spillovers from ICTs of the order of one or two tenths of percentage point. R&D in services, ICTs and firm and management-based innovation have featured.

[28] Australia was low on employment protection legislation, middling (in 1993) to low (in 1998) on regulatory burdens on startups and middling on overall regulatory burdens.

[29] Gretton, Gali and Parham (2002) find a positive relationship between ICT use and productivity growth in manufacturing. Given the steady growth in manufacturing productivity, this suggests that ICT-related productivity gains in manufacturing have been offset by other factors.

Diverse competitive pressures and greater flexibilities in labour markets appear to have been drivers and enablers.

v) Human capital

Human capital accumulation can affect productivity growth in two ways. First, the educational attainment, skills and experience embodied in workers directly influence their output per hour worked. Second, human capital can interact with other aspects of production — the rate of innovation, absorption of technology or the accumulation of physical capital. Education and training are central to the accumulation of knowledge and ideas, a feature of endogenous growth models. However, there are measurement difficulties and empirical controversies about the specific way in which education affects productivity. See Temple (2001), Dowrick (2003), Rogers (2003b) and Engelbrecht (2003). One issue is whether it is the level of human capital or the accumulation of additional human capital that matters.

Several key studies take the accumulation viewpoint. Dowrick (2003) gleans from the empirical literature and his own work (Dowrick and Rogers 2002) that an increase in the average years of schooling by 0.8 of a year could raise Australia's annual productivity growth by a third of a percentage point from both of the above direct and indirect effects. He bases his computations on the schooling data of Barro and Lee (2001). Using a different dataset on years of schooling, the OECD estimated that an additional year of schooling would raise productivity levels by between about 3 and 6 per cent in a country with Australia's current average schooling. Dowrick's computation is a combination of a productivity level effect, which is at the upper end of the OECD's estimated range, and a growth effect.

Barnes and Kennard (2002) used a growth accounting framework to explore the extent to which embodied education and skill effects have contributed to MFP growth, as measured by the ABS. They based their analysis on experimental ABS estimates of inputs of skill, which are related to gender, educational attainment and potential workforce experience. They found that growth in skill contributed around 0.2 of a percentage point to MFP growth on average between 1984-85 and 1997-98.

What do these estimates tell us about the contribution of education to Australia's 1990s productivity surge? According to the human capital accumulation view, a faster rate of increase in human capital is needed to generate a productivity acceleration. In the Barro and Lee data that Dowrick relied upon, the increase in average schooling amongst Australians, aged 25 years and over, was 0.4 of a year greater over the 1990s, compared with the 1980s. However, the OECD data suggest that average schooling in the working-age population decelerated from an 1980s increase of 0.5 of a year to a 1990s increase of 0.2 a year (OECD 2003b). The ABS estimates used by Barnes and Kennard, which include experience as well as educational attainment, suggest that the

accumulation of skill also decelerated between the 1980s and 1990s (Figure 6). Given some doubts about the trends in the Barro and Lee data (Temple 2001 and Engelbrecht 2003), the weight of evidence suggests there was a slower rate of accumulation of human capital in the Australian workforce in the 1990s, which all else equal would have *detracted* from a productivity acceleration in the 1990s.

Although they did not provide empirical support, Barnes and Kennard were careful not to rule out productivity effects associated with the *level* of education. They noted, for example, that OECD countries with high rates of ICT take up also had relatively high levels of average schooling. On both Barro and Lee and OECD estimates, Australia has had relatively high average schooling over a number of decades. This also suggests that human capital has not operated as a constraint on Australia's earlier productivity performance, relative to other countries.

vi) Infrastructure

Infrastructure industries have made a major direct contribution to Australia's productivity performance over the past two decades. Productivity growth has been strong and has accelerated in electricity, gas & water, communication services and transport & storage (Table 1). However, only in transport & storage has productivity growth picked up in the 1990s.

According to another branch of endogenous growth theory, public spending on infrastructure can also have indirect spillover effects on aggregate productivity. In the Australian context, Otto and Voss (1994, 1996) found that, from the mid-1960s to the end of the 1980s, public capital stocks had a positive effect on MFP growth in private sector industries. Madden and Savage (1998) found that telephone infrastructure (as measured by the number of telephones and telephone lines per head) increased Australia's GDP per employee over 1950 to 1994. They saw this result as supporting the view that improved communications brings lower transport and transactions costs, improved marketing information and accelerated diffusion of knowledge.

However, as Dowrick (2001) noted, Australian public investment has been declining rather than increasing since the mid-1980s, making it unlikely that an increase in public infrastructure could help explain Australia's productivity surge. Nevertheless, it may be that technological advances and improvements in efficiency (for example, in communications and transport) have enabled new services and better utilisation of infrastructure and that these may have brought spillover gains to other Australian industries such as agriculture, mining and distribution (wholesaling), where there have been substantial productivity improvements. However, there appear to be no studies available to shed light on this issue.

vii) Factor markets

Empirical studies generally find that the link between product market competition and productivity growth is positive and robust and, increasingly, they also find that dynamic efficiency gains from product market competition require well-functioning factor markets to reallocate labour and capital (Ahn 2002). This was revealed in general terms in the OECD Growth Project and specifically in relation to the rate of uptake of ICTs and the ability to use them to greatest advantage (Gust and Marquez 2002).

Improvements in the operation of capital markets could have played a role in Australia's 1990s productivity surge. Over the past two decades Australia has moved from exchange controls and rationing of capital to unrestricted capital movements allocated by more sophisticated institutions and processes for lending, capital raising and corporate governance.[30] In addition to the Growth Project analysis, the survey of Edison *et al* (2002) suggests that capital account liberalisation and stock market liberalisation have had positive effects on growth in developed countries. Australia's finance & insurance industry also contributed to the aggregate productivity uplift in direct and substantial fashion through its own improved productivity performance.

Labour markets have become more flexible, particularly with greater focus on enterprise bargaining. As noted in this survey, there is a range of evidence that flexibility in labour markets has allowed work and organisational arrangements to be restructured and labour to be reallocated; and has facilitated the productive use of technology. Loundes, Tseng and Wooden (2003) surveyed the literature and found that, whilst there were indications that the introduction of enterprise bargaining had improved Australian productivity, lack of data has frustrated analysis that might provide conclusive proof. Nevertheless, Fry, Jarvis and Loundes (2002) found that organisations that have embraced industrial relations reforms had significantly higher self-assessed LP compared with their competitors, after controlling for other influences.

IV Conclusion

There is sufficiently robust evidence to establish six stylised facts about Australia's productivity performance in the 1990s. First, LP and MFP both accelerated strongly — by around 1 percentage point or so. Second, the acceleration in LP was due to increased efficiency (MFP) rather than additional capital deepening. Third, the shift in MFP growth got underway in the early 1990s. Fourth, from an international perspective, Australia went from a long-held position of productivity growth laggard to become one of the OECD frontrunners. Fifth, the productivity acceleration has been broadly based across industry sectors, has included a new set of service industry contributors, but bypassed the manufacturing sector at the aggregate level in the mid-1990s. Sixth, the

[30] Rogers (2003a) finds evidence from a 1995 survey of firms that competition is positively related to productivity, but in management-operated firms rather than owner-operated firms.

productivity acceleration was associated with growth in both labour and capital inputs that was above long-term trend.

The evidence from formal models on the sources of Australia's productivity revival is not extensive. There are few analytical studies of Australia's aggregate productivity performance in general and very few on the sources of the recent surge in particular. However, some insights into the sources of productivity improvement can also be gleaned from cross-country studies and industry sector analyses (as well as case studies and less formal observation of correlations between trends in productivity and its determinants), although most of the cross-country studies do not allow for specific market, institutional and policy conditions that are relevant to Australia. These are important. A major insight from the OECD Growth Project was that particular policy and institutional factors separated the stronger performing countries from the weaker performers in the 1990s.

Despite its shortcomings, the empirical literature presents a reasonably clear picture of the major determinants of Australia's productivity growth and its revival in the 1990s. The accumulation of physical and human capital has provided a foundation for productivity growth over the long term. Specifically on the 1990s revival, however, available empirical studies point towards openness and domestic R&D (and innovation generally) as having major positive effects. Whilst the general evidence on spillovers to Australia from international R&D is unclear, there is evidence that Australia has also reaped spillover gains from the ICTs developed elsewhere. Whilst the *level* and type of available human capital has likely also played a part, the timing of *accumulation* in human capital does not fit the timing of the 1990s productivity acceleration.

Although specific magnitudes remain uncertain, the estimates suggest increases in productivity growth of the following orders of magnitude in response to changes witnessed in the Australian economy since the mid-1980s: half a percentage point from increased openness, three-tenths of a percentage point from domestic R&D and two-tenths from ICT-related innovation. However, since estimation has not been precise, these orders of magnitude should be treated with caution. It is also by no means clear that they are additive. For example, the ICT-related gains could be at least partly due to domestic R&D (and indirect human capital effects). Nevertheless, the orders of magnitude are broadly consistent with the observed productivity acceleration.

The crucial underlying issue, though, is why Australia became more open, increased its R&D effort, and invested heavily in and found innovative uses for ICTs. The Australian evidence supports the OECD conclusion that policy and institutional factors have been instrumental in driving and enabling improved productivity performance in the 1990s. Policies that have opened the economy and strengthened competition have provided incentives to be more productive and provided access to new technologies and

knowledge. Policies that have encouraged more flexiblity in product and factor markets have given firms greater ability to adjust and innovate. Policies have also provided incentives for more R&D effort since the mid-1980s. Other factors are likely to have also contributed. Stability in the macro environment (due again in part to policy action) would have helped to maintain output and improve productivity. Notwithstanding the macro evidence on human capital accumulation, specific skill formation in workers and management have assisted innovation and specifically innovation associated with the use of ICTs.

The combination of proximate and underlying influences is at least capable of providing a plausible explanation for Australia's productivity revival that fits the stylised facts. Greater openness, competition and flexibility, were taking effect by the early 1990s. They help explain the delivery of sizeable efficiency gains and why, with the relaxation of policy constraints, Australia moved from productivity growth laggard to the international forefront. They also help explain why productivity improved in service industries, partly due to ICTs and associated innovation. On the coexistence of strong growth in productivity and inputs of capital and labour, improved efficiency of operation of factor markets may have had some positive effect.

The empirical studies point to a combination of level and growth effects in Australia's productivity revival. There is a strong element of catch-up as improvements in technical efficiency has shifted the economy towards production possibilities that have already been established in other countries. This would see Australia's productivity growth slow, as the gaps with other countries narrow. But there is also an element of frontier-shifting innovation, most readily seen the application of ICTs to new products and processes. This element suggests higher productivity growth could be ongoing. Dowrick (2003) has also predicted ongoing productivity gains associated with the development and absorption of knowledge and ideas.

Finally, there is scope for more research to improve understanding of Australia's productivity performance. Some of the areas indicated in this survey are: further analysis of productivity spillovers from R&D, education and training and economic infrastructure; further analysis of the effects of competition, openness and operation of factor and product markets; and the measurement of productivity. Complementary research at the aggregate, industry and micro level is needed. Given the importance of differences in behaviour at the firm level, micro analysis is especially important in improving understanding of how technological, organisational and policy influences combine to affect productivity growth.

Appendix 1 Existence, timing and size of a structural break

This appendix reviews evidence on the existence, timing and extent of a productivity shift in the 1990s. A complicating factor is the need to allow for the likely effects of the early 1990s recession.

The ABS method of calculating productivity growth between peaks in productivity cycles is one way of controlling for business (and other) cycle effects. As shown in Table 1, the ABS productivity-cycle averages reveal a 1.1 percentage point acceleration in underlying MFP growth in the mid-1990s cycle, compared with the previous cycle. Casual inspection of the ABS productivity cycles suggests a surge beyond the performance typical of the late 1970s and 1980s took place from 1993-94.

Another way to circumvent effects of the business cycle is to use the ABS trend series (estimated by the ABS from an 11-period Henderson moving average). This series suggests a turning point in 1990-91. With that year as the dividing point between the 1980s and the 1990s there is an acceleration of around 0.9 of a percentage point.

Quiggin (2001) selected periods based on the business cycle and found MFP growth of 1.2 per cent a year over the period 1988-89 to 1999-2000 and 0.7 per cent a year over the previous period (1981-82 to 1988-89) — a 0.5 percentage point acceleration. However, as Quiggin recognised, the business cycle approach is sensitive to selection of peak at the end of the 1980s. He selected 1988-89 as a business cycle peak based on a review of 'GDP, unemployment and other macroeconomic data'. However, others have identified 1989-90[31]; and the ABS series on market sector output also puts 1989-90 as the peak. Quiggin reports that, when 1989-90 is used, annual MFP growth accelerates from 0.4 per cent in the 1980s to 1.4 per cent in the 1990s — a 1 percentage point acceleration. Thus, whilst Quiggin's preferred figures show a quite sizeable 0.5 percentage point acceleration in MFP, there are grounds to view this estimate as biased downward.

Gruen and Stevens (2000) adopted a business cycle approach, but their method is less sensitive to period selection because trends are fitted through productivity estimates from business cycle troughs to peaks. They found an 0.9 percentage point acceleration between the period 1982-83 to 1989-90 and the period 1990-91 to 1998-99.

Parham (1999, 2000) illustrated a structural break in Australia's 'growth path' formed from a plot of annual observations of labour productivity against the capital-labour ratio.[32] Observations in the 1990s depart from the projection of a curve fitted to

[31] For example, Gruen and Stevens (2000). Quiggin notes that the Melbourne Institute put the peak at late 1989.

[32] An increase in the contribution of MFP, relative to capital deepening, shows as a vertical shift or a steeper gradient in the string of observations. The fitted curve captures the historical

historical observations. Although the timing of the departure cannot be determined precisely, Parham notes the different behaviour in the 1990-91 recession (labour productivity consistent with the fitted historical pattern at the observed capital-labour ratio), compared with the 1982-83 recession (labour productivity below the historical pattern at the observed capital-labour ratio). This could indicate that the 1990s recession brought a more thorough shake-out of labour and less productive firms and operations. If so, the structural break in productivity could have occurred as early as 1990-91.

Dowrick (2001)[33] observed from annual changes in a three-period moving average of MFP that productivity growth had returned to golden age rates by 1993-94. He also used an error correction model to analyse productivity trends and found a 1.4 percentage point uplift in underlying MFP growth in the 1990s, purged of cyclical effects. He introduced period effects defined by business cycles, with his 1990s period starting in 1990-91. Whilst he formally established a structural break from 1990-91, he did not explore other possibilities for the timing of the break.

The Productivity Commission (PC 2003) also used an error correction model with periods defined by productivity cycles and found a structural break (albeit weaker at 0.9 of a percentage point) from 1988-89. Recognising the possible drawback in pre-specifying the timing of breaks, the Commission went on to use a time series model that did not impose any external timing information on the detection of changes in trend. It found distinct changes in trend productivity growth, from a low of around 0.5 per cent a year in the mid-1980s and a steady climb from the late 1980s to a high at over 1.5 per cent a year in the mid-1990s. These results confirm the existence of a strong 1990s productivity surge of around 1 percentage point via a method that is not sensitive to period selection or cyclical effect.

In conclusion, the evidence of a strong productivity surge in the 1990s is strong. Estimates of the size of the acceleration in MFP growth (adjusted for capital composition effects) fall within the bounds of 0.5 to 1.4 percentage points, although there is some doubt about the lower-end estimate. Giving weight to methods that make formal allowance for cyclical effects and are less sensitive to period selection, there are strong grounds to conclude that the acceleration has been around 1 percentage point or so. Certainly, the official ABS estimate of 1.1 percentage points has strong support. The timing remains difficult to pinpoint. The shift could have started in the midst of the recession. But it seems to have been clearly established by 1993-94.

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relationship up until 1990-91. It is non-linear to allow for relatively fast MFP growth in earlier decades followed by a period of slower growth.

[33] This paper is a refinement of earlier work (Dowrick 1998).

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