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IT use and Australia's productivity: Where are we now?

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About this report

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Contents

Executive summary ... 1
1 Introduction ... 4
2 How ICTs affect productivity ... 7
3 Setting the scene: trends in IT use and productivity ... 11
4 The growth accounting approach ... 23
5. Data ... 29
6 Key findings ... 32
7 Conclusions ... 52
References ... 54
A. Manufacturing ... 55
B. Electricity, gas, water and waste services ... 66
C. Wholesale trade ... 76
D. Retail trade ... 89
E. Transport, postal and warehousing ... 103
F. Information, media and telecommunications (IMT) ... 113
G. Financial and insurance services ... 126
H. Rental, hiring and real estate services ... 139
I. Professional, scientific and technical services ... 150

Executive summary

Digital technologies such as fast computers, portable devices, remote sensors, and 'smart' machines are key foundations for the transformation of businesses in almost all industries. They provide a platform for innovation and growth.

Earlier research at the Productivity Commission showed the accelerated use of computers brought substantial productivity gains in the 1990s. Australia was one of the first countries to realise productivity gains from the innovative use of information and communication technologies (ICTs).

Measuring productivity gains from ICTs is now more challenging, as digital technologies are no longer primarily confined to 'connected computers', but are embedded in all sorts of machinery, equipment and household goods. Changes in products and processes can be significant, but their productivity effects can be difficult to quantify. More sophisticated data and analysis, and a multifaceted approach, are required.

This paper takes a first step by revisiting the earlier Productivity Commission work. Like the earlier work, this paper covers computer hardware and software only, as the necessary data from the Australian Bureau of Statistics (ABS) do not allow separate identification of digital communications equipment. This paper generally refers to 'information technology' (IT) rather than information and communications technology (ICT).

Growth accounting, which attributes Australia's labour productivity growth to various components, identifies contributions from 'capital deepening' (use of capital assets such as buildings, plant, machinery and equipment increases more rapidly than labour) and 'multi-factor productivity' (MFP; MFP growth comes through innovation in business products and processes).

Computers, and ICT in general, are labour-saving. They can substitute for existing use of labour or use of them can grow more rapidly, relative to growth in labour, as output expands. Either way, the ratio of IT capital to labour increases, which is capital deepening. Computers increase labour productivity by adding to the capital available to labour.

The contribution of computers to capital deepening can be separated from the contribution of other forms of capital. Computers (and ICT) can also influence MFP growth. They provide a platform upon which users can develop product and process innovations. These computer-based innovations cannot be separated from other types of innovations in the growth accounting framework.

The paper also adds an important extension to the earlier work. The analysis focusses on the possibility that IT can also have a capital-saving effect. That is, IT can reduce the requirements for other forms of capital in the production of goods and services, which also means a lift in (non-IT) capital productivity.

Key findings

The key findings below generally identify statistical associations rather than the causal mechanisms:

- Growth in the stocks of IT—as measured by the ABS—has slowed.

  - From 2003-04, the rate of growth over the following ten years was about 60 per cent of the rate of growth over the previous decade (from 1993-94).
  - A sharp slowdown in the growth of computer hardware from 2007-08 was a large factor.
- The rate of IT capital deepening has declined.
  - This has meant a slower rate of IT capital deepening or substitution of computers for people. Importantly, the rate of growth in labour has been about the same in both decades. The decline came from slower growth in IT.
  - IT capital deepening contributed about 0.5 of a percentage point to annual labour productivity growth in the decade from 2003-04, compared with 0.8 of a percentage point in the decade from 1993-94.
  - This represented about 25 per cent of both the 3.1 per cent a year growth in labour productivity in the earlier decade and the 2.1 per cent a year growth in labour productivity in the latter decade.
- There is a wide variation in the size of IT capital deepening effects across industries.
  - The strongest substitution of IT for labour occurred in the finance industry, followed by the information, media and telecommunications industry, wholesaling and construction.
- Evidence supports the view that IT also has a capital-saving effect.
  - Increased IT use is correlated with improvements in the productivity of other assets.
  - The clearest case of a potential link is that IT may have enabled a reduction in the use of land and buildings. Further research is needed to provide firm evidence.
  - There are also possibilities across a range of individual assets and individual industries. The finance industry showed the strongest rise in non-IT capital productivity.
- IT and skilled labour appear to be complements.
  - While IT substitutes for unskilled labour, skilled labour is able to use IT to positive effect. The finance industry is a prime case in point.

Conclusion

The effects of IT use on Australia's productivity through a labour-saving effect seem to have diminished.

However, further information and analysis are required before coming to a firm conclusion on this. The slowdown in investment in computer hardware from 2007-08 needs to be better understood. It could be a temporary pause because of the uncertainty created by the global financial crisis, or it could be that more of computers' work is now being performed by smart phones and similar devices, which are not included in this analysis due to data limitations. A strong pickup in IT growth in recent times seems at least consistent with the 'temporary pause' explanation.

The effects of IT use on labour are complex. While there are substitution effects, there is also a complementarity between IT and skilled labour. This implies that obtaining qualifications and developing IT-related skills could help reduce the possibility of becoming displaced from work in the digital age.

IT use also has the potential to generate productivity-enhancing effects through capital saving. Better coordination and information processing achieved through use of IT enable businesses to conserve on their use of other assets, such as land and buildings. Examples are the closure of bank branches and the transformation of the wholesaling function from storage-based operations to minimum-handling logistics. Vehicles and machinery can be used more sparingly.

Overall, the use of information technology is still generating productivity effects in Australia—in different ways, in different industries. IT also complements skilled labour and saves certain forms of capital.

The transformation of businesses based on digital technologies is a complex story with many variations. Analysis of how digital technologies affect productivity needs to take account of variations in production and investment strategies at the level of firms. Government policies need to ensure the business environment is geared in general ways to stimulate and enable innovation based on digital technologies. The widespread, multifaceted and 'organic' way in which ICT-based innovation takes place runs counter to the notion of specific policies directed in specific areas.

1 Introduction

1.1 Background

Australia's productivity growth surged in the 1990s. Multifactor productivity growth rose to a record high of 2.6 per cent a year in the mid-to-late 1990s, compared with a long-term average of 0.9 per cent a year.[1]

Information and communications technologies were shown to have played an important part in this surge. Productivity gains came from innovative uses of ICTs and were most obvious in services industries including wholesale trade, retail trade and finance.[a]

It became evident internationally that ICTs were bringing potential productivity gains, although they were not realised uniformly. Along with the US, Australia was early to access gains from ICT use.

The apparent inability of some countries to access productivity gains led to careful international analysis.[2] The business environment firms operate in was found to matter. Countries with strong competitive pressures and institutions that allowed rapid change in organisational structures had the drivers and flexibility to introduce new business models that ICTs enabled.

In this regard, the series of microeconomic reforms introduced in Australia are seen as an important precursor to the innovative use of ICTs. The reforms sharpened competitive pressures, opened the economy—including to technologies developed overseas—stimulated industry restructuring and allowed more flexibility to introduce new production arrangements.

It was also found that innovative use of ICTs needed other complementary investments.[3] The firms achieving success in innovative use of ICTs were also investing in intangibles. That is, they invested in firm-specific skills; organisational structures and means of linking closely to markets so they could better define directions for productive change.

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[1] ABS , Australian System of National Accounts, Cat. No. 5260.0.55.002, 2013–14 issue, 31/10/2014

[2] OECD (Organisation for Economic Co-operation and Development) (2004), The Economic Impact of ICT: Measurement, Evidence and Implications, OECD, Paris.

[3] Brynjolfsson, E., L.M. Hitt and S. Yang (2000), 'Intangible Assets: How the Interaction of Computers and Organisational Structure Affects Stock Market Valuations', MIT Working Paper, Massachusetts Institute of Technology, Massachusetts.

1.1.1 Research focus

Australia's productivity growth slumped in the 2000s and MFP growth has even been negative over an extended period.

To a large extent, the slump is due to some extraneous factors including the mining boom and increased capital requirements in the utilities sector.[4] The slump is not expected to go on indefinitely but productivity growth is unlikely to return to its surge rates.

Nevertheless, it is possible that fewer gains have been realised from the use of ICTs. Some of the opportunities for innovative use may have been exhausted or the business environment may have become less conducive to innovative use.

On the other hand, ICTs continue to be more pervasive and exist in new forms, which could have opened up new productivity opportunities. Productivity gains may be there but may have been swamped by other productivity developments, or do not show up because they do not fit standard measurement techniques.

These were the key questions raised in the initiation of Bureau of Communications Research's (BCR) Digital Productivity Project.[5] BCR commenced the project at the time of its establishment in 2014 to further economic analysis in this area, and in order to better understand the economic impact of digital development in Australia.

This current paper was envisaged as the first of a number of initiatives to be carried out as part of the Digital Productivity Project. However, with changes to the Machinery of Government in October 2015, the BCR no longer has ongoing responsibility for analysis of digital productivity and this paper will be the last initiative in the project.

1.2 Analysing digital productivity

Measuring the effect ICTs and digital technologies have on productivity has become a lot harder as they have become more sophisticated and pervasive.

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[4] See for example: PC (Productivity Commission) (2004), 'ICT Use and Productivity: A Synthesis from Studies of Australian Firms', Commission Research Paper, Productivity Commission, Canberra. Parham, D. (2012), 'Australia's Productivity Growth Slump: Signs of Crisis, Adjustment or Both?', Visiting Researcher Paper, Productivity Commission, Canberra. Topp, V. and T. Kulys (2012), 'Productivity in Electricity, Gas and Water: Measurement and Interpretation', Staff Working Paper, Productivity Commission, Canberra

[5] BCR (Bureau of Communications Research) (2015), 'A primer on digital productivity', Department of Communications, Canberra, May.

Around the late 1990s and early 2000s, analysis of digital productivity was confined to the productivity effects of hardware and software that is computers, because it was just after desktop computers became widely available and were connected through the Internet.

Back then, communications networks and services, computer services, and various embedded digital technologies such as on-board computers in motor vehicles, and the 'internet of things', that is machines communicating with machines were not included. But they are now pervasive and very much a part of the digital transformation taking place throughout the economy.

This paper was conceived as an initial foray into the broad area of digital productivity. In essence, it is an update of the Productivity Commission work in the early 2000s and asks '*Where are we now?*' The same scope of digitisation, that is 'connected computers', is used. We realise the analysis of digital productivity is now much broader, has many conceptual challenges and requires confrontation of difficult measurement issues, but those issues are beyond the scope of this paper.

Traditional growth accounting is the centrepiece of this current investigation. Being based on national accounts data, it takes the traditional scope of digital technologies that encompasses computer hardware and software. Like previous analysis, it does not include communications equipment or infrastructure.

In section 2, we will refer to ICTs in setting up the analytical framework as that is where the principles apply. The implementation in subsequent sections, however, is restricted to information technology.

We introduce some new perspectives and provide some new insights in this paper. Traditional analysis has focused on the relationships between IT, labour and labour productivity. Here, we also consider relationships between IT, other forms of capital and capital productivity.

The growth accounting approach can only tell part of the digital productivity story, as will be explained in section 4. But we regard it as a good place to start.

2 How ICTs affect productivity

In this section, we set out a conceptual framework for analysing the effects ICTs can have on productivity.

2.1 Links between ICTs and productivity

There are three ways ICTs can affect labour productivity.

2.1.1 MFP gains in the production of ICTs

Producers of ICT equipment can add product enhancements such as more powerful processors and more on-board storage in computers. When they do this, they make higher-quality products (increase their output) without increasing their use of inputs by much, if at all.

This is an example of a multifactor productivity (MFP) gain in ICT-producing industries.

Figure 2.1 illustrates the nature of an MFP gain. The starting point is a production function that combines labour (L) and capital (K) to generate output of goods and services (Y). It can be written as:

$Y = f(K, L).M$ where $f(.)$ represents an unspecified function and M is MFP.

Dividing both sides of the equation by L:

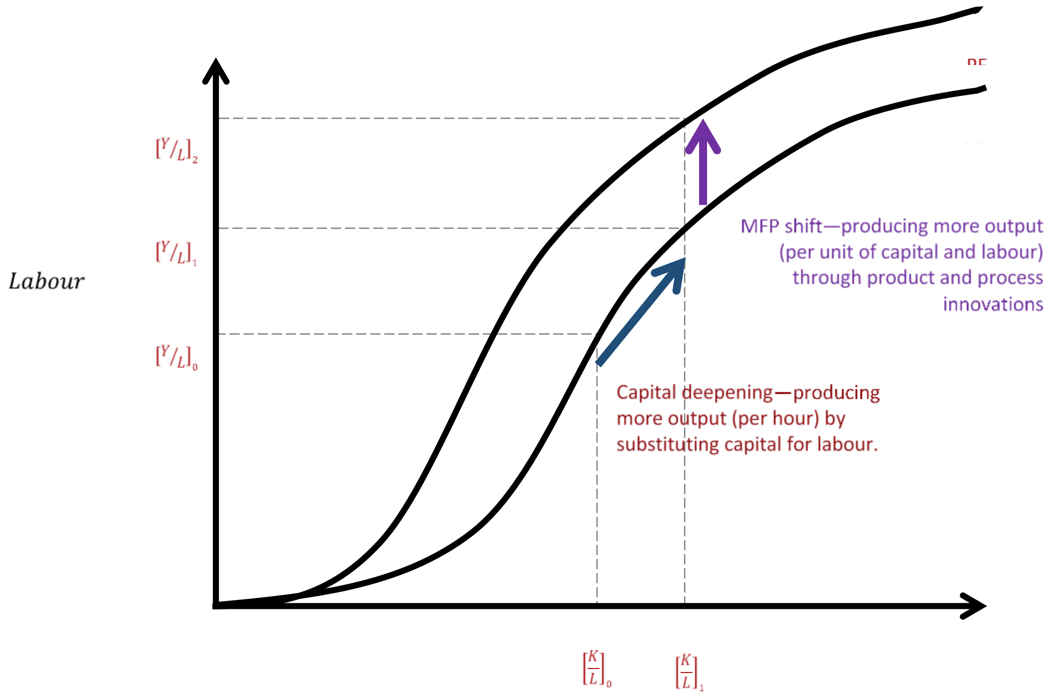
$$\frac{Y}{L} = f\left(\frac{K}{L}, 1\right).M$$

This says labour productivity $({}^{Y}/_{L})$ is a function of the capital-labour ratio and MFP.

In Figure 2.1, the capital-labour ratio is on the horizontal axis and labour productivity on the vertical axis. With MFP at its initial level the initial production function is shown as PF_0. With an initial capital-labour ratio of $[{}^{K}/_{L}]_1$ output produced per unit of labour, or labour productivity, is $[{}^{Y}/_{L}]_1$.

The ability of ICT producers to produce more powerful computers is a technological advance or increase in MFP represented as a shift in the production function to PF_1. With the same input ratio of $[{}^{K}/_{L}]_1$ labour productivity increases to $[{}^{Y}/_{L}]_2$.

Figure 2.1 Illustration of how ICT production and use can affect productivity



2.1.2 Capital deepening in using industries

We now move to the productivity gains that can be derived through the use of ICTs. Since Australia does not produce a lot of ICTs, gains from using them are much more pertinent for us.

ICTs can offer businesses opportunities to invest in them, rather than employ labour when it comes to routine tasks. For example, computers can perform routine account-keeping tasks that used to be performed by staff.

That is substitution of capital for labour, or capital deepening. It is represented in Figure 2.1 as an increase in the capital-labour ratio from $[K/L]_0$ to $[K/L]_1$. Since there is no change in MFP, production is read off the original production function PF_0. Labour productivity rises from $[Y/L]_0$ to$[Y/L]_1$.

Constant MFP means there is no fundamental change in products or processes. Firms are essentially going about the same business in the same way. There is a shift around the same production function.

The capital-deepening mechanism—ICTs substitute for labour—comes about because ICTs provide a cheaper way of doing essentially the same things. As computers and related technologies have become more powerful, cheaper and easier to use, businesses have chosen to use more of them, relative to the amount of labour they use, to produce their goods and services.

2.1.3 MFP gains in using industries

ICTs can provide further opportunities for productivity gains by providing a platform for using firms to develop and introduce innovations in their own products and processes. For example:

- New products—businesses have used ICTs to produce information-hungry financial products, provide the convenience of automatic teller machines, sell travel and accommodation bookings to widely-dispersed customers via the internet and coordinate and sell real-time back loading of transport vehicles.

- New processes—businesses have used ICTs to better coordinate activities in different locations, streamline business processes, provide remote sensing, gather more information and carry out more analysis to improve efficiency and reduce waste.

This is represented as a shift of the production function akin to the case presented above for producers of ICTs. This time, however, the reference is to producers of other goods and services.

In practice, innovative use of ICTs is likely to combine both elements—a shift around the production function with cheaper ICTs and a shift of the production function with the new product or process.

2.2 ICTs as a disruptive general-purpose technology

The sorts of innovations ICTs have enabled are not just incremental. They can require and enable fundamental change in a firm's operation. That is why they are often linked to new business models—producing quite different products and in quite different ways. Because of the fundamental changes they can bring they are also referred to as disruptive technologies.

ICTs have brought widespread as well as disruptive change throughout the economy, and because of this combination, many have classed them as a general-purpose technology. A general-purpose technology rewrites the way production in an economy is structured and organised. Examples of general-purpose technologies include the steam engine, electricity and the motor vehicle.[b]

2.3 The need for complementary investments

The innovation gains from ICTs normally need deep change—disruption, transformation and development of new business models—which can be costly.

Other complementary investments are needed to bring about all the changes required to realise productivity improvements. Complementary investments could be in: research and development to develop suitable software systems, gathering customer information and setting up databases, training staff in the use of new information systems, restructuring an organisation and reassigning tasks and responsibilities.

Recognition of the importance of complementary investments has led to recent research interest in investments in intangibles.[6] The intangibles that are commonly measured are:

- Computerised information—software and computerised databases.
- Innovative property—scientific and non-scientific R&D and design.
- Economic competencies—brand equity, firm-specific human capital and organisational capital.

Barnes and McClure[7] found that about one-third of Australia's investment in 2005–06 was in intangibles. Elnasri and Fox[8] found the share had slipped to about a quarter by 2012–13, largely due to growth in tangible investment in the mining industry. They also noted the ABS national accounts data covered only 42 per cent of total intangible investment in 2012–13.

[6] Corrado, C., C. Hulten and D. Sichel (2006), 'Intangible Capital and Economic Growth', NBER Working Paper No, 11948, National Bureau of Economic Research, Cambridge, Massachusetts.

[7] Barnes, P. and A. McClure (2009), 'Investents in Intangible Assets and Australia's Productivity Growth', Staff Working Paper, Productivity Commission, Canberra.

[8] Elnasri, A. and K.J. Fox (2015), 'The Contribution of Research and Innovation to Productivity', UNSW Economics Discussion Paper 2014–08 (updated).

3 Setting the scene: trends in IT use and productivity

This section presents trends in investment in, and holdings of, IT assets throughout the Australian economy during the 1990s and 2000s. The decades before and after 2003–04 are compared. These correspond broadly to a high productivity growth period (1993–94 to 2003–04) and a low productivity growth period (2003–04 to 2013–14).

A specific objective is to identify industries that are heavy or growing users of IT and those that have had strong productivity growth. These industries warrant closer attention in the growth accounting.

The data in this section covers three assets included by the ABS in information technology, as presented in the Australian System of National Accounts[9]:

- computers and peripherals
- electrical and electronic equipment, and
- computer software.

Electrical and electronic equipment includes communications equipment that is 'analogue' rather than digital, as well as other equipment not related to communications. Electrical and electronic (E&E) equipment is included here, but excluded from the growth accounting presented in later sections.

3.1 IT use in Australia

Figure 3.1 (below) shows the very strong investment there has been in IT. Annual investment in all three forms of technology was below $2 billion (in 2012–13 dollars) in the early 1990s but is now at $16.9 billion for software, $12.7 billion for hardware and $9.9 billion for E&E equipment.

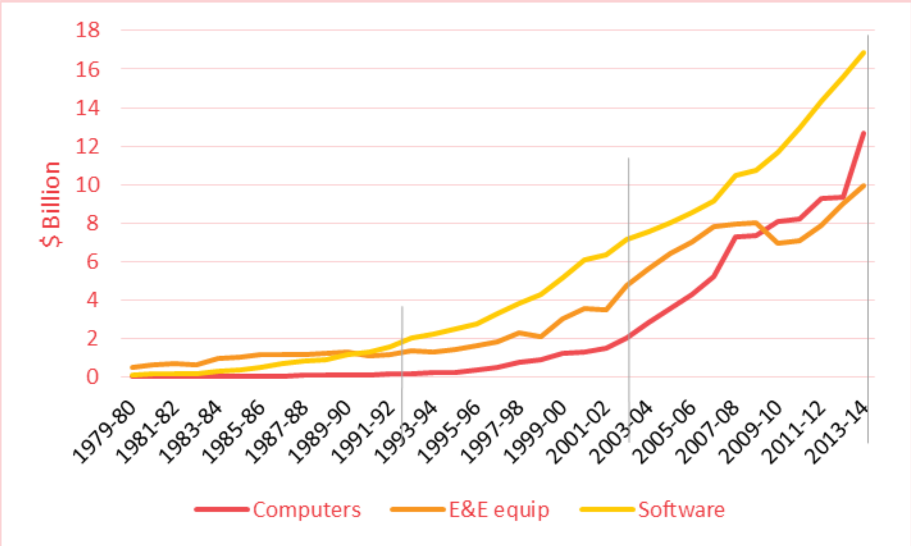
The rate of growth in investment eased in the 2000s. Growth in software investment slowed from a very rapid 30 per cent a year in the decade before 2003–04 to 16 per cent a year in the decade after. Over the same periods, growth in hardware investment slowed from 13 to eight per cent a year.

Figure 3.1 shows investment in E&E equipment stalled in the mid-2000s, but then resumed growth in the 2010s. The average rate of growth in the two periods was 15 and six per cent a year respectively.

The rate of growth in hardware investment has been variable since the mid-2000s. It slowed considerably after a brief acceleration in 2007–08, which may have been prompted by the global financial crisis. There was a 40 per cent rise in hardware investment in 2013–14, which could possibly be catch-up after deferred investment.

[9] ABS, Australian System of National Accounts,Cat. No. 5204.0, tables 69–71, Canberra, 31/10/2014

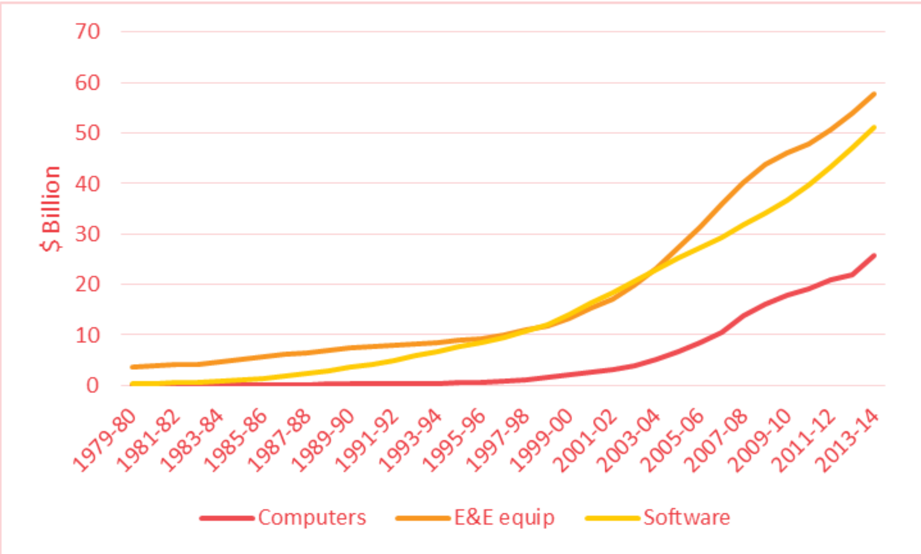
Figure 3.1: Investment in computers, electrical and electronic equipment and software, all industries ($ billion, cvm, reference year 2012–13)



Source: ABS Cat. No. 5204.0, Table 70 (Gross Fixed Capital Formation)

Figure 3.2 shows that strong growth in investment has led to strong growth in capital stocks. Net capital stocks have grown from below $10 billion in the early 1990s (and less than $300 million in the case of computers) to $51 billion in software, $26 billion in hardware and $58 billion for E&E equipment.

Figure 3.2: Net capital stocks of computers, electrical and electronic equipment and software, all industries ($ billion, cvm, reference year 2012–13)



Source: ABS Cat. No. 5204.0, Table 69

Table 3.1 shows the rate of growth in capital stocks slowed after 2003–04 (first two columns), and the growth in stocks of hardware and E&E equipment slowed in the second half of the 2000s (last two columns). Growth in hardware slowed after 2007–08 and in E&E equipment after 2008–09.

Table 3.1: Average annual rate of growth in net capital stocks of computers, electrical and electronic equipment and software, all industries, before and after 2003–04 (% pa)

	1993–94 to 2003–04	2003–04 to 2013–14	2003–04 to 2007–08	2007–08 to 2013–14
Computers	29.0	17.5	28.4	10.8
E&E equipment	10.5	9.5	14.6	6.3
Software	13.1	8.3	8.4	8.2

Source: Author estimates

3.2 Industry trends

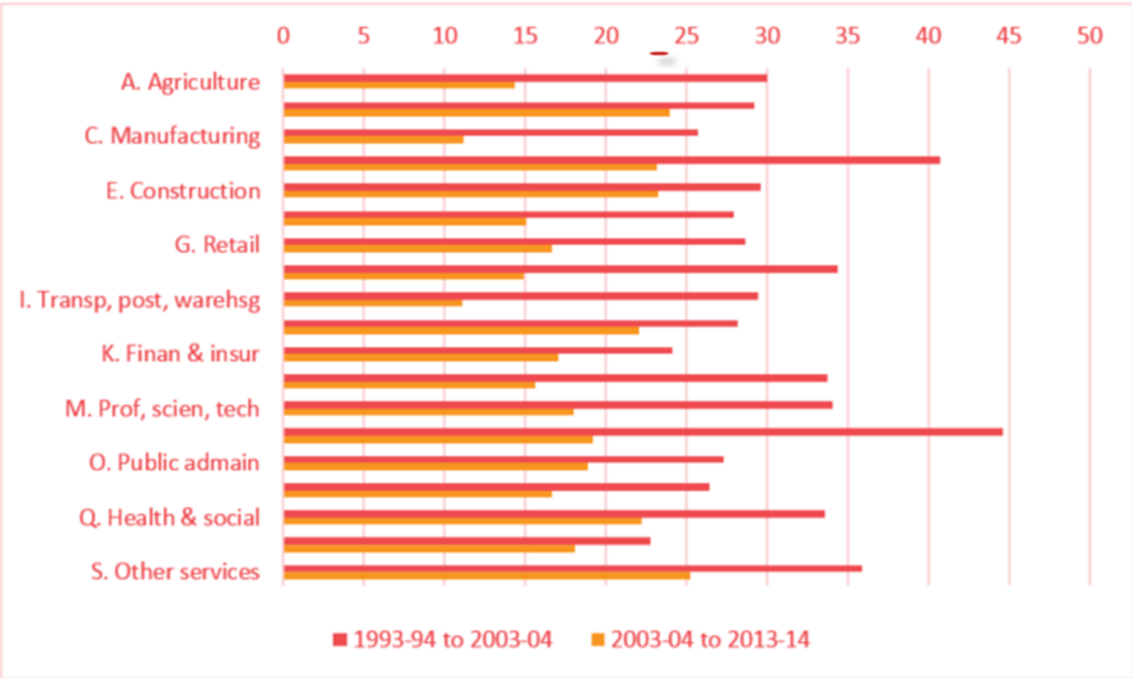
During the 1990s and 2000s, the growth in IT assets was fairly evenly spread across industries, while their distribution remained skewed.

3.2.1 Computers

Figure 3.3 shows the industry growth in computer hardware in the two decades from 1993–94. The two industries that stand out, with over 40 per cent average annual growth in the 10 years to 2003–04, are administrative and support services, and electricity, gas, water and waste services.

That aside, growth was fairly even across industries. The slowdown in growth from the first to the second decade was also fairly evenly spread across industries.

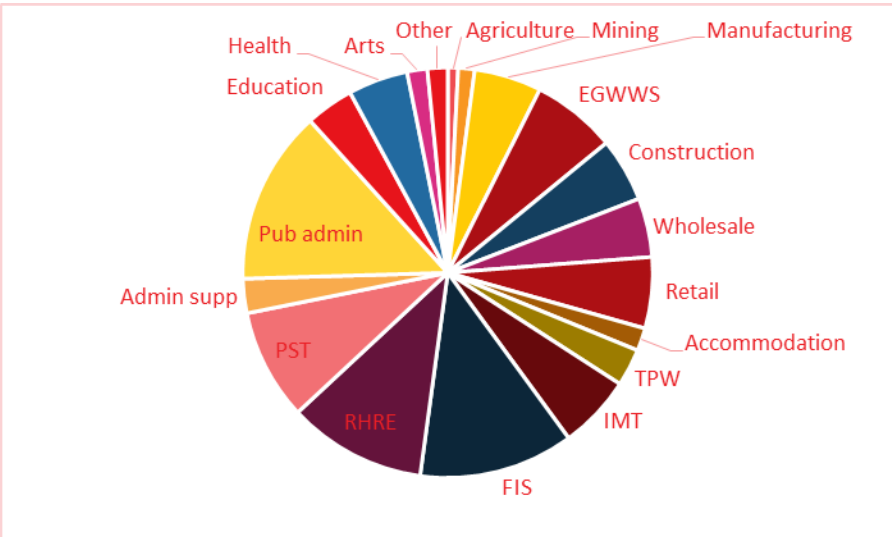
Figure 3.3: Annual average growth rates in net capital stocks of computers, 1993–94 to 2003–04 and 2003–04 to 2013–14, by industry (% pa)



Source: Author estimates

While growth in stocks was fairly evenly spread, the distribution of computers is concentrated in some industries. Figure 3.4 shows the distribution in 2013–14. The biggest holdings are in services industries—public administration, financial and insurance services (FIS), rental, hiring and real estate services (RHRE) and professional scientific and technical services (PST). The stocks of computers in RHRE include assets that are leased out to other industries.

Figure 3.4: Industry distribution of net capital stocks of computers in 2013–14

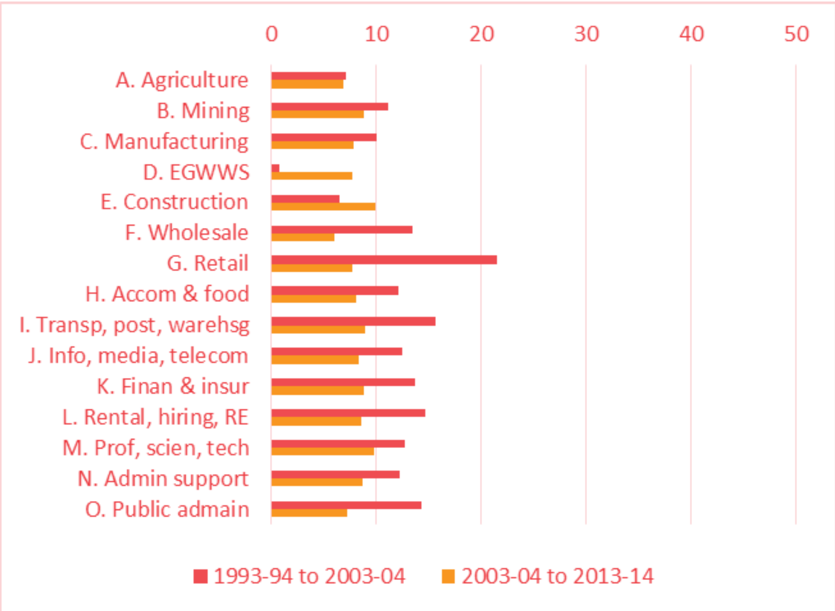


Source: Author estimates based on ABS national accounts data

3.2.2 Software

Figure 3.5 shows the growth of stocks of software was evenly distributed (with two main exceptions) and the slowdown in growth in the second decade was almost universal. The utilities sector, made up of electricity, gas, water and waste services (EGWWS), was one exception with minimal growth up to 2003–04 and much stronger growth after that. The very strong growth in software of over 20 per cent a year in retail trade in the earlier decade is the other standout exception.

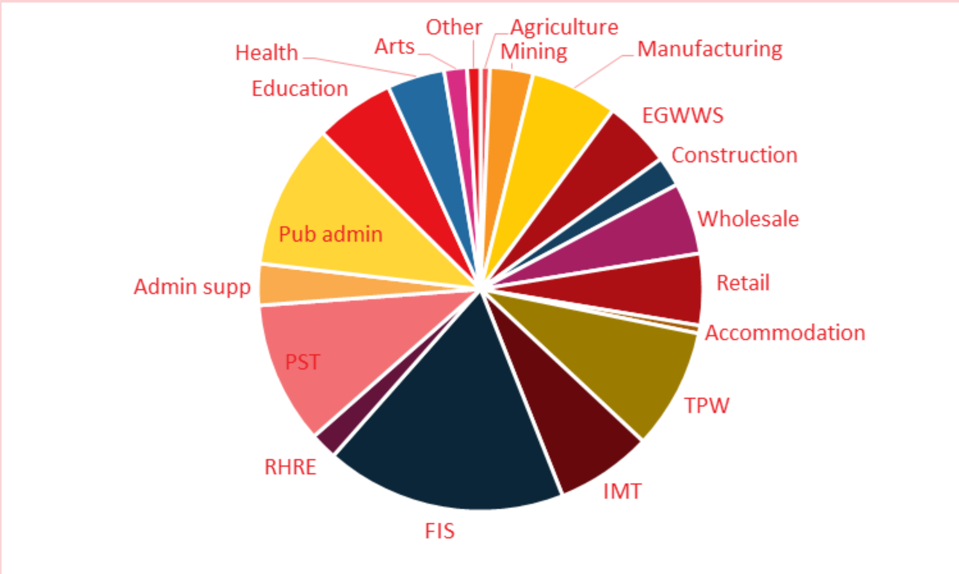
Figure 3.5: Annual average growth rates in net capital stocks of software, 1993–94 to 2003–04 and 2003–04 to 2013–14, by industry (% pa)



Source: Author estimates based on ABS national accounts data

Figure 3.6 shows the financial sector is the biggest user of software. Public administration, professional scientific and technical services and information, media and telecommunications (IMT), which are large users of hardware, are also large users of software. Transport postal and warehousing looms as an important software user.

Figure 3.6: Industry distribution of net capital stocks of software in 2013–14



Source: Author estimates based on ABS national accounts data

3.2.3 Electrical and electronic equipment

Figure 3.7 shows that of IT assets, growth in E&E equipment has perhaps been the most even across industries from 2003-04 to 2013-14. Administrative and support services and the government dominated areas of health care and social assistance, and education and training stand out for their growth in E&E equipment in the earlier 10-year period (1993–94 to 2003–04).

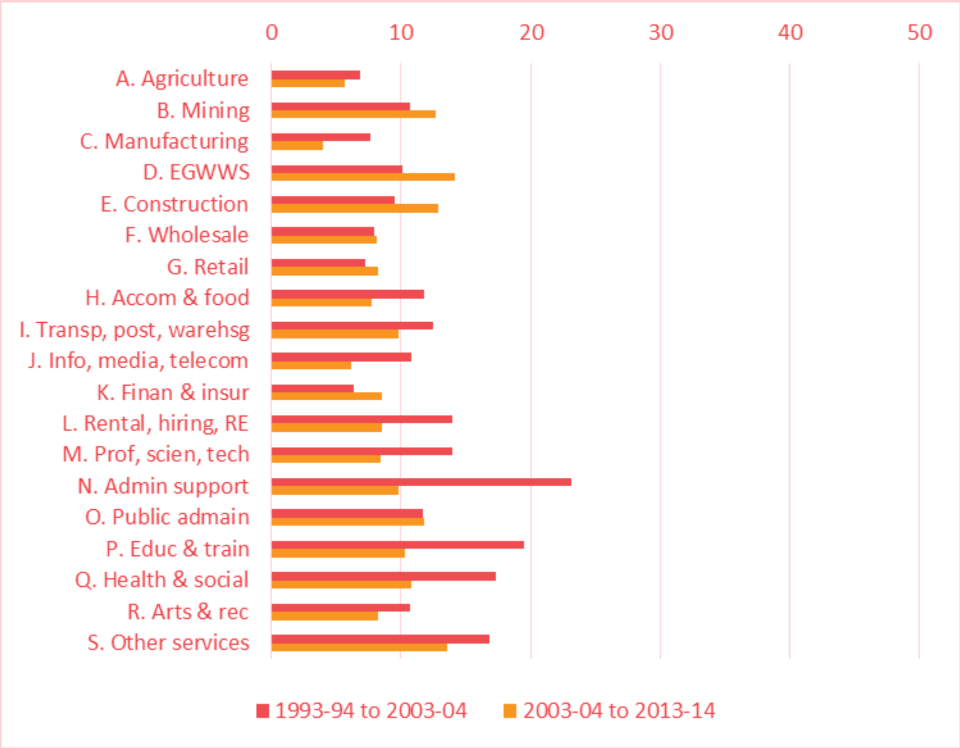
More industries had stronger growth in the second decade relative to the first decade in this category—mining; electricity, gas, water and waste services (EGWWS), construction, retail, and finance.

Figure 3.8 (below) shows two industries take large shares of electrical and electronic equipment—EGWWS and information, media, and telecommunications. The dominance of EGWWS perhaps illustrates more than anything else that the E&E equipment category includes more than communications equipment.

It seems very possible that communications equipment would be a large part of IMT's holding. However, that could be switching equipment and the like, which presumably forms a large part of communications infrastructure. If so, it would not be part of the converging IT and communications technologies embedded in devices that are in common use in production activities.

Those two industries aside, the distribution across other industries is fairly even.

Figure 3.7: Annual average growth rates in net capital stocks of E&E equipment, 1993–94 to 2003–04 and 2003–04 to 2013–14, by industry (% pa)



Source: Author estimates based on ABS national accounts data

Figure 3.8: Industry distribution of net capital stocks of E&E equipment in 2013–14

Source: Author estimates based on ABS national accounts data

3.2.4 Industries to watch

Table 3.2 summarises the prominent industries when it comes to IT characteristics.

Considering the number of ticks and first and second places, the industries that appear to be the most important users of hardware and software are:

- electricity, gas, water and waste services
- transport, postal and warehousing
- information media and telecommunications
- financial and insurance services
- rental, hiring and real estate services (although it is distorted by holding assets for lease)
- professional, scientific and technical services, and
- public administration.

Table 3.2: Summary of industries that feature in characteristics of computer and software use

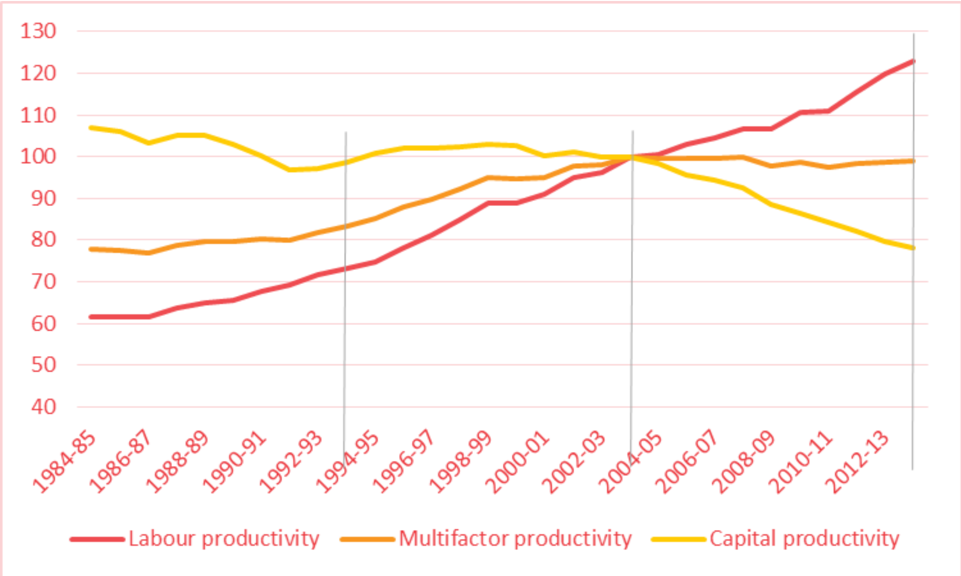
	Computers		Software	
	Growth	Distribution	Growth	Distribution
A. Agriculture				
B. Mining				
C. Manufacturing				
D. EGWWS	2			
E. Construction				
F. Wholesale			✓	
G. Retail			1	
H. Accom & food	✓		✓	
I. Transp, post, warehsg			✓	✓
J. Info, media, telecom			✓	✓
K. Fin & insur		2	✓	1
L. Rental, hiring, RE	✓	✓	✓	
M. Prof, sci, tech	✓	✓	✓	3
N. Admin support	1		✓	
O. Public admin		1	✓	2
P. Educ & train			✓	
Q. Health & social	✓		✓	
R. Arts & rec			✓	
S. Other services	✓		✓	

Note: importance is denoted by ✓, whereas the numbers denote scores

3.3 Productivity

Figure 3.9 shows the decade between 1993–94 and 2003–04 was a relatively high productivity growth period while the second one, 2003–04 to 2013–14, was low. The two 10-year periods before and after 2003–04 were chosen to highlight differences in productivity performance.

Figure 3.9: Productivity in Australia's 12-industry market sector, 1984–85 to 2013–14 (index, 2003–04 = 100)



Source: ABS Cat. No. 5260.0.55.002

After 2003–04, labour productivity slowed from 3.2 per cent a year to 2.1 per cent, capital productivity turned negative and multifactor productivity, which can be viewed as weighted average of labour productivity and capital productivity, stagnated.

Table 3.3 illustrates how productivity growth varied widely across industries.

Table 3.3: Productivity growth rates by industry, 1993–94 to 2003–04 and 2003–04 to 2013–14 (% pa)

	Labour productivity		Multifactor productivity		Capital productivity	
	1993–94 to 2003–04	2003–04 to 2013–14	1993–94 to 2003–04	2003–04 to 2013–14	1993–94 to 2003–04	2003–04 to 2013–14
A. Agriculture	4.51	3.45	3.68	1.47	4.51	3.45
B. Mining	1.87	-4.42	0.13	-4.81	1.87	-4.42
C. Manufacturing	2.53	1.09	0.95	-0.47	2.53	1.09
D. EGWWS	2.54	-3.87	-0.18	-4.00	2.54	-3.87
E. Construction	1.90	2.18	1.90	1.18	1.90	2.18
F. Wholesale	6.59	2.19	4.39	0.73	6.59	2.19
G. Retail	3.08	2.48	2.14	1.50	3.08	2.48
H. Accom & food	1.85	0.58	1.52	0.12	1.85	0.58
I. Transp, post, warehsg	2.43	1.50	1.98	0.11	2.43	1.50
J. Info, media, telecom	4.06	3.80	0.88	-0.10	4.06	3.80
K. Finan & insur	3.79	2.74	1.51	2.15	3.79	2.74
L. Rental, hiring, RE	-0.15	1.25	-3.68	-1.80	-0.15	1.25
M. Prof, scien, tech	2.20	0.21	1.59	-0.40	2.20	0.21
N. Admin support	0.52	0.48	-0.02	0.12	0.52	0.48
O. Public admin	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
P. Educ & train	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Q. Health & social	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
R. Arts & rec	0.85	0.74	-0.41	0.00	2.91	-0.11
S. Other services	2.91	-0.11	1.10	-1.51	3.16	2.09

Source: Author estimates based on data from ABS Cat. No. 5260.0.55.002

Industries that showed strong productivity growth, that is rates above 3 per cent a year, included:

- agriculture
- wholesale trade
- retail trade
- information media and telecommunications
- financial and insurance services, and
- other services.

Two industries appear on both the list of important IT users and the list of strong productivity performers: information media and telecommunications and financial and insurance services. They warrant particular attention in the growth accounting that follows.

4 The growth accounting approach

This section sets out the standard growth accounting model as it has been used to analyse IT and productivity. While it captures the capital deepening effect of IT on labour productivity growth, it does not identify the effects of the innovation platform IT provides for MFP growth. However, this issue is addressed in part by also examining the effects IT may have on the productivity of non-IT capital.

The next subsection sets out the model in mathematical form. It is an expression of the concepts set out in Section 2 and Figure 2.1. Readers without a mathematical background can skim before picking up on the strengths and weaknesses of the growth accounting model in subsection 4.2.

4.1 The traditional model

A Cobb-Douglas production function provides a starting point for the traditional growth accounting model. The quantum of output produced in year t, Y_t is expressed as a function of the quantum of capital used K_t, the quantum of labour used L_t, and multifactor productivity M_t:

1. $$Y_t = K_t^{\propto} . L_t^{1-\alpha} . M_t$$

The exponents on capital α, and labour 1-α, are the respective output elasticities of the factors of production. With an assumption of constant returns to scale, they sum to unity.

Dividing each side by L_t and dropping the time subscript for convenience:

2. $$\frac{Y}{L} = \left[\frac{K}{L}\right]^{\alpha} . M$$

The left hand side is labour productivity and equation 2 expresses it as a function of the capital-labour ratio and multifactor productivity. This relationship can be expressed in terms of growth, with a hat '^' over a variable signifying growth in that variable:

3. $$\widehat{\left[\frac{Y}{L}\right]} = \alpha . \widehat{\left[\frac{K}{L}\right]} + \widehat{M}$$

This key growth accounting relationship expresses labour productivity growth as the sum of capital deepening $\alpha . \widehat{\left[\frac{K}{L}\right]}$ and multifactor productivity growth.

The growth accounting relationship is operationalised with an assumption of competitive output and factor markets, so capital and labour are paid according to their marginal products. Then:

4. $$\alpha = \frac{\partial Y}{\partial K} . \frac{K}{Y} = \frac{rK}{Y} = s_K$$

Where r is the cost of capital and s_K is the share of capital in total value added (income and costs).

So in the final equation labour productivity growth $\widehat{LP}$ is expressed as:

5. $$\widehat{LP} = s_K.\left[\widehat{\frac{K}{L}}\right] + \widehat{M}$$

The advantage of equation 5 over 3 is that the capital share of income can be obtained from national accounts data. It is not necessary to estimate a value for the output elasticity α.

4.1.1 Distinguishing between IT and non-IT capital

The effect of IT capital on labour productivity (LP) growth is introduced by splitting the capital deepening component into an IT-capital deepening element, and a non-IT-capital deepening element. The implicit assumption here is that the amount of IT capital used can be separated from, or is independent of, the amount of non-IT capital used. (Further work in this report challenges this assumption.)

To do this separation, a relationship that aggregates IT capital K_I, and non-IT capital K_N, is used and in a form that is consistent with the aggregation relationship used by the ABS in the productivity accounts:[c]

6. $$K = K_I^{\beta}.K_N^{1-\beta}$$

Substituting 6 into 37. $$\frac{Y}{L} = \left[\frac{K_I^{\beta}}{L^{\beta}}\right]^{\alpha}.\left[\frac{K_N^{1-\beta}}{L^{1-\beta}}\right]^{\alpha}.M$$

Again using 4 and shares of capital income to substitute for β and 1-β, this equation can be written in LP growth terms as:

8. $$\widehat{LP} = s_K.s_I\left(\widehat{K_I} - \hat{L}\right) + s_K.s_N(\widehat{K_N} - \hat{L}) + \widehat{M}$$

Here, s_I and s_N are the shares of IT and non-IT in total capital income respectively. That is, LP growth can be broken into three contributions coming from:

- IT capital deepening
- non-IT capital deepening, and
- multifactor productivity growth.

The IT capital deepening contribution in 8 can be further disaggregated into hardware and software contributions. The first term on the right hand side of 8 can be expressed as:

9. $$s_K.s_I.s_S\left(\widehat{K_S} - \hat{L}\right) + s_K.s_I.s_H(\widehat{K_H} - \hat{L})$$

Here, s_S and s_H are the software and hardware shares in IT capital income and $\widehat{K_S}$ and $\widehat{K_H}$ refer to growth in software and hardware respectively. The relationship here expresses the sum of the software contribution and the hardware contribution to IT capital deepening.

4.2 The model's strengths and weaknesses

This growth accounting model has been used widely in the international literature to analyse the effect of IT on labour productivity growth: it is the most common method and why BCR has used it in this report. However, it does have omissions that are important to point out in order to properly understand its findings.

Growth accounting is a statistical decomposition of productivity into contributions from growth in output and inputs; it doesn't indicate causality and interrelationships. For example, capital and MFP are presented as separate elements of production, whereas MFP gains may actually raise the returns on capital and induce more capital investment.

Through the IT-capital deepening component—the first term on the right hand side of equation eight— growth accounting identifies the scope for IT to penetrate an industry and contribute to labour productivity growth as a substitute for labour.

This can happen, for example, in carrying out routine computational, presentational and storage tasks and reducing the need for middle-level management to supervise such routine tasks. Having fewer staffing overheads and more capital to work with effectively enhances the productivity of ongoing employees.

The major omission from traditional growth accounting is a mechanism to identify any MFP gains linked specifically to IT use. The MFP term on the right hand side of equation eight picks up MFP gains from any source, including innovations enabled by IT use. The IT-based productivity gains must be identified and measured by some other technique, for example econometric analysis.

There are further limitations that are not necessarily confined to growth accounting. Nevertheless, they are qualifications relevant to the interpretation of the analysis presented in this paper.

First, there is the issue of skill complementarity. As shown, growth accounting identifies the degree of substitution of IT capital for labour. However, there is evidence of skill bias associated with IT use. That is, while IT substitutes for unskilled labour in routine tasks it is complementary to skilled labour. Armed with hardware and software packages, skilled employees can carry out more sophisticated and higher value-adding tasks.

Skill complementarity would show up as co-movement between IT use and employment of skilled labour. However, the standard growth accounting formulation does not pick up this mechanism. It identifies net substitution effects for labour as a whole. (In principle, it could pick up net complementary effects for labour as a whole if complementarities outweighed substitution effects.)

Second, the standard analysis does not identify the combined or joint role of IT and complementary investments in enabling productivity gains. Again, this would have to be investigated through econometric analysis.

4.3 Extensions for this paper

To address some of the weaknesses outlined earlier in this section, this paper goes beyond the standard growth accounting framework to examine the effects IT use may have on capital productivity; any association between IT use and skills; and whether IT use allows any efficiency gains in the use of intermediate inputs.

4.3.1 Capital productivity

An important new step in this paper is to examine the effects IT use may have on capital productivity. Greater use of IT may reduce the requirements for other assets. For example, use of remote sensors is likely to reduce the requirements for motor vehicles to take staff to sites to carry out monitoring. Reducing the requirements for assets is the same as improving their productivity. The ratio of output produced to capital asset used has increased.

A simple and exploratory approach is taken to look at capital productivity effects.[d] In combination with accounting for LP growth, assessing capital productivity provides a statistical accounting way of looking at some effects of IT on MFP growth. If some association between IT use and non-IT capital productivity is found, it would provide a case for these effects to be investigated more rigorously through a re-specified production function and, probably, a different analytical technique.

From equation 1 (dropping the time subscript):

9. $$M = \left[\frac{Y}{K}\right]^{\alpha} . \left[\frac{Y}{L}\right]^{1-\alpha}$$

In growth terms and substituting income/cost shares for output elasticities:

10. $$\widehat{M} = s_K \widehat{\left[\frac{Y}{K}\right]} + s_L . \widehat{\left[\frac{Y}{L}\right]}$$

That is, MFP growth can be represented as a weighted average of capital productivity growth and labour productivity growth, where the factor income shares are the weights.

In addition, we know the contribution of IT to labour productivity growth through IT capital deepening. Multiplying that by s_L gives the contribution of IT capital deepening to MFP growth.

Borrowing from 6, capital productivity in 10 can be decomposed according to:

11. $$\widehat{\left[\frac{Y}{K}\right]} = s_I\left(\hat{Y} - \widehat{K_I}\right) + \ s_N\left(\hat{Y} - \widehat{K_N}\right)$$

Substituting into 10:

12. $$\widehat{M} = s_K . s_I\left(\hat{Y} - \widehat{K_I}\right) + \ s_K . s_N\left(\hat{Y} - \widehat{K_N}\right) + s_L . \widehat{\left[\frac{Y}{L}\right]}$$

The second term is the contribution of non-IT capital productivity to MFP growth. If some contribution of IT to non-IT capital productivity can be established, that second term in 12 highlights the importance of a second channel for IT to influence MFP growth.

A link between IT and non-IT productivity was not formally analysed, however. The degree of correlation between IT capital and the productivity of non-IT assets is simply examined, collectively and individually. That correlation does not necessarily mean causality should be kept in mind. That is, even with high correlation with IT use, the productivity of an asset could rise because of some other unrelated factor, such as a technological advance embedded in the asset.

4.3.2 Skills

Skills are part of labour supply. Their evolution and effect on MFP can be assessed through the ABS quality-adjusted labour input (QALI) measure.

QALI refines the standard hours worked measure of labour input. The productivity measures presented above are based on this simple count of total hours worked. The implicit assumption is that an hour worked by all skill groups is equally productive. QALI relaxes this assumption by weighting the hours worked by different skill groups according to their relative average wage. This calls on the assumption that relative wages of skill groups reflect their relative productivities.

The difference between growth in QALI and growth in hours worked is the growth in average skill. It is strictly the change in skill composition.[e] But if there is a general trend toward skill, the wedge between growth in QALI and in hours worked will be positive and can be thought of as the growth in the weighted average skill level.

As noted above, IT may be skill biased, in which case an association between IT use and increase in skills may show up.

The possible link between IT use and skills was not investigated in any formal way. Rather, the degree of correlation between IT capital and QALI change was observed. Again, correlation does not necessarily mean causality, which could run in either direction.

4.3.3 Intermediates

Finally, whether IT use allows any efficiency gains in the use of intermediate inputs was considered. Intermediate inputs are purchased materials such as components and energy, as well as purchased services, such as accountancy and data services.

As with the other possible efficiencies, this is only investigated in an informal way through correlation.

The productivity of intermediate use is determined with respect to gross output rather than value added.

5 Implementation in the current study

This section outlines the data and methods used to implement the growth accounting in this study. It is important to note the analysis refers to two asset classes:

- machinery and equipment (computers)
- intellectual property products (computer software).

These asset classes do not include communications equipment. As outlined in sections 1 and 3, digital communications equipment cannot be separately identified in the ABS national accounts data.

The Productivity Commission took the same approach in its earlier growth accounting work. The analysis BCR presents in this document updates that earlier work.

It would be an important and useful step if the ABS were to provide national accounts data that separately identifies communications equipment.

5. Data

Unless otherwise stated, the data for this paper were all drawn from the ABS productivity data cube, published on the ABS website as Cat. No. 5260.0.55.002.

The ABS productivity estimates are based on the concept of a flow of capital services from productive capital stocks. Productive capital stocks represent the capacity of assets to deliver a flow of capital services. Depreciation is based on physical wear and tear rather than market value. The flow of capital services is assumed to be proportional to the volume of productive capital stock.

A principal requirement for the growth accounting exercise is to split the total productive capital stock into IT and non-IT components. Direct estimates are not published.[f] The productivity data cube does, however, present the base data to enable construction of the two components.

The base data are productive capital stocks of 18 individual assets and their rental prices, in both the incorporated and unincorporated sectors, in each of the 16 major industries within the market sector. The rental price (or cost of capital) is the price of a unit of capital and can be thought of as the price a commercial lessor would charge to hire out a unit of an asset. It covers depreciation, a normal rate of return and expected capital gains.

The published data had to be formed into more aggregated stocks. For each industry, the incorporated and unincorporated holdings of each asset were first aggregated. The stocks of individual assets were then aggregated into IT and non-IT groupings. For the aggregate market sector analysis, IT and non-IT stocks were aggregated across industries.

The Törnqvist relationship was used in aggregation. Törnqvist aggregation takes the following form, for example, in aggregating hardware in the incorporated sector (H_I) and hardware in the unincorporated sector (H_U) into total hardware (H):

13. $$\frac{H^t}{H^{t-1}} = \left[\frac{H_I^t}{H_I^{t-1}}\right]^{w_I^t} . \left[\frac{H_U^t}{H_U^{t-1}}\right]^{w_U^t}$$

Where:

$$w_I^t = \frac{1}{2}(s_I^t + s_I^{t-1})\text{and } w_U^t = \frac{1}{2}(s_U^t + s_U^{t-1}).$$

The shares s_I^t and s_U^t are, respectively, the shares of the incorporated and unincorporated sectors in the total capital income attributable to hardware in the industry concerned. The income shares are formed from data on the productive capital stocks, multiplied by their rental price.[g]

5.1 Determining periods of analysis

The essential element of the growth accounting exercise is to decompose rates of growth in labour productivity (LP) and multifactor productivity (MFP)—see Section 4.

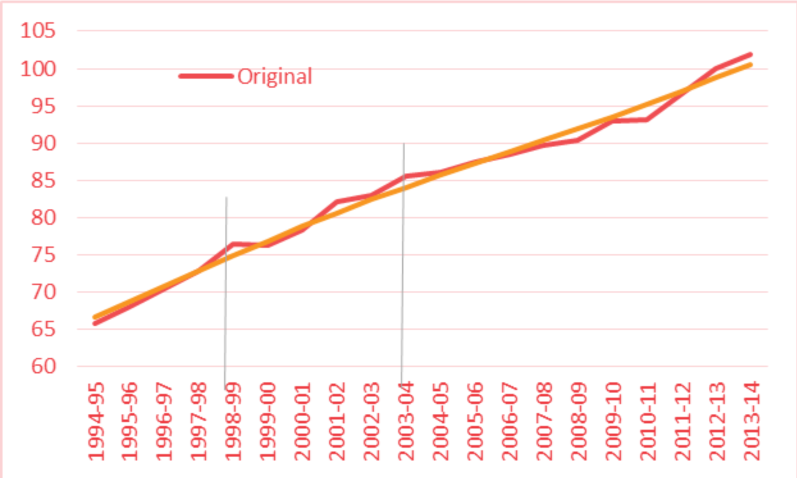
To do this credibly, it is essential to decompose underlying or trend rates of LP and MFP growth. Contributions to short-term movements that were subject to influence, for example, from the business cycle could be quite misleading.

A method similar to one used by the ABS was used to determine underlying rates of productivity growth. They were taken to be actual rates of productivity growth between the same points in successive productivity cycles, namely, from the peak in one cycle to the peak in the next.

Peaks were determined as high points in actual values in the series above a smoothed version of the series. We formed the smoothed series with a Hodrick-Prescott filter[h] (λ = 100).[i] At least initially, a peak is determined to be where an actual value is more than one per cent above the smoothed value and is the proportionately highest value above the smoothed series in a string of years above trend.

To illustrate, the actual and smoothed series for market sector labour productivity are shown in Figure 5.1.

Figure 5.1 Market sector labour productivity: original and smoothed with a Hodrick-Prescott filter (index, original 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002 and author's estimates

The BCR exercised judgment to determine periods for analysis. In part, this was in acknowledgment that the process used to identify peaks is not definitive.

Barnes[10] shows the identification of productivity peaks can be sensitive to the smoothing technique used. In some cases, an additional peak was introduced even though it does not strictly satisfy the decision rule. This allowed analysis of a period of specific interest.

[10] Barnes, P. (2011), 'Multifactor Productivity Cycles at the Industry Level', Staff Working Paper, Productivity Commission, Canberra

In some cases, identified peaks were suppressed where it was believed it would not provide any additional insight in the analysis, for example, where one peak is very close to another.

Peaks in the labour productivity series and multifactor series were determined separately. Nevertheless, there was a high degree of commonality in peaks in both series.

5.2 The industry analysis template

The growth accounting decompositions were carried out for individual industries according to a standard template. Following the issues discussed in section 4, the template covered:

- Growth in hardware, software and total IT capital.
- Decomposition of growth in labour productivity, identifying the contribution of IT capital deepening.
- An assessment of growth in skills and the correlation with IT use.
- An assessment of trends in non-IT capital productivity, in aggregate and for individual assets, and the correlation with IT use.
- An assessment of the productivity of intermediates use and the correlation with IT use.
- An assessment of MFP growth cycles and possible IT contributions through IT capital deepening and improvements on non-IT capital productivity.

The industry studies are presented individually in the Appendices. (Appendix labels follow the ABS industry division classifications.) A summary of results together with the market sector results are presented in section 6.

6 Key findings

The results presented in this section cover the market sector of the economy for which the ABS generates productivity estimates. The productivity growth accounting was carried out for the market sector as a whole and for its industries.

The log difference method has been used to calculate continuous growth rates. That is, the growth rate is the log of the ratio of values in the end year and start year of a period, divided by the number of years in the period. The alternative would be to calculate a discrete annual average growth rate which, when compounded or multiplied each year by one plus the growth rate, would take the starting value to the end value in a period.

The two methods produce similar results for small changes. The discrete method is more familiar, but the continuous method has the advantage in growth accounting of producing fewer or smaller approximation errors. That is, contributions from constituent factors such as capital deepening and MFP growth are more likely to add up to the growth in the parent variable (LP growth).

6.1 Market sector productivity

The results are presented for both the current ABS market sector, which covers 16 industries, and for a previous market sector grouping covering 12 industries. These are referred to as the MS-16 and MS-12 respectively and their industry coverage is presented in Table 6.1.

One advantage of the MS-12 grouping is that a longer time series, starting in 1989–90, can be analysed, whereas the MS-16 series starts in 1994–95. The other advantage is that it enables ready comparison with the earlier Productivity Commission analysis, which was based similarly on the 12-industry grouping.

Nevertheless, greater weight should be given, in principle, to the MS-16 results. The rental, hiring and real estate services (RHRE) industry—included in MS-16 but not in MS-12—has stocks of IT assets that are leased to other industries. The ABS allocates leased assets on the basis of ownership rather than use. That is, they are counted as part of the RHRE capital stock.[j] Use of assets rather than ownership matters for productivity purposes. And so an allocation based on use would be preferred.

The MS-16 grouping averts this problem because all leased assets owned by RHRE are included as part of the market sector capital stock. This does not apply, however, to the MS-12 grouping.

Table 6.1: Industry coverage of MS-12 and MS-16 groupings and proportion of GDP (at basic values) in 2013–14[a]

	Inclusion in MS-12	Per cent of GDP
A Agriculture, Forestry and Fishing	✓	2.5
B Mining	✓	8.9
C Manufacturing	✓	6.8
D Electricity, Gas, Water and Waste Services	✓	2.9
E Construction	✓	8.4
F Wholesale Trade	✓	4.2
G Retail Trade	✓	4.8
H Accommodation and Food Services	✓	2.4
I Transport, Postal and Warehousing	✓	5.1
J Information, Media and Telecommunications	✓	3.0
K Financial and Insurance Services	✓	9.0
L Rental, Hiring and Real Estate Services		2.8
M Professional, Scientific and Technical Services		6.8
N Administrative and Support Services		3.1
R Arts and Recreation Services	✓	0.9
S Other Services		1.9
Total		**73.5**

Note: a. The letters A, B, C and so on refer to the industry division classifications used by the ABS. Numbers may not add up due to rounding.

Source: ABS Cat No. 5204.0

6.1.1 16-industry market sector (MS-16)

The initial step was to split the available series, which spans 1994–95 to 2013–14, into two at the year 2003–04. Neither 1994–95 nor 2013–14 were declared by the ABS to be productivity peaks, but 2003–04 was. The period 1994–95 to 2003–04 approximates a time of high productivity growth, whereas 2003–04 to 2013–14 was a period of slow (labour) productivity growth, dominated by the mining boom.

Labour productivity

The labour productivity growth accounting for the two periods is presented in Table 6.2. The disappearance of MFP growth more than accounted for the 1.2 percentage point slowdown in labour productivity growth from the first to the second period. There was, however, more capital deepening from non-IT capital, principally associated with the mining boom.

The key finding from the IT perspective is that the contribution of IT capital deepening to labour productivity declined quite markedly between periods. While it accounted for 0.8 of a percentage point of the annual rate of LP growth in the first period, IT capital deepening's contribution fell in the 2000s to 0.5 of a percentage point. This came as the rate of IT growth slowed from 18.5 to 11.7 per cent a year, and the rate of growth in hours worked increased slightly from 1.1 to 1.2 per cent a year.

Nevertheless, 0.5 of a percentage point is still a large contribution.

In both periods, IT capital deepening accounted for about a quarter of LP growth and hardware accounted for about two-thirds of the IT capital deepening.

Table 6.2: Accounting for LP growth in the MS-16 before and after 2003–04a

	1994–95 to 2003–04	2003–04 to 2013–14
Capital deepening (pp)	1.4	1.9
IT capital deepening (pp)	0.8	0.5
Hardware (pp)	0.5	0.3
Software (pp)	0.3	0.2
Non-IT capital deepening (pp)	0.6	1.4
MFP growth (pp and % pa)	1.6	-0.2
Labour productivity growth (% pa)	2.9	1.7

Note: a. Growth rates and contributions are calculated from differences in logged values.
Numbers may not add up due to rounding.

Source: Author estimates

Each of the two periods was then divided, using 1998–99 as the breakpoint in the first period and 2007–08 in the second. The resulting four periods are shown in Table 6.3. Because the two new breakpoints have been identified by the ABS as productivity peaks, the middle two periods—from 1998–99 to 2003–04 and 2003–04 to 2007–08—are ABS productivity cycles.

The main additional information about IT capital deepening from the split into four periods is that the hardware contribution faded in the second half of the 2000s. Overall, IT capital deepening was weaker in the fourth period, due to the hardware contribution falling from 0.5 to 0.2 of a percentage point.

Table 6.3: Accounting for LP growth in the MS-16 over four periods[a]

	1994-95 to 1998-99	1998-99 to 2003-04	2003-04 to 2007-08	2007-08 to 2013-14
Capital deepening (pp)	1.5	1.3	1.6	2.1
IT capital deepening (pp)	0.8	0.7	0.7	0.3
Hardware (pp)	0.5	0.5	0.5	0.2
Software (pp)	0.3	0.3	0.2	0.2
Non-IT capital deepening	0.6	0.5	0.9	1.8
MFP growth (pp and %pa)	2.3	1.0	-0.4	0.0
Labour productivity growth (%pa)	3.8	2.3	1.2	2.1

Note: a. Growth rates and contributions are calculated from differences in logged values. Numbers may not add up due to rounding.

Source: Author estimates

Non-IT capital productivity

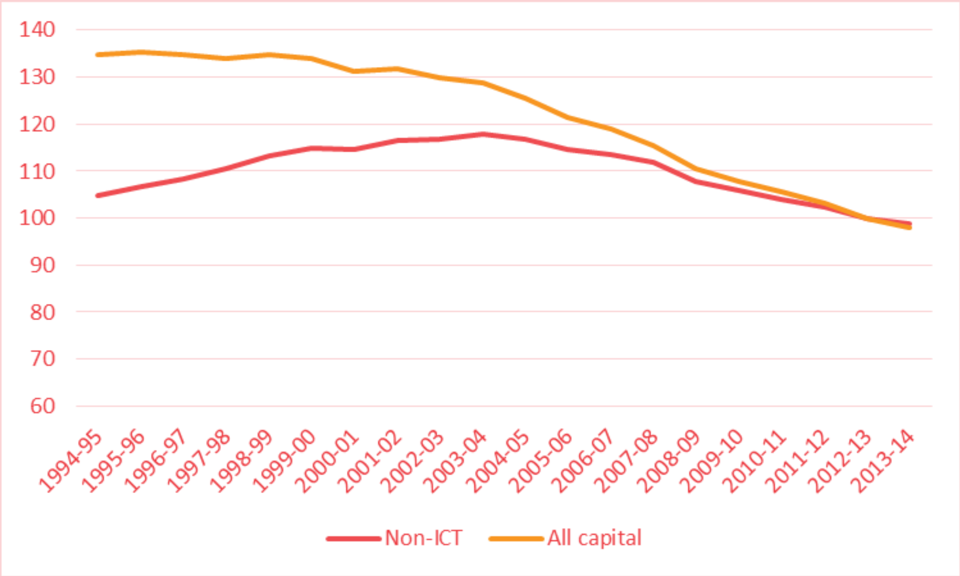
As discussed in section 4, there is an interest in the potential for IT to lower the unit requirements for other assets. Lower unit requirements would show up as higher productivity of non-IT assets.

As can be seen in Figure 6.1, at the aggregate MS-16 level the productivity of non-IT capital increased up to 2003–04. This improvement was correlated with the increased uptake of IT. (Correlation, however, does not necessarily mean there was a causal relationship between IT use and lower requirements for other assets.)

Non-IT capital productivity deteriorated after 2003–04. While this was also a period of slower growth in IT, the most likely cause of the productivity fall was the expansion of the mining capital stock, in advance of output growth, as part of the mining boom. Capital productivity has declined markedly in mining.[11]

[11] Topp, V. and T. Kulys (2012), 'Productivity in Electricity, Gas and Water: Measurement and Interpretation', Staff Working Paper, Productivity Commission, Canberra.

Figure 6.1: The productivity of all capital and non-IT capital in the MS-16 (index, 2012–13 = 100)



Source: Author estimates

We also examined the productivity of individual non-IT assets. Assets, aside from ownership transfer costs and industry-specific assets (such as mineral exploration and livestock), are listed in Table 6.4.

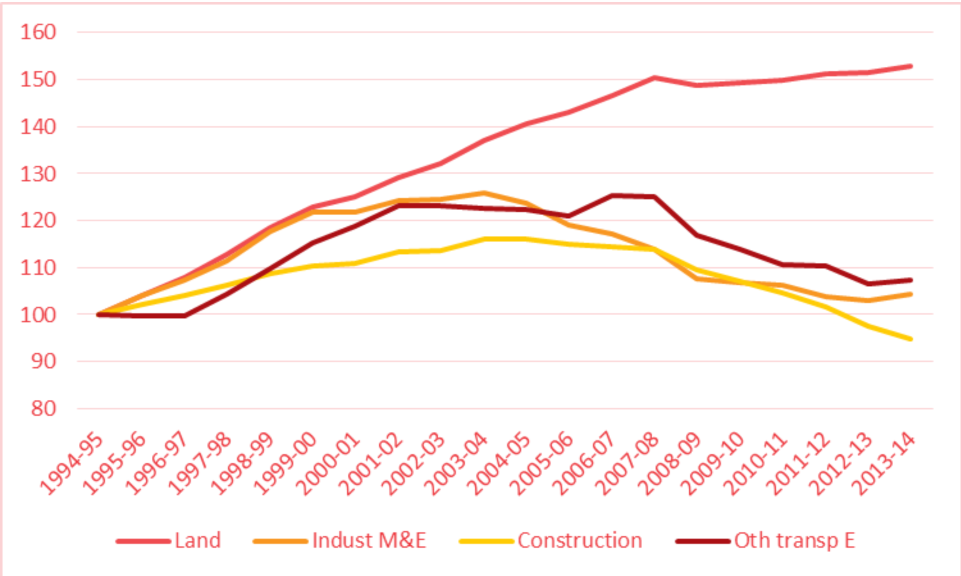
The table shows the share of each asset in the total capital income in the MS-16 in 2003–04, to give an indication of the relative importance of each asset. It then provides a comparison of the annual average rate of growth in capital productivity for each asset, before and after 2003–04. The time path of capital productivity for selected assets is also shown in Figure 6.2.

Table 6.4: Share of non-IT assets in 2003–04 capital income (%) and annual average rate of growth in capital productivity (% pa)

	2003–04 income share	Productivity growth	
		1994–95 to 2003–04	2003–04 to 2013–14
Research and development	3	-1.1	-4.6
Inventories—Non-farm	6	0.2	1.3
Land	11	3.6	1.1
Machinery and equipment			
- Electrical and electronic equip	7	-5.8	-5.8
- Industrial machinery and equip	16	2.6	-1.9
- Other plant and equipment	7	-0.9	-0.7
- Other transport equipment	5	2.3	-1.3
- Road vehicles	10	0.5	-3.3
Non-dwelling construction	31	1.7	-2.0

Source: Author estimates

Figure 6.2: Capital productivity for selected non-IT assets (index, 2012–13 = 100)



Source: Author estimates

Land shows the largest increase in capital productivity with growth of 3.6 per cent a year up to 2003–04. Unlike most assets, land continued to show positive growth in productivity after 2003–04. Figure 6.2 shows the strong growth continued to 2007–08.

The improvement in non-dwelling construction productivity in the first period is significant, given that this asset class accounted for around 30 per cent of capital costs and showed improvement in its productivity at a rate of 1.7 per cent a year. It was after 2004–05 that the productivity of non-dwelling construction declined. Again, this would have been heavily influenced by the mining boom, given that most of the investment was in mine construction, which is included in this asset class.

Industrial machinery and equipment is another asset of interest. With an income share of 16 per cent, it matters. It had strong growth in productivity of 2.6 per cent a year in the 1990s.

Inventories was the only asset class to show stronger (positive) productivity growth in the second period than in the first.

MFP growth

As discussed in section 4, the possible effect of IT on MFP was examined by, firstly, decomposing MFP growth into contributions from labour productivity growth and capital productivity growth and then examining how IT may influence each of these.

The first part is shown in Table 6.5 as the contribution of labour productivity plus the contribution of capital productivity growth equals MFP growth. Lower, and indeed negative, MFP growth in the post 2003–04 period can be attributed to a weaker labour productivity contribution and, even more, to a more-negative capital productivity contribution.

The IT part of the LP contribution is through the IT capital deepening contribution. It is smaller than shown in Table 6.2 because the IT capital deepening contributions in that table have to be weighted by the labour income share to be part of the LP contribution to MFP growth in Table 6.5.

Table 6.5: Accounting for MFP growth in the MS-16 before and after 2003–04

	1994–95 to 2003–04	2003–04 to 2013–14
Labour productivity contribution (pp)	1.8	1.0
IT capital deepening component (pp)	0.5	0.3
Capital productivity contribution (pp)	-0.2	-1.1
IT contribution (pp)	-0.6	-0.4
Non-IT contribution (pp)	0.5	-0.7
MFP growth (% pa)	1.6	-0.2

Source: Author estimates. Numbers may not add up due to rounding.

At this aggregate level, IT appears to have had some association with MFP growth in the first period. It contributed half a percentage point through labour productivity and may have had some influence on the positive improvement in non-IT capital productivity. In the second period, the contribution to labour productivity growth was smaller and the non-IT contribution was negative.

6.1.2 12-industry market sector (MS-12)

Labour productivity growth accounting was also carried out for the MS-12, for comparison with the MS-16 results above and with the earlier PC results for the MS-12.

As it turns out, there are not big differences between the MS-16 results (Table 6.3) and the MS-12 results (Table 6.6). There is more IT capital deepening in the MS-16 in the first two periods (the 1990s) due to more hardware capital deepening. In the last period (late 2000s) there is slightly more IT capital deepening in the MS-12, due to greater software capital deepening.

There are no major differences between the MS-16 and MS-12 results, despite the fact rental, hiring and real estate services industry holds a large share of hardware assets—accounting for around 13 per cent of total hardware income in 2003–04.

Table 6.6: Accounting for LP growth in the MS-12 over four periods

	1993-94 to 1998-99	1998-99 to 2003-04	2003-04 to 2007-08	2007-08 to 2013-14
Capital deepening (pp)	1.3	1.3	1.6	2.5
IT capital deepening (pp)	0.8	0.7	0.6	0.3
Hardware (pp)	*0.4*	*0.5*	*0.4*	*0.2*
Software (pp)	*0.3*	*0.3*	*0.2*	*0.2*
Non-IT capital deepening (pp)	0.5	0.6	1.0	2.2
MFP growth (% pa and pp)	2.6	1.0	0.0	-0.1
Labour productivity growth (% pa)	3.9	2.3	1.6	2.4

Note: a. Growth rates and contributions are calculated as differences in logged values. Numbers may not add up due to rounding.

Source: Author estimates

There are not large differences between the MS-12 results generated here and the results from the earlier PC exercise (Table 6.7). The ABS productivity estimates have been revised, with both MFP growth and LP growth larger in the period 1993–94 to 1998–99, which is common to both exercises. There has also been some revision to IT data, with a redistribution of capital deepening away from IT to non-IT in the current analysis, compared with the PC analysis.

Table 6.7: Results from 2004 Productivity Commission growth accounting for the MS-12

	1988-89 to 1993-94	1993-94 to 1998-99
Capital deepening (pp)	1.3	1.3
IT capital deepening (pp)	0.6	1.0
Hardware (pp)	*0.2*	*0.6*
Software (pp)	*0.4*	*0.3*
Non-IT capital deepening (pp)	0.7	0.4
MFP growth (% pa and pp)	0.7	1.8
Labour productivity growth (% pa)	2.0	3.2

Source: Productivity Commission (2004), 'ICT Use and Productivity: A Synthesis from Studies of Australian Firms', Commission Research Paper.

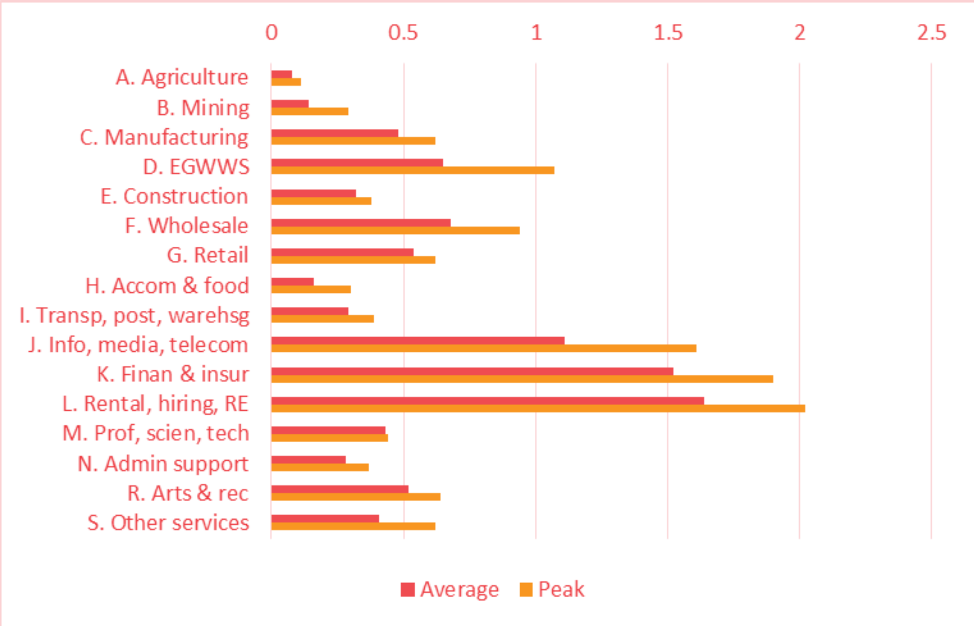
6.2 Industries overview

Growth accounting was also carried out for individual industries. Selected industry studies are reported in detail in the Appendices. Here, major industry effects are highlighted.

6.2.1 IT capital deepening

Figure 6.3 shows how IT capital deepening has varied across industries. It has averaged 1.5 per cent a year in finance and insurance services and even more in rental, hiring and real estate services. Information, media and telecommunications services had IT capital deepening at a little more than 1 per cent a year. Most industries are around 0.5 per cent a year or below.

Figure 6.3: Average and peak[a] rates of IT capital deepening in MS-16 industries from 1989-90 to 2013-14[b] (per cent per year)



Note: a. Peak rates are the highest rate over any productivity cycle. b. From 1994-95 for industries L, M, N and S.

Source: Author estimates

Table 6.8 shows the ratio of average IT capital deepening to average LP growth over the available series for each industry. It suggests that IT capital deepening has provided important proportional contributions to LP growth in nearly all industries.

Table 6.8: Ratio of average rate of IT capital deepening to average LP growth in MS-16 industries from 1989–90 to 2013–14 (%)

	Ratio		Ratio
A. Agriculture	2	I. Trans, post, warehousing	14
B. Mining	(-ve)	J. Info, media, telecomm	24
C. Manufacturing	25	K. Finan and insur services	38
D. EGWWS	>100	L. Rental, hiring, real estate[a]	>100
E. Construction	17	M. Prof, scientific, technical[a]	38
F. Wholesale trade	20	N. Administrative support[a]	56
G. Retail trade	20	R. Arts and recreation	71
H. Accom and food services	18	S. Other services[a]	32

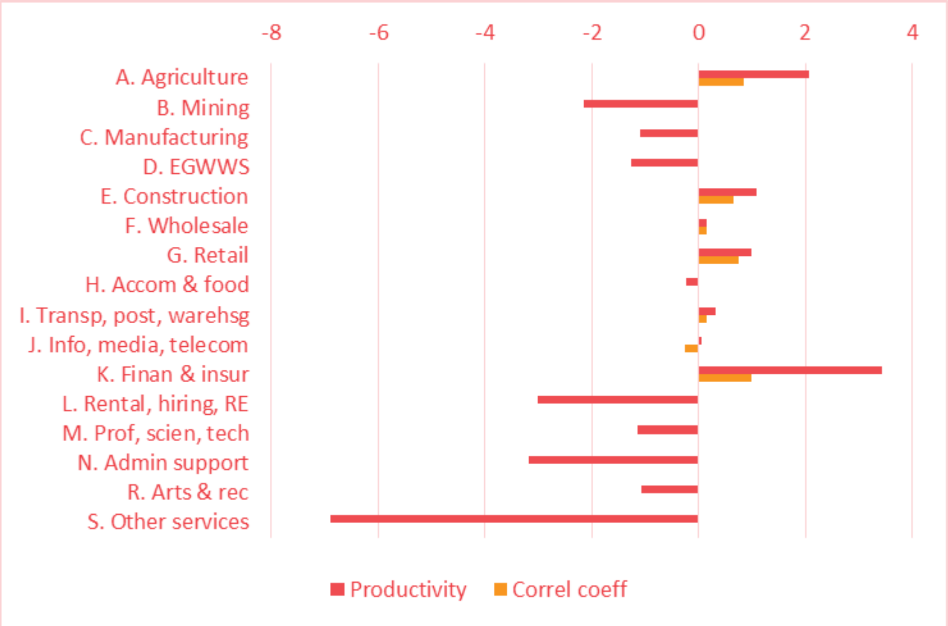
Note: a. From 1994–95

Source: Author estimates

6.2.2 Non-IT capital productivity

Figure 6.4 shows the growth in non-IT capital productivity varied widely across industries. FIS had very strong growth at over 3 per cent a year. On the other hand, there were some notable negatives in mining, manufacturing and electricity, gas, water and waste services, which have collectively contributed overwhelmingly to the decline in Australia's capital productivity.[12] There are also some strong negatives among services industries.

Figure 6.4: Rates of growth in non-IT capital productivity (%) and correlation between non-IT capital productivity and IT stocks, by industry



Source: Author estimates

Possible associations with IT use become clearer when the productivity of individual assets is reviewed.

Inventories productivity has grown strongly in some industries—especially construction (Figure 6.5). The correlation with IT use is also generally high, as indicated by the orange bars in Figure 6.5. (Perfect correlation would be indicated by a value of one.)

[12] Parham, D. (2012), 'Australia's Productivity Growth Slump: Signs of Crisis, Adjustment or Both?', Visiting Researcher Paper, Productivity Commission, Canberra.

Figure 6.5: Growth in the productivity of inventories use (% pa) and coefficient of correlation with IT use, by industry

Note: a. Industry does not hold inventories

Source: Author estimates

Figure 6.6 shows there was strong growth in land productivity and a strong correlation with IT use in some industries. In some cases, it is easy to see a possible link. Electronic banking saved back-room operations and enabled branch closures. IT also enabled rationalisation and closure of warehousing facilities.

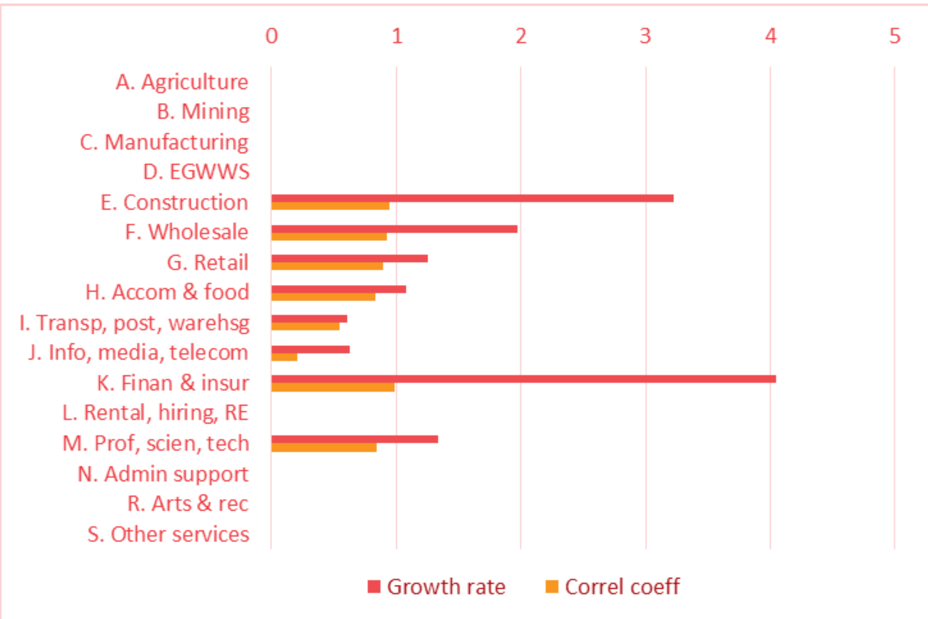
Figure 6.6: Growth in productivity of land use (% pa) and coefficient of correlation with IT use, by industry

Note: a. No change in the amount of land in this industry

Source: Author estimates

Lower requirements for land often went hand in hand with lower unit requirements for buildings, which form part of non-dwelling construction assets. Consequently, a number of industries that show strong growth in Figure 6.6 also show up with strong growth in Figure 6.7 (non-dwelling construction assets).

Figure 6.7: Growth in productivity of use of non-dwelling construction (% pa) and coefficient of correlation with IT use, by industry



Source: Author estimates

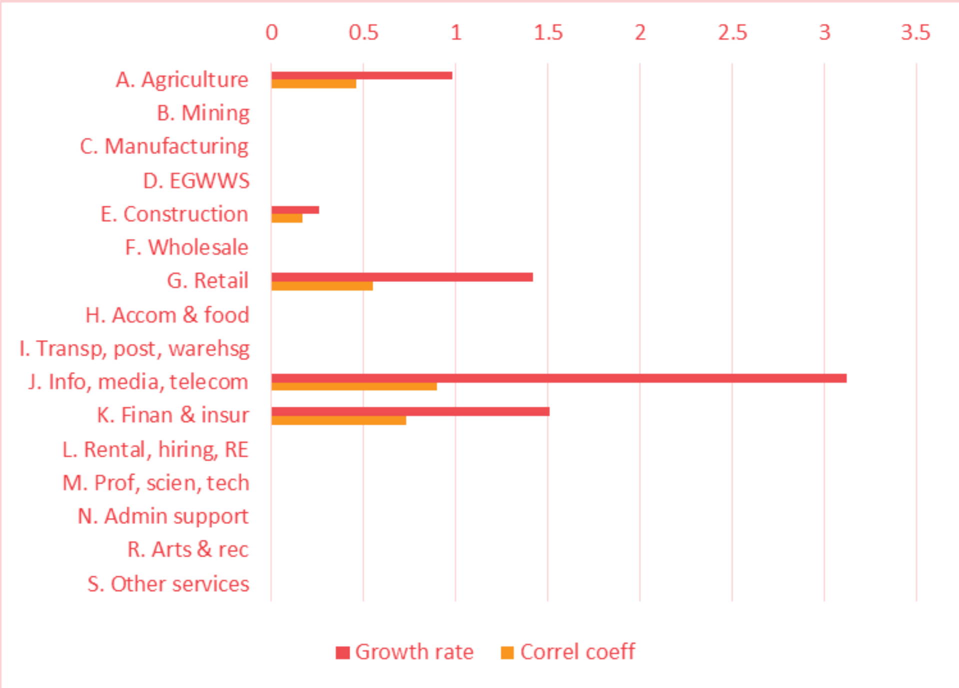
Industrial machinery and equipment was one of the assets identified at the MS-16 level as showing improvement in productivity. Figure 6.8 shows IMT and FIS as two industries with strong growth in the productivity of this asset class.

Figure 6.8: Growth in productivity of use of industrial machinery and equipment (% pa) and coefficient of correlation with IT use, by industry

Source: Author estimates

Figure 6.9 shows unit requirements for road vehicles also declined in a few industries, in particular FIS and IMT, with a strong association with IT use.

Figure 6.9: Growth in productivity of road vehicles use (% pa) and coefficient of correlation with IT use, by industry



Source: Author estimates

6.2.3 Skills

Section 4 mentioned that while IT is a substitute for labour broadly, there may be some complementarity between IT use and the use of skilled labour. This possibility was examined in a very simplified way by looking at the correlation between the increase in average skill, indicated by the ABS's QALI measure, and IT use. Table 6.9 displays, for each industry, the growth in average skill over the observation period and correlation with IT use.

Table 6.9: Increase in skill[a] from 1989–90 to 2013–14 and correlation with IT use, by industry

	Skill increase (%)	IT correlation		Skill increase (%)	IT correlation
A. Agriculture	6.6	0.96	I. Transp, post, warehsg	8.4	0.93
B. Mining	6.8	0.77	J. Info, media, telecom	11.6	0.98
C. Manufacturing	11.4	0.95	K. Finan & insur	22.8	0.94
D. EGWWS	8.8	0.55	L. Rental, hiring, RE[b]	11.8	0.97
E. Construction	5.1	0.91	M. Prof, scien, tech[b]	11.8	0.98
F. Wholesale	13.3	0.98	N. Admin support[b]	11.9	0.98
G. Retail	7.4	0.98	R. Arts & rec	6.0	0.85
H. Accom & food	1.3	0.67	S. Other services[b]	2.1	0.03

Notes: a. Determined from growth in quality-adjusted labour input (see section 4). b. For 1994–95 to 2013–14

Source: Author estimates

The strongest growth in skill (22.8 per cent) has been in FIS where there was also a very high correlation with IT use. There was middle-order growth in skills in wholesale trade, IMT, RHRE, PST and administrative and support services, all with a high degree of correlation with IT.

While this examination is not rigorous it is sufficient to suggest that skills have been part of the dynamics of some industries and that IT may well have been an associated factor.

6.3 Industry highlights

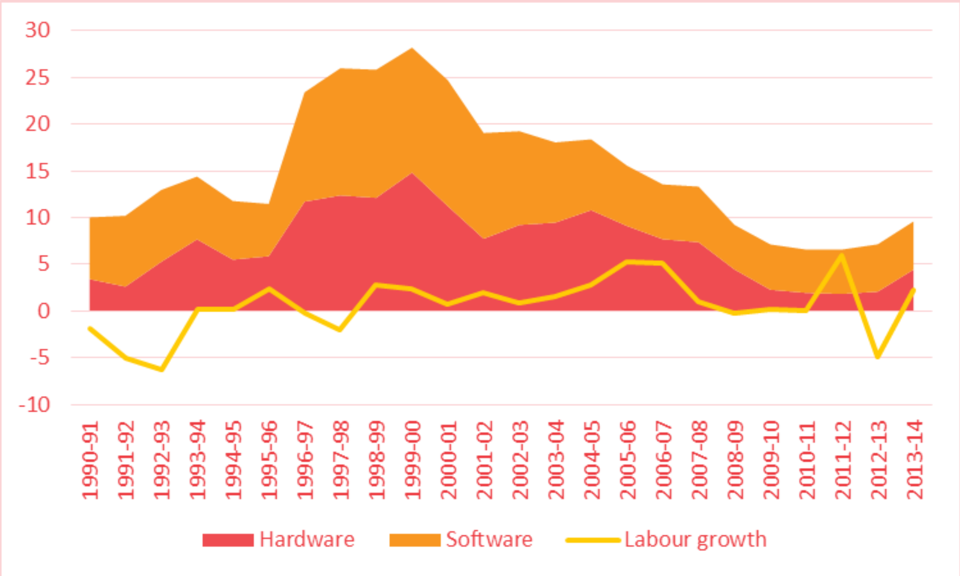
There is wide variation across industries in the intensity of their IT use and their productivity performance.

6.3.1 Financial and insurance services

Financial and insurance services provides the clearest evidence that strong productivity performance has been associated with IT use.

Figure 6.9 shows the strong growth in IT from the mid-1990s, with very strong contributions from both hardware and software. The mid-1990s to the mid-2000s was evidently a period of strong IT capital deepening since, not only was IT growth strong, but labour growth was also weak.

Figure 6.10: Contributions of hardware and software to IT growth (pp) and labour growth (%) in financial and insurance services



Source: Author estimates

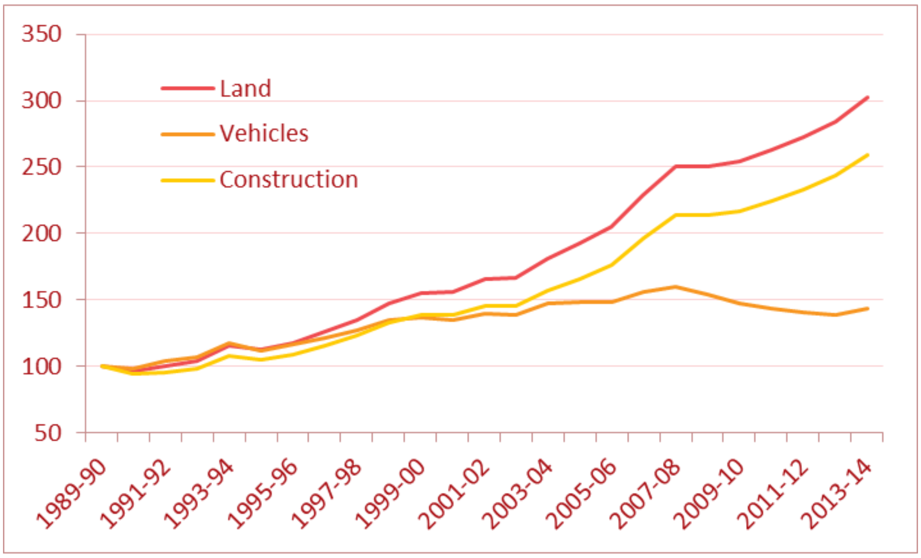
IT capital deepening indeed made a strong contribution to LP growth through this period. Labour productivity growth in the two productivity cycles within 1993–94 to 2007–08 was strong at 4.4 and 3.5 per cent a year. IT capital deepening accounted for around 1.9 percentage points or 40-50 per cent of that growth.

That is, without much change in the quantity of labour used, strong growth in IT played an important part in enabling the industry to generate more output. However, as just noted, there was strong growth in skilled labour—the strongest of all industries.

FIS also showed the strongest improvement in non-IT capital productivity (Figure 6.5). From 1989-90, the productivity of non-IT assets picked up by 125 per cent. A lot of this improvement came from lower unit requirements for buildings (non-dwelling construction), which represents about half of capital costs in FIS. The productivity improvements for this asset class and two others—land (11 per cent of capital costs) and road vehicles (7 per cent)—are shown in Figure 6.11.

The productivities of these assets rose by 65 per cent for buildings and by 100 per cent for land and road vehicles until 2007–08. After that, the asset productivities stagnated or declined.

Figure 6.11: Productivity of land, road vehicles and non-dwelling construction in FIS (index, 2012–13 = 100)



Source: Author estimates

The detailed study of FIS is presented as Appendix K.

6.3.2 Information, media and telecommunications services

IMT has generally experienced strong LP growth. Aside from a period in the 1990s when MFP growth was strong, capital deepening has made the main contribution to LP growth. Table 6.10 shows representative estimates for productivity cycles in the new millennium.

IT has contributed around 0.8 of a percentage points to LP growth over these cycles through capital deepening. That is a strong contribution, although not quite as strong as in FIS.

Table 6.10: Labour productivity growth accounting for IMT

	2003–04 to 2009–10	2009–10 to 2013–14
Capital deepening (pp)	4.0	3.6
IT capital deepening (pp)	0.7	0.8
Hardware	0.5	0.4
Software	0.2	0.4
Non-IT capital deepening (pp)	3.3	2.8
MFP growth (% pa)	0.1	-0.5
Labour productivity growth (% pa)	4.2	3.1

Source: Author estimates. Numbers may not add up due to rounding.

There was little overall change in the productivity of non-IT assets as a group. Improvement in the 1990s was largely offset by deterioration in the 2000s. The major asset category in IMT is non-dwelling construction, which includes communications infrastructure.

This complicates the asset productivity assessment as the productivity of non-dwelling construction would likely fall with investment in long-term improvements in infrastructure. Key results for individual assets were as follows:

- Industrial machinery and equipment showed strong and steady increase in capital productivity of more than 200 per cent for the whole period. (Correlation coefficient with IT use = 0.93.)
- Non-dwelling construction showed a strong increase of 31 per cent up until 1998–99, but then reversed most of that gain by 2013–14. (Correlation coefficient with IT use = 0.21.)
- Land showed an increase of 52 per cent until 2010–11. (Correlation coefficient with IT use = 0.86.)

Other transport equipment showed a very large increase from a small base. (Correlation coefficient with IT use = 0.97.)

The details of the IMT analysis are presented in Appendix VI.

6.3.3 Wholesale trade

Wholesale trade had a lift in MFP growth that featured in Australia's productivity surge in the 1990s. However, MFP growth has since receded and capital deepening provided the main source of continuing strong LP growth in the first half of the 2000s. Since the mid-2000s, capital productivity, MFP growth and LP growth have all declined.

IT contributed a steady 0.7 to 0.9 of a percentage point to LP growth through capital deepening up to the mid-2000s. The relative contributions from hardware and software were two to one respectively.

Since the mid-2000s, however, the IT contribution has dropped back to 0.4 of a percentage point.

The productivity of non-IT assets, as a group, improved over 25 per cent coming out of the early-1990s recession until the end of the decade. There has been a small decline since the turn of the millennium.

The productivity of land and buildings has improved in the order of 100 per cent since the early 1990s. The improvement has been monotonic—that is, continuous and steady. That is consistent with IT enabling a rationalisation of use of storage depots.

The productivity of industrial machinery and equipment and of road vehicles also improved up until around this time. Productivity has fallen in these asset classes since then.

IT could have had substantial productivity-enhancing effects in this industry through capital deepening and by enabling a fast-flow-through approach to wholesaling, at the expense of the traditional storage-based approach.

Details on the growth accounting for wholesale trade are provided in Appendix III.

6.3.4 Retail trade

IT capital deepening contributed a steady 0.6 of a percentage point to LP growth for most of the observation period.

There was steady improvement in the group of non-IT assets (by about 25 per cent) up until 2004–05, with no major move thereafter. The productivity of individual assets increased over the period, with some variation in the sub-periods in which they grew strongest.

Land showed the strongest and steadiest increase in capital productivity at around 80 per cent for the whole period. (Correlation coefficient with IT use = 0.94.)

The productivity of buildings increased by about 35 per cent over the whole period. (Correlation coefficient with IT use = 0.90.)

The productivity of road vehicles increased over 60 per cent up to 2004–05, before falling back. (Correlation coefficient = 0.55.)

The productivity of other plant and equipment increased in the 1990s, but was basically flat thereafter. (Correlation coefficient = 0.43.)

There was little overall change in inventories productivity in the 1990s, but it improved by around 20 per cent in the 2000s. (Correlation coefficient = 0.93.)

Retail trade was the one industry in which the requirements for intermediate inputs declined.

Details on the retail study are provided in Appendix G.

7 Conclusions

Some clear points have emerged from this study:

- The rate of growth in the use of IT has declined in the 2000s. There has been a slowdown in growth of computer hardware since 2007–08.
- As a result of the slowdown, the importance of IT capital deepening in standard growth accounting has declined. The estimates from this paper suggest its contribution to LP growth has fallen from 0.8 to 0.5 of a percentage point.
- A 0.5 of a percentage point contribution to the annual rate of labour productivity growth is still large. It represents about a quarter of labour productivity growth.
- The paper presents some initial evidence that IT could improve overall productivity in the economy by reducing the requirements for other assets. The observations in this study suggest this influence may be important. However, the analysis did not attempt to isolate IT effects from other influences on asset productivities.
- The clearest possibility of an IT link is in reducing the unit requirements for land and buildings. But there is a range of possibilities in regard to different assets and industries.
- It is likely IT complements skilled labour, especially in the financial sector.
- IT intensity and effects vary widely across industries. It makes more sense to analyse IT as a micro phenomenon that has different effects in different industries and firms rather than as a macro phenomenon.
- IT and productivity impacts appear reasonably clear and reasonably large in some industries, starting with financial and insurance services. Other industries include information, media and telecommunications services, wholesale trade and retail. However, possible links especially through the productivity of individual non-IT assets emerge in many industries.

The magnitudes presented in the study are not precise:

- The indications of skill bias and augmentation of non-IT capital undermines the assumptions upon which growth accounting is based. While the estimates are indicative, more precise estimates would require a more-sophisticated econometric approach.
- The effects of other conditioning influences such as complementary intangible investments are not included.

There are some data limitations on important analysis:

- It is not possible to isolate the use of communications equipment in the ABS productivity data cube: that restricts analysis to IT rather than ICTs.
- The public sector is a big user of IT but no productivity measures are available. While productivity in the public sector is of considerable importance and interest in its own right, the ability to investigate the productivity impacts of IT use would be valuable.

Some issues for further analysis come out of the study:

> Why has growth in IT use slowed, especially after 2007–08? Is there a causal association with slower productivity growth? If so, in which direction does the causation run? That is, is productivity growth slower because of slower growth in IT, or do fewer opportunities for productivity improvement mean the steam goes out of IT demand?

References

ABS, Australian System of National Accounts, Cat. No. 5260.0.55.002, 2013–14 issue, 31/10/2014

ABS, Australian System of National Accounts, Cat. No. 5204.0, Tables 69–71, Canberra, 31/10/2014

ABS, Retail and Wholesale Industries, Cat. No. 8622.0 Canberra 31/07/2014

Barnes, P. (2011), 'Multifactor Productivity Cycles at the Industry Level', Staff Working Paper, Productivity Commission, Canberra.

Barnes, P. and A. McClure (2009), 'Investents in Intangible Assets and Australia's Productivity Growth', Staff Working Paper, Productivity Commission, Canberra.

Bresnahan, T. and T. Trajtenberg (1992), 'General Purpose Technologies: 'Engines of Growth?', NBER Working Paper No, 11948, National Bureau of Economic Research, Cambridge, Massachusetts.

Bureau of Communications Research (2015), 'A primer on digital productivity', Department of Communications, Canberra, May.

Brynjolfsson, E., L.M. Hitt and S. Yang (2000), 'Intangible Assets: How the Interaction of Computers and Organisational Structure Affects Stock Market Valuations', MIT Working Paper, Massachusetts Institute of Technology, Massachusetts.

Corrado, C., C. Hulten and D. Sichel (2006), 'Intangible Capital and Economic Growth', NBER Working Paper No, 11948, National Bureau of Economic Research, Cambridge, Massachusetts.

Elnasri, A. and K.J. Fox (2015), 'The Contribution of Research and Innovation to Productivity', UNSW Economics Discussion Paper 2014–08 (updated).

Jovanovich, B. and P. Rousseau (2005), 'General Purpose Technologies', NBER Working Paper No. 11093, National Bureau of Economic Research, Cambridge, Massachusetts.

OECD (Organisation for Economic Co-operation and Development) (2004), The Economic Impact of ICT: Measurement, Evidence and Implications, OECD, Paris.

Parham, D. (2012), 'Australia's Productivity Growth Slump: Signs of Crisis, Adjustment or Both?', Visiting Researcher Paper, Productivity Commission, Canberra.

PC (Productivity Commission) (2004), 'ICT Use and Productivity: A Synthesis from Studies of Australian Firms', Commission Research Paper, Productivity Commission, Canberra.

PC (2009), 'Australia's Productivity Performance', Commission Submission, Productivity Commission, Canberra.

Topp, V. and T. Kulys (2012), 'Productivity in Electricity, Gas and Water: Measurement and Interpretation', Staff Working Paper, Productivity Commission, Canberra.

A. Manufacturing

Key Points

Between 1989–90 and 2013–14, there was slow growth in manufacturing up to a watershed year in 2007–08, when output and labour use declined and capital use plateaued.

Information Technology (IT) stock grew rapidly until 2007–08 with annual rates of growth typically 15 per cent or more. However, IT represented only 8 per cent of capital costs.

For a long time, manufacturing was roughly evenly divided between software and hardware costs, but it became software intensive when hardware growth dropped off after 2007–08.

The IT capital deepening contribution to labour productivity (LP) growth has been steady at around 0.5 to 0.6 of a percentage point, although this halved after 2007–08:

- IT capital deepening accounted for about a quarter of LP growth in the sector.
- Most of the IT capital contribution came from hardware.

Average skill level increased by 11 per cent over the period under review, with a correlation coefficient with IT use of 0.95.

There was no improvement in non-IT capital productivity in manufacturing during the review period:

- The productivity of non-IT assets as a group fell by nearly 25 per cent.
- The productivities of nearly all individual assets also fell.
- Industrial machinery and equipment—the largest capital cost in manufacturing—was a temporary exception. Its productivity increased through the 1990s and early 2000s, but a complete fall after that offset any gains.

As a result is no correlation with IT use and the only identified channel through which IT could affect multifactor productivity growth is the capital deepening effect via labour productivity.

The Australian Bureau of Statistics (ABS) identifies the following subdivisions within the manufacturing sector:

- food, beverage and tobacco products
- textile, clothing and other manufacturing
- wood and paper products
- printing and recorded media
- petroleum, coal, chemical and rubber products
- non-metallic mineral products

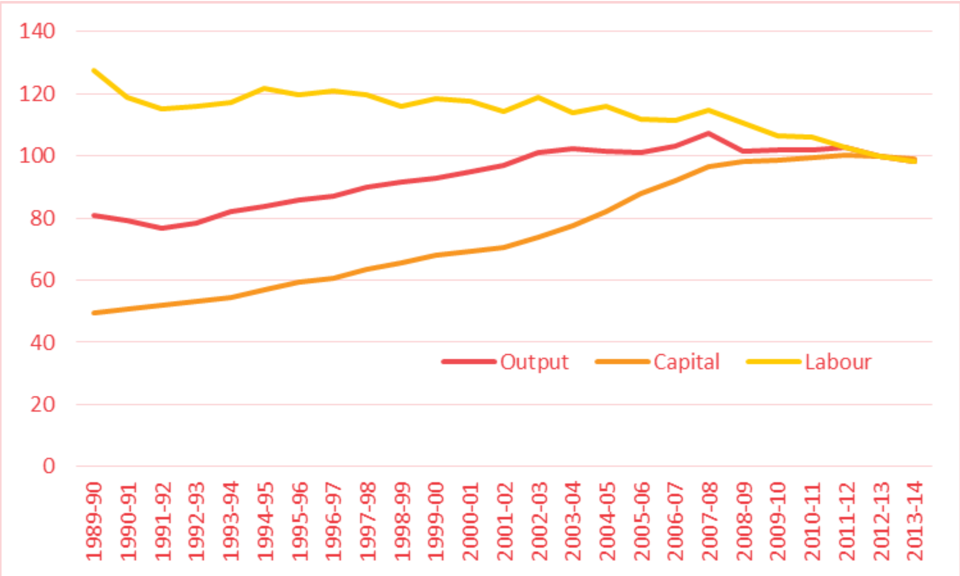
- metal products
- machinery and equipment.

From 1989–90, the sector expanded slowly up until what appears to be a watershed year in 2007-08, when it started to decline and stall, likely due to external pressures associated with the global financial crisis and the mining boom.

After the early-1990s recession, output grew steadily, capital grew reasonably rapidly, but use of labour declined gradually (Figure A1). Since 2007–08, output has declined, capital has been static and labour use has declined more rapidly. The average annual rates of growth from 1989–90 to 2013–14 are 0.8 per cent for output, 2.9 per cent for capital and -1.0 per cent for labour.

Over that same period, manufacturing declined from 15.0 per cent of GDP to just 6.8 per cent.[k]

Figure A1: Output, capital, and labour in manufacturing (index, 2012–13 = 100)



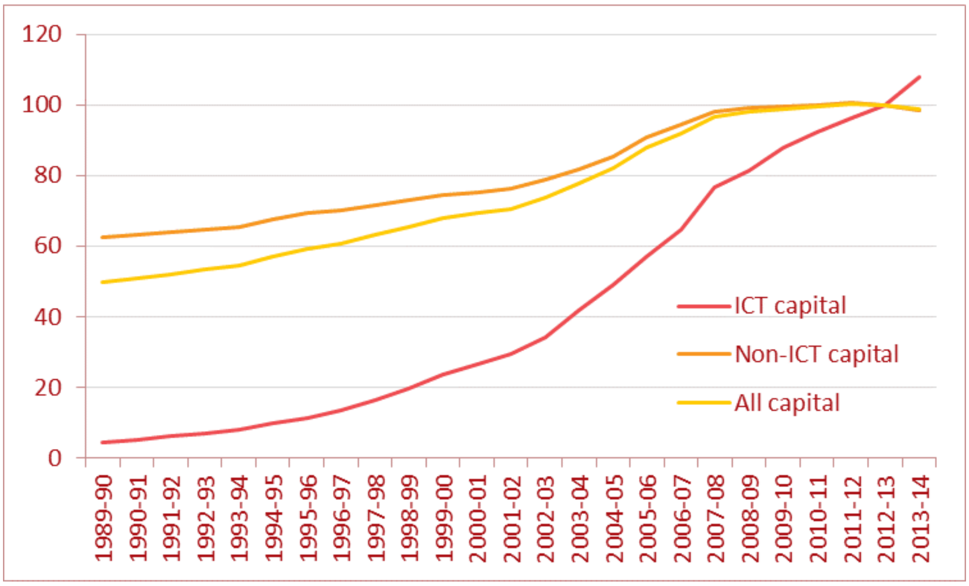
Source: ABS Cat. No. 5260.0.55.002

A.1 Growth in IT capital

There was strong growth in Information Technology (IT) use in manufacturing in the 1990s and into the 2000s, up to 2007–08 (Figure A2). Annual rates of growth in IT capital were in the region of 15 per cent (Figure A3). The average annual rate of growth in IT over the period was 13.4 per cent.

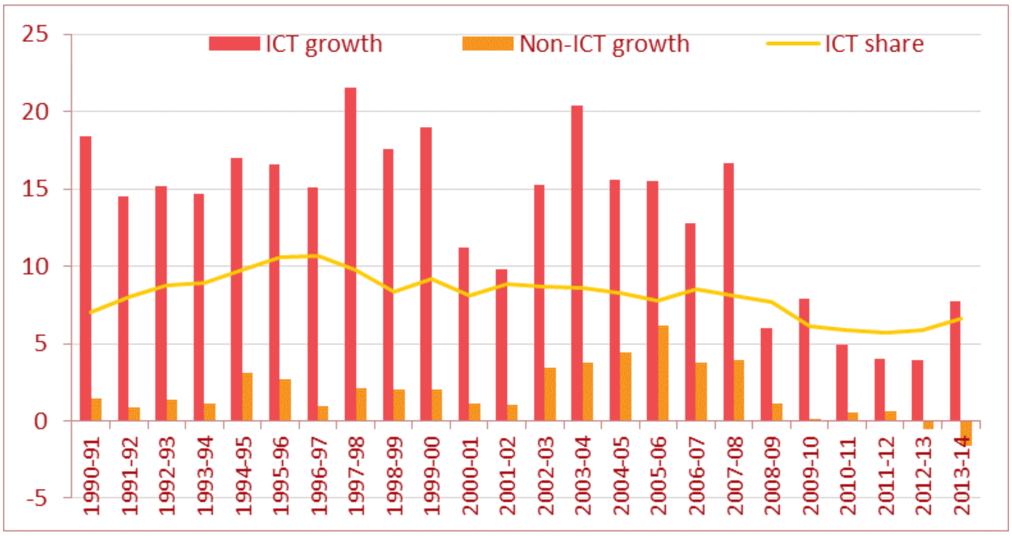
IT has been an important but not major part of total capital in the sector. It has accounted for between 5 and 10 per cent of capital income for most of the period (Figure). The overall average is 8 per cent, split evenly between hardware and software.

Figure A2: Capital, IT capital and non-IT capital in manufacturing (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002 and author estimates

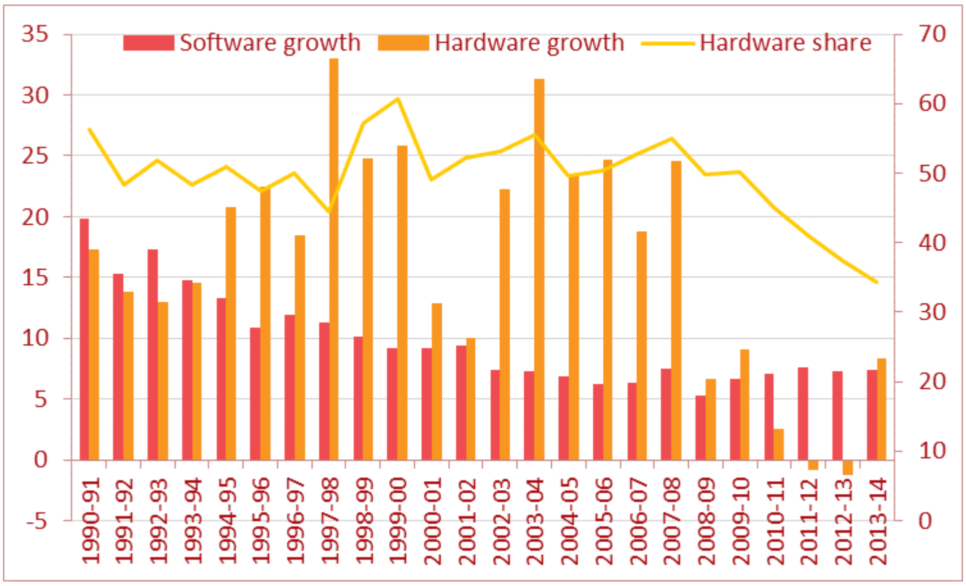
Figure A3: Annual growth in IT and non-IT capital (% per year) and the IT share of capital income (%) in manufacturing



Source: Author estimates

The growth in IT between the mid-1990s and mid-2000s was mainly in hardware (Figure A4). The sector became more software intensive (as indicated by the hardware share in Figure A4) when the share of hardware dropped off after 2007–08.

Figure A4: Annual growth in software and hardware (% per year) and hardware share of IT capital income (%) in manufacturing



Source: Author estimates

A.2 Labour productivity growth

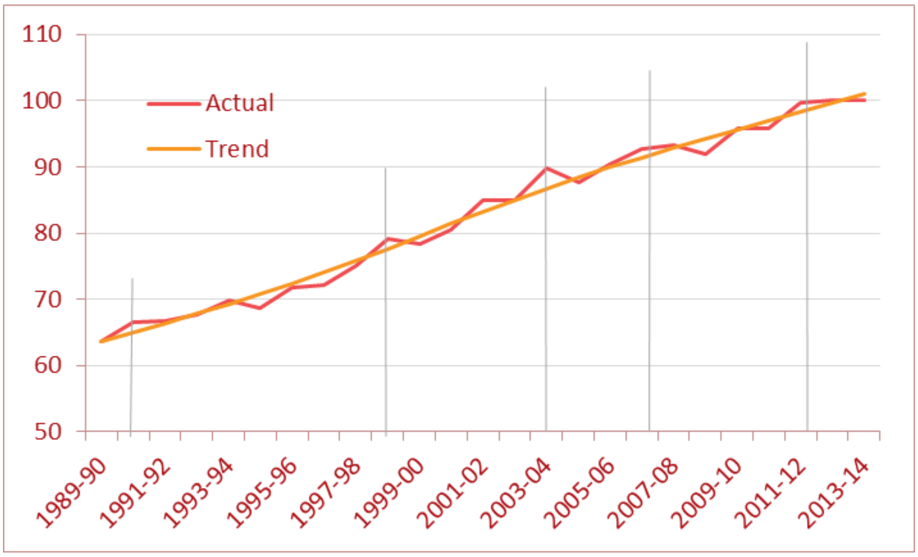
Labour productivity (LP) growth in manufacturing was moderate to slow from 1989–90, increasing 57 per cent to 2013–14 (Figure A5). The average annual rate of growth in trend LP was 1.9 per cent.

Peaks in LP cycles took place in 1990–91, 1998–99, 2001–02, 2003–04, 2006–07 and 2011–12 according to the method set out in section 5.3 (Figure). The peak in 2001–02 was overlooked as it was deemed to not provide much difference in trend from its near neighbour in 2003–04.

Productivity growth over the LP cycles has slowed considerably. Average growth rates in actual LP over cycles were:

- 1990–91 to 1998–99: 2.2 per cent a year
- 1998–99 to 2003–04: 2.5 per cent a year
- 2003–04 to 2006–07: 1.1 per cent a year, and
- 2006–07 to 2011–12: 1.5 per cent a year.[l]

Figure A5: Actual and trend labour productivity in manufacturing[a] (index, actual 2012–13 = 100)



Note: a. Trend series formed with a Hodrick-Prescott filter λ = 100

Source: ABS Cat. No. 5260.0.55.002 and author estimates

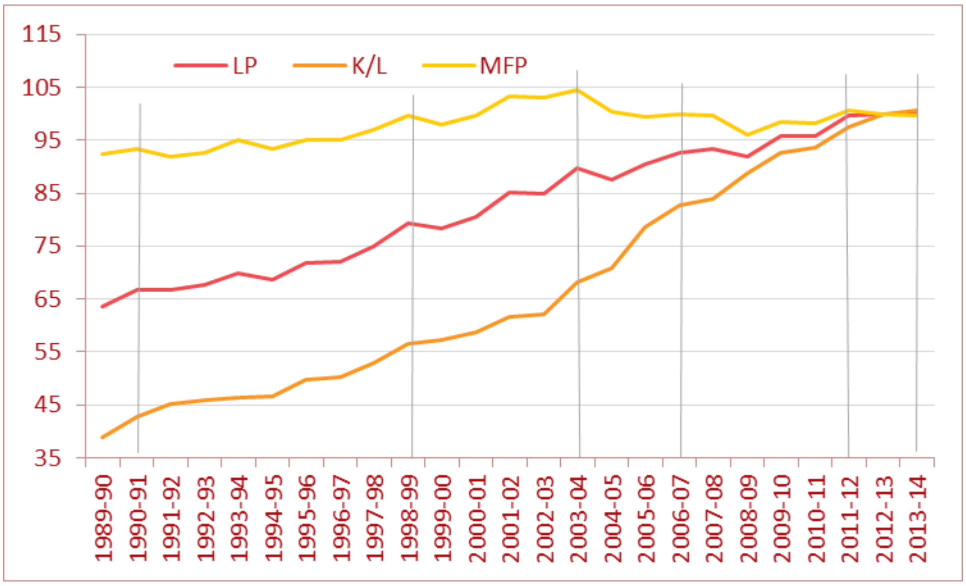
A.2.1 IT capital deepening and LP growth

The growth in labour productivity can be decomposed into contributions from capital deepening and multifactor productivity (MFP) growth. Capital deepening is growth in the capital-labour ratio, multiplied by the share of total industry income attributed to capital.

The greater contribution of capital deepening is clearly evident from a glance at Figure A.6.

MFP increased 21 per cent and the capital-labour ratio grew nearly 160 per cent (from approximately 40 in 1989-90 to 100 in 2013-14) through the combination of strong capital growth and labour shedding. (The capital-labour ratio needs to be weighted by the capital share of total income, which averaged 0.39, to indicate its contribution.)

Figure A6: Labour productivity (LP), the capital–labour ratio (K/L) and multifactor productivity (MFP) in manufacturing (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002

The dominance of capital deepening is confirmed by the formal growth accounting in Table A1.

Capital deepening accounted for at least 60 per cent of labour productivity growth in each cycle. Apart from the first cycle, non-IT capital accounted for more of the capital deepening than growth in IT capital.

The IT capital deepening contribution was steady, only varying in the range of 0.5 to 0.7 of a percentage point. The smallest contribution came in the last period reviewed when there was less growth in investment in IT. IT capital deepening accounted for around a quarter to a third—between 24 and 37 per cent—of LP growth over three of the cycles.

In keeping with its stronger growth, hardware made the stronger contribution to IT capital deepening, especially in the middle two cycles.

Table A1: Labour productivity growth accounting in manufacturing (per cent per annum and percentage points)[a]

	1990–91 to 1998–99	1998–99 to 2003–04	2003–04 to 2006–07	2006–07 to 2011–12
Capital deepening	1.4 (63)	1.5 (61)	2.6 (>100)	1.3 (89)
IT capital deepening	0.7 (30)	0.6 (24)	0.7 (60)	0.5 (37)
Non-IT capital deepening	0.7 (32)	0.9 (37)	2.0 (>100)	0.8 (53)
MFP growth	0.8 (37)	1.0 (39)	-1.5 (<0)	0.2 (11)
Labour productivity growth	2.2 (100)	2.5 (100)	1.1 (100)	1.5 (100)

Note: a. Figures in brackets refer to percentages of labour productivity growth. Numbers may not add up due to rounding

Source: Author estimates

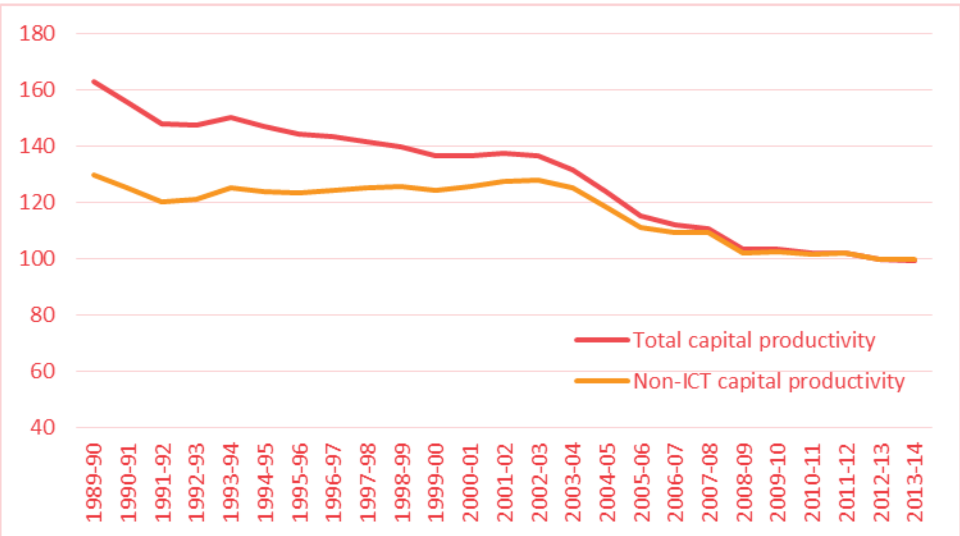
A.2.2 IT use and skills

Over the period analysed, the average skill level in the industry increased steadily by 11 per cent (based on data from ABS Cat. No. 5260.0.55.002). Even though the stock of IT capital increased by much more, there was a high degree of correlation between the two. The correlation coefficient between IT capital and the index of skill composition is 0.95.

A.3 IT, asset use, and capital productivity

IT can enhance the productivity of other assets. This does not appear to have happened in manufacturing in terms of the productivity of all non-IT assets (Figure A7). Non-IT capital productivity was flat until 2002–03, after which it fell by over 20 per cent.

Figure A7: Capital productivity of all assets and non-IT assets in manufacturing (index, 2012–13 = 100)

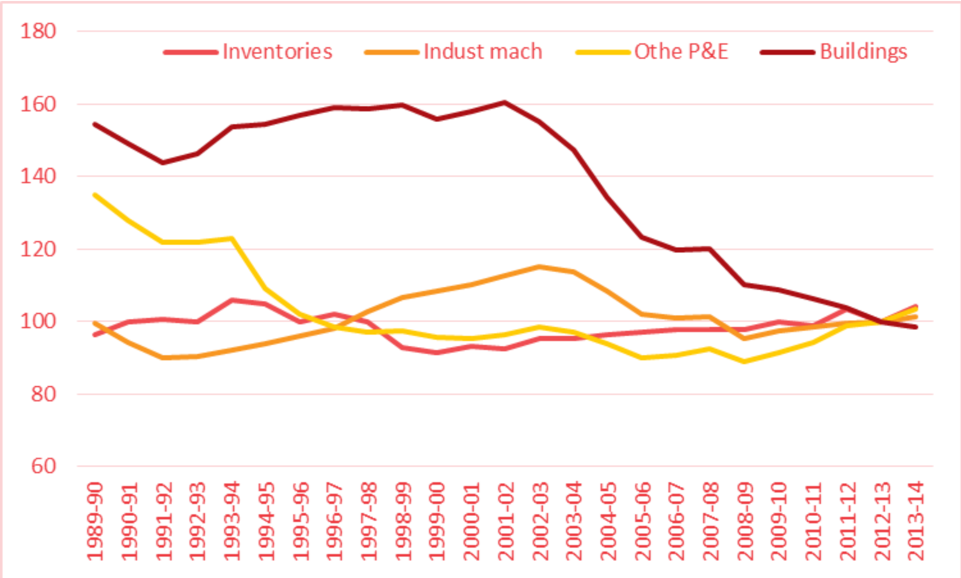


Source: Author estimates

The productivity of individual assets was also investigated. The major non-IT capital inputs in manufacturing are: industrial machinery and equipment (32 per cent of capital income[m]), buildings (25 per cent), inventories (9 per cent) and other plant equipment (9 per cent).

None of these assets increased in productivity (Figure A8). Industrial machinery and equipment is a minor exception with an increase over the 1990s and early 2000s, after which there was an almost complete offset. There was a decrease in capital productivity among the other non-IT assets. Buildings productivity fell nearly 40 per cent after 2000-01.

Figure A8: Asset productivity–the ratio of value added to use of selected assets in manufacturing (index, 2012–13 = 100)



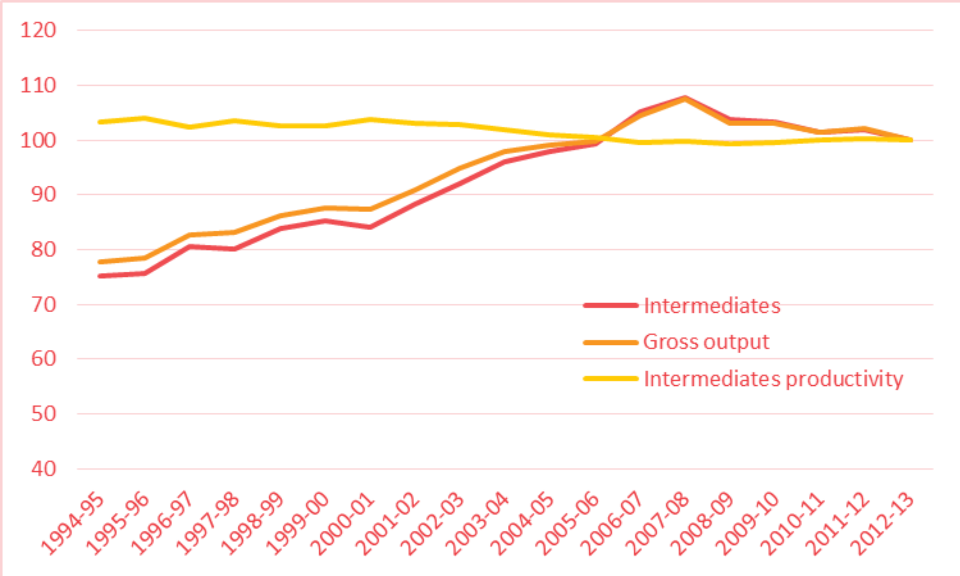
Source: Author estimates

A.4 Use of intermediates

The possibility that IT could help improve the efficiency with which intermediate inputs are used was also examined. Intermediate inputs are purchased materials (components), energy and services. In the case of intermediate input use, productivity is determined in reference to the gross output rather than the value added, measure of output.

However, the efficiency of intermediates use declined slightly in manufacturing over the period reviewed (Figure A9).

Figure A9: Gross output, intermediate input use and intermediate input productivity in manufacturing (index, 2012–13 = 100)



Source: Author estimates

A.5 MFP growth

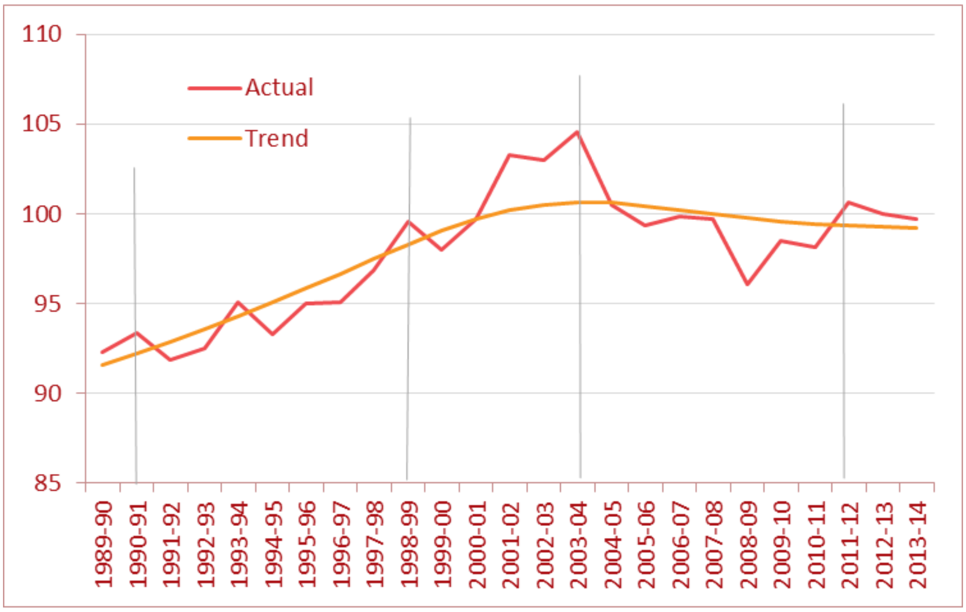
The association between IT and MFP was examined in the context of MFP cycles (Figure A10). The timing of MFP cycles and LP cycles coincided, with the exceptions that 2000–01 and 2006–07 were not MFP peaks.

The rates of MFP growth in the identified cycles were:

- 1990–91 to 1998–99: 0.8 per cent per year
- 1998–99 to 2003–04: 1.0 per cent per year, and
- 2003–04 to 2011–12: -0.5 per cent per year.

For current purposes MFP growth is a weighted average of LP growth and capital productivity growth, with the respective income shares as the weights. This allowed the influences of IT growth on MFP to be seen as a combination of substitution effects on labour and capital.

Figure A10: Actual and trend MFP in manufacturing [a] (index, actual 2012–13 = 100)



Note: a. Trend series formed with a Hodrick-Prescott filter λ = 100

Source: ABS Cat. No. 5260.0.55.002 and author estimates

Table A2 shows the MFP growth accounting. The labour productivity growth contribution plus the capital productivity contribution equals the MFP growth presented in the bottom row.

In the period under review, capital productivity was a drag on MFP growth in all cycles leaving labour productivity as the positive contributor. From this analysis, the only positive contribution of IT to MFP appears to be via capital deepening in the LP channel. This contribution accounts for about 0.4 of a percentage point of annual MFP growth. [n]

Table A2: Multifactor productivity growth accounting over MFP cycles in manufacturing (percentage points)

	1990–91 to 1998–99	1998–99 to 2003–04	2003–04 to 2011–12
LP growth contribution	1.3	1.5	0.8
of which			
IT capital deepening	0.4	0.4	0.3
KP growth contribution	-0.5	-0.5	-1.3
of which			
IT capital productivity	-0.24	-0.09	-0.33
Non-IT capital productivity	-0.27	-0.41	-0.96
MFP growth	0.8	1.0	-0.5

Source: Author estimates. Numbers may not add up due to rounding.

B. Electricity, gas, water and waste services

Key points

From 1989–90, there was slow and steady output growth in electricity, gas, water and waste services (EGWWS). Capital growth was strong in the 2000s. There was labour shedding in the 1990s, but a return to strong growth in labour from 2004–05:

> The sector is capital intensive, with a capital income share averaging about 64 per cent.

While growth in Information Technology (IT) averaged 18.5 per cent a year, that growth did not have a big influence on growth in total capital because IT represented only about 6.6 per cent of capital costs.

There was strong growth in both labour productivity (LP) and multifactor productivity (MFP) in the 1990s, followed by prolonged and deep falls in the 2000s.

The contribution of IT capital deepening to LP growth has been quite strong in this sector. It has been in the range of 0.5 to 0.7 of a percentage point, with a jump to 1.1 percentage points between 1997–98 and 2000–01.

> Hardware made the major contribution from the mid-1990s.

> Average skill level of labour in this industry increased by 9 per cent over the period with a correlation coefficient with IT use of 0.56.

There were two distinct periods of movement in non-IT capital productivity. It increased 13 per cent in the 1990s but fell 35 per cent after that. The productivity of other plant and equipment improved 75 per cent in the 1990s.

Despite being a relatively small part of the industry's asset holdings, IT made a sizeable contribution to LP growth and most likely to MFP growth in the 1990s.

According to the Australian Bureau of Statistics (ABS), businesses in the electricity, gas, water and waste services (EGWWS) sector provide electricity, gas through mains systems, water, drainage, and sewage services. It also includes businesses primarily engaged in the collection, treatment and disposal of waste materials, remediation of contaminated materials (including land), and materials recovery activities.

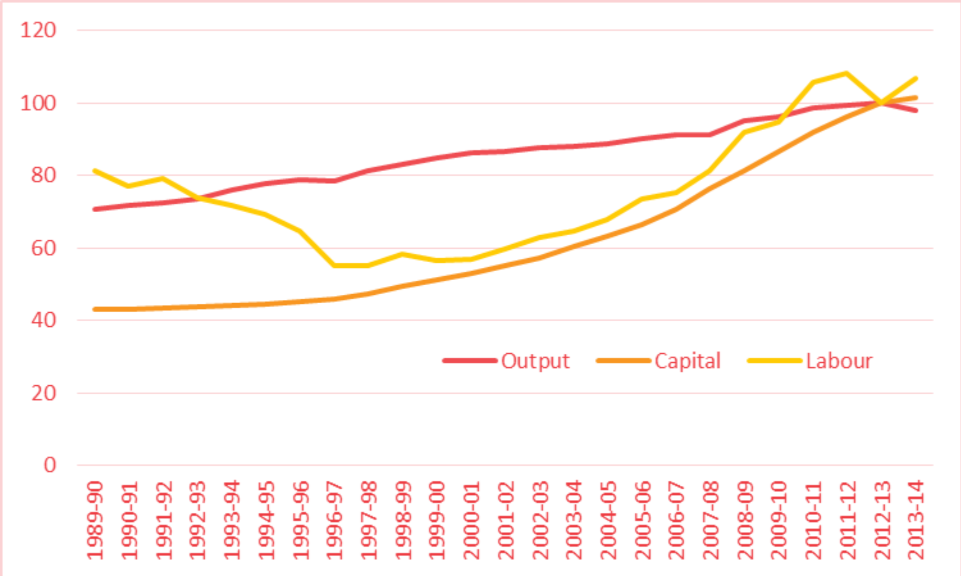
EGWWS grew slowly but steadily through the 1990s and 2000s (Figure II2). Its annual growth in output volumes averaged 1.4 per cent from 1989–90 to 2013–14, which was below the average for GDP. Consequently, the sector declined from 4.0 per cent of GDP in 1989–90 to 2.9 per cent in 2013–14.[o]

There was solid growth in capital (Figure B1), which averaged 3.6 per cent a year over the period under review (1989–90 to 2013–14). However, there was more-rapid growth after 2000–01: 5.3 per cent a year compared with 1.9 per cent a year before that.

Growth in labour averaged 1.1 per cent a year but varied greatly over the period. There was labour shedding to 1997–98, followed by a slow rise to 2004–05. After that, hours worked growth averaged over 5 per cent a year.

The sector is capital intensive with the capital income share averaging 64 per cent.

Figure B1: Capital, labour and output in EGWWS (index, 2012–13 = 100)



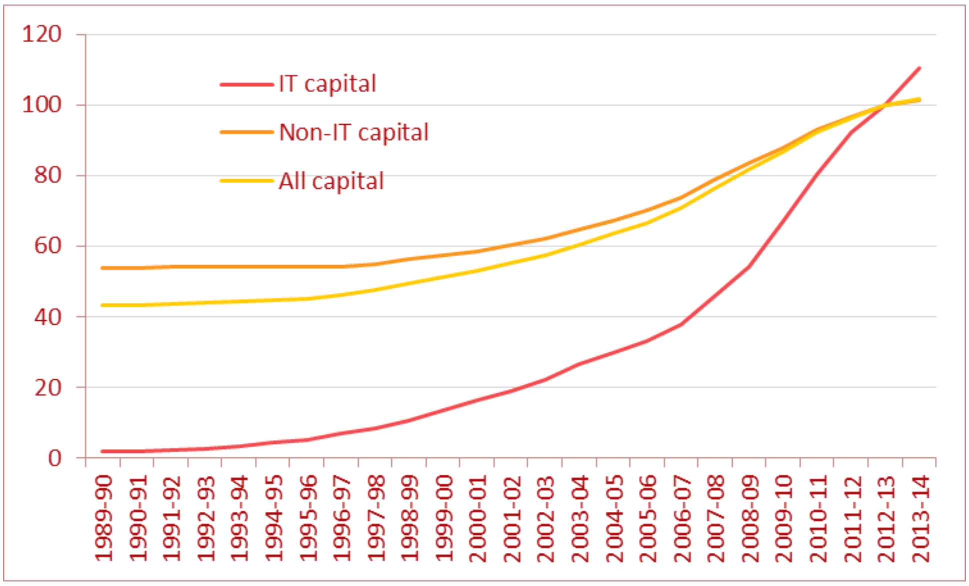
Source: ABS Cat. No. 5260.0.55.002

B.1 Growth in information technology capital

Given EGWWS has extensive asset holdings, for example in electricity generation and distribution, Information Technology (IT) represents only a small proportion of the sector's assets. Since 1989–90, IT has accounted for an average of 6.5 per cent of capital costs but the percentage has varied greatly (Figure B2). The sector accounts for about 7 per cent of hardware use in the economy and 5 per cent of software use.

While the growth in IT capital was strong, averaging 18.5 per cent a year, that growth did not have a big influence on growth in total capital due to EGWWS's relatively small holdings of IT. Growth in total capital was mostly in line with growth in non-IT capital, which averaged 2.7 per cent a year (Figure B2).

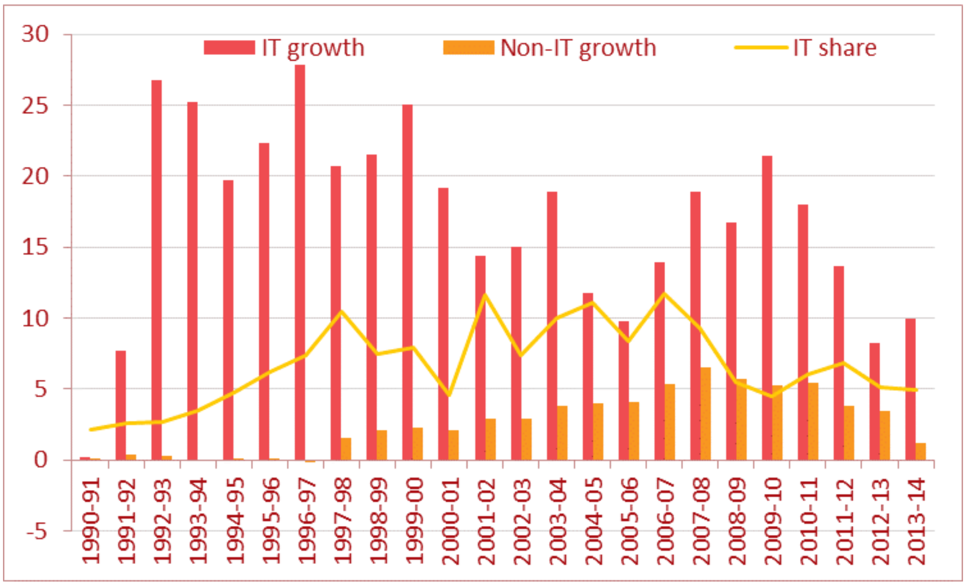
Figure B2: Capital, IT capital and non-IT capital in EGWWS (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002 and author estimates

Annual rates of growth in IT were strongest in the 1990s (Figure B3). Unlike other industries, there was hardly any slowdown in the growth of IT investment after 2007–08.

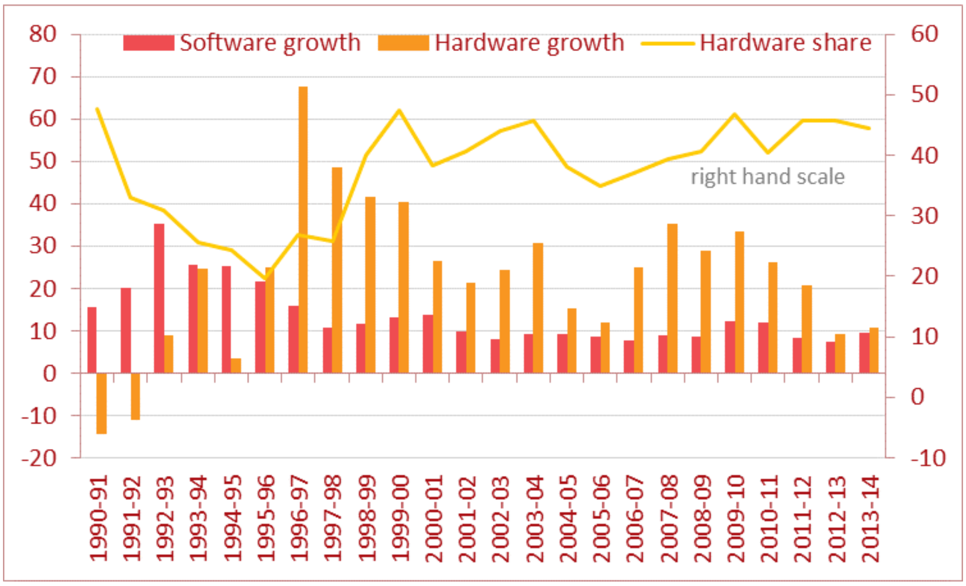
Figure B3: Annual growth in IT and non-IT capital (% per year) and the IT share of capital income (%) in EGGWS



Source: Author estimates

Growth in hardware was stronger than in software from the mid-1990s (Figure B4). The sector has been mostly software intensive, indicated by a hardware share of less than 50 per cent (Figure B4).

Figure B4: Annual growth in software and hardware (% per year) and hardware share of IT capital income (%) in EGWWS



Source: Author estimates

B.2 Labour productivity growth

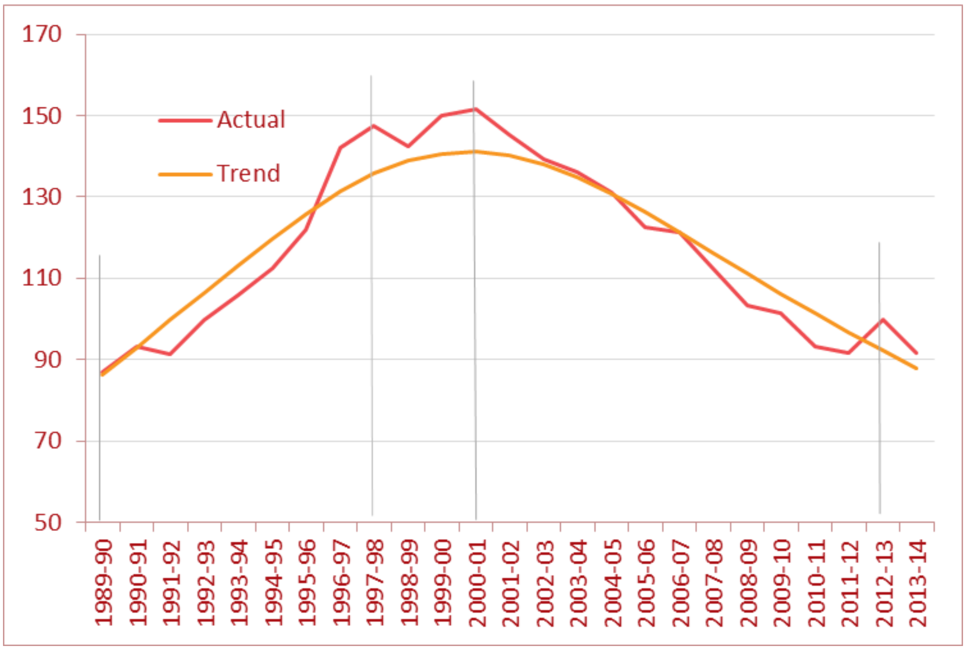
With weak but steady growth in output, growth in labour productivity was largely determined by variations in labour growth. The level of labour productivity increased by only 6 per cent between 1989–90 and 2013–14.

Figure B5 shows that peaks in labour productivity (LP) cycles occurred in 1997–98, 2000–01 and 2012–13 according to the method set out in section 5.3. In addition, a peak at 1989–90 was imposed.

Productivity growth over these LP cycles was:

- 1989–90 to 1997–98: 6.9 per cent a year
- 1997–98 to 2000–01: 0.9 per cent a year, and
- 2000–01 to 2012–13: -3.4 per cent a year. [p]

Figure B5: Actual and trend labour productivity in EGWWS[a] (index, actual 2012–13 = 100)



Note: a. Trend series formed with a Hodrick-Prescott filter λ = 100

Source: ABS Cat. No. 5260.0.55.002 and author estimates

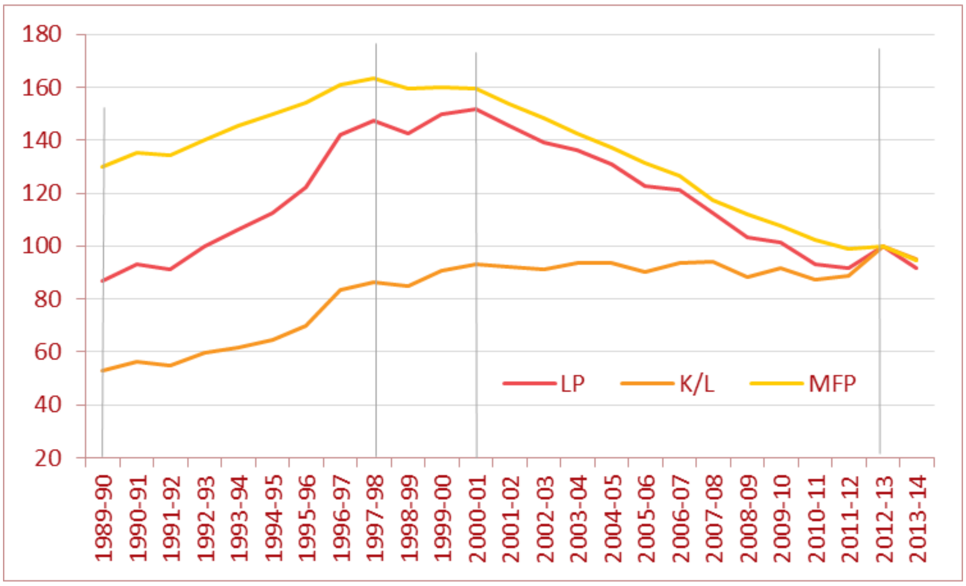
B.2.1 IT capital deepening and LP growth

The growth in labour productivity can be decomposed into contributions from capital deepening and multifactor productivity (MFP) growth (section 4). Capital deepening is growth in the capital-labour ratio, multiplied by the share of total industry income attributed to capital.

Labour productivity, the capital-labour ratio and MFP are illustrated in Figure B6. While the capital-labour ratio increased by 80 per cent, MFP declined over the whole period by 27 per cent. As a result, the small rise in labour productivity was all down to capital deepening.[q]

The contribution of IT capital deepening to LP growth was quite strong in this sector for the period under review. It was in the range of 0.5 to 0.7 of a percentage point, with a jump to 1.1 percentage points between 1997–98 and 2000–01 (Table B1). Hardware made the major contribution from the mid-1990s

Figure B6: Labour productivity (LP), the capital-labour ratio (K/L) and multifactor productivity (MFP) in EGWWS (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002

Table B1: Labour productivity growth accounting in EGWWS (per cent per annum and percentage points)[a]

	1989–90 to 1997–98	1997–98 to 2000–01	2000–01 to 2012–13
Capital deepening	3.8 (57)	1.7	0.4
ICT capital deepening	0.7 (11)	1.1	0.5
Hardware	*0.2*	*0.7*	*0.4*
Software	*0.5*	*0.3*	*0.1*
Non-ICT capital deepening	3.0 (46)	0.6	-0.1
MFP growth	2.8 (43)	-0.8	-3.9
Labour productivity growth	6.6 (100)	0.9	-3.5

Note: a. Figures in brackets refer to percentages of labour productivity growth. Numbers may not add up due to rounding.

Source: Author estimates

B.2.2 IT use and skills

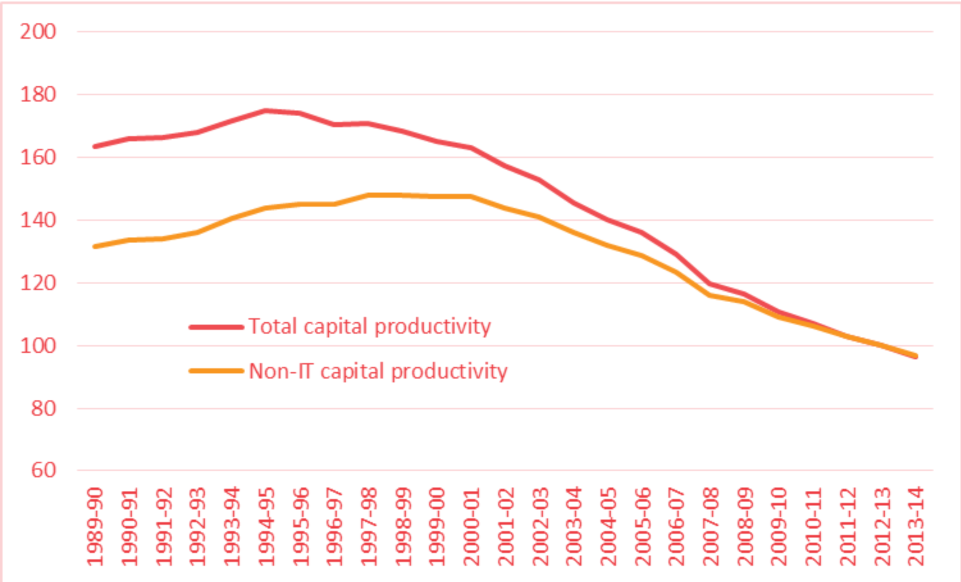
Average skill increased by 9 per cent over the period reviewed with most of that increase coming in the 1990s. The average crept up to a peak increase of nearly 11 per cent in 2005–06 before slipping back. There was a moderate degree of correlation (coefficient of 0.56) with IT capital.

B.3 IT, asset use, and capital productivity

The productivity of total capital and of non-IT capital is shown in Figure B7.

Non-IT capital productivity can be divided into two contrasting periods. It grew 13 per cent over the nine years (1.3 per cent a year) up until 1998–99, but then declined by 35 per cent over the next 15 years (-2.8 per cent a year). While there was correlation with growth in the IT stock in the first period, there was negative correlation in the second period.

Figure B7: Capital productivity of all assets and non-IT assets in EGWWS (index, 2012–13 = 100)



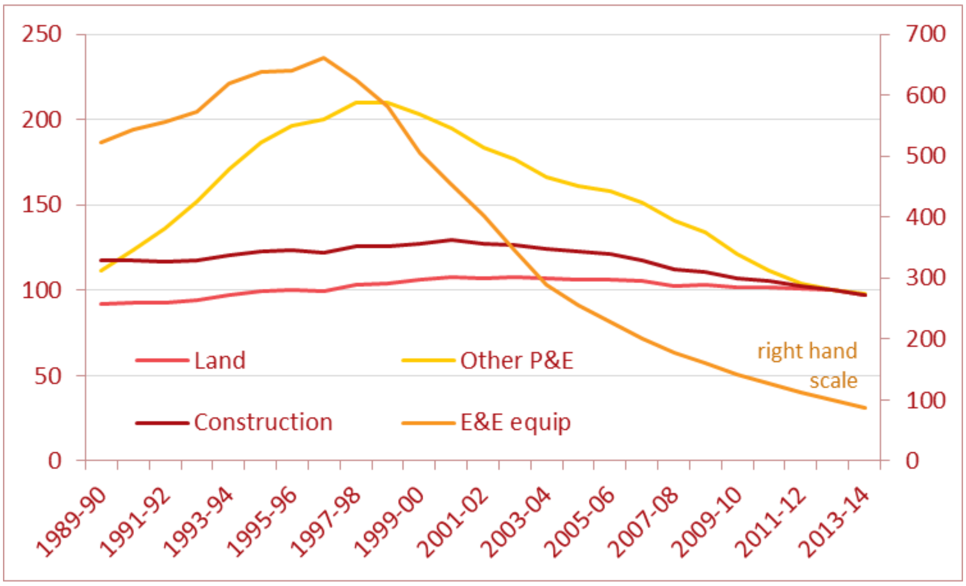
Source: Author estimates

The major non-IT assets in EGWWS are: structures (61 per cent of capital income)[r], land (9 per cent), electrical and electronic equipment (7 per cent) and other plant and equipment (6 per cent).

The productivity of these major assets improved over at least part of the period (Figure B8). Changes from 1989–90 to 2000–01 were:

- structures: 10 per cent
- land: 17 per cent
- electrical and electronic equipment: -13 per cent, and
- other plant and equipment: 75 per cent.

Figure B8: Asset productivity—the ratio of value added[a] to use of selected assets in EGWWS



Source: Author estimates.

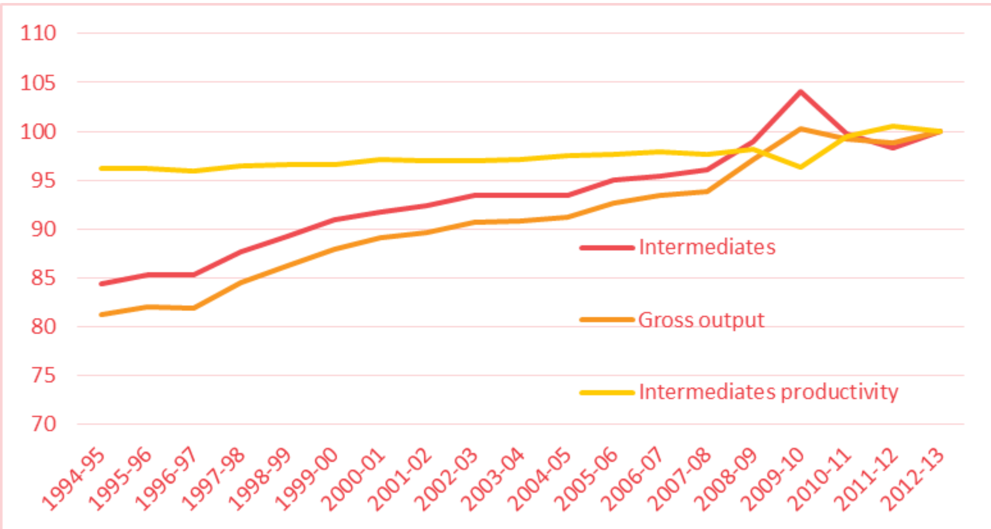
[a] Value added refers to output measure, which explains how capital productivity is derived.

B.4 Use of intermediates

Intermediate inputs are purchased materials, energy and services, used as inputs to production. In the case of intermediate input use, productivity is determined with reference to the gross output rather than the value added measure of output.

The productivity of intermediates increased 4 per cent over the entire period (Figure B9).

Figure B9: Gross output, intermediate input use and intermediate input productivity in EGWWS (index, 2012–13 = 100)

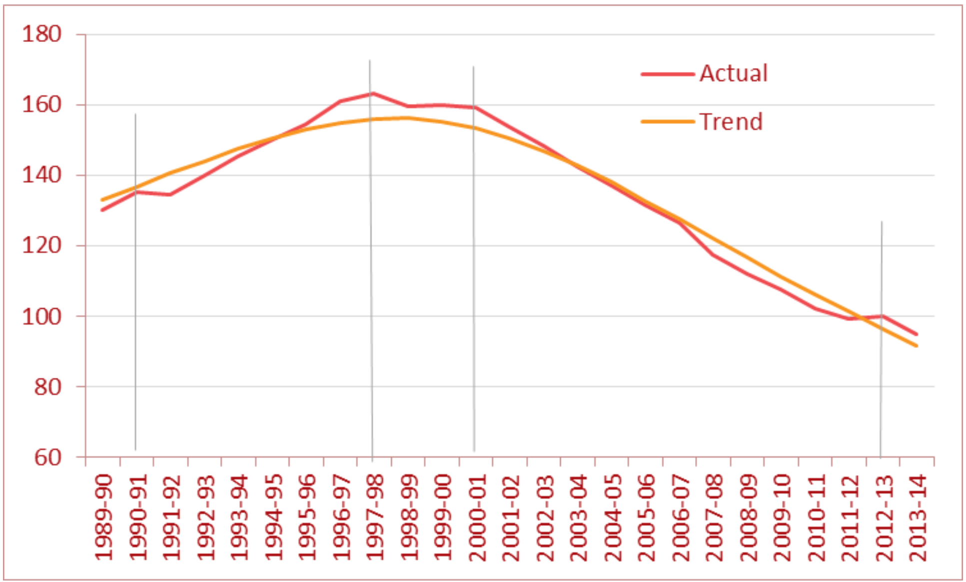


Source: Author estimates

B.5 MFP growth

The association between IT and MFP was examined in the context of MFP cycles (Figure B10). As with labour productivity, MFP peaks occurred in 1997–98, 2000–01 and 2012–13. A peak in 1990–91 was also imposed in order to analyse the 1990s.

Figure B10: Actual and trend MFP in EGWWS[a] (index, actual 2012–13 = 100)



Note: a. Trend series formed with a Hodrick-Prescott filter λ = 100

Source: ABS Cat. No. 5260.0.55.002 and author estimates

Table B2 shows the MFP growth accounting. The labour productivity growth contribution plus the capital productivity contribution equals the MFP growth presented in the bottom row.

The IT contribution through IT capital deepening and LP growth was 0.2 to 0.3 of a percentage point. There may have been a link between IT use and improvements in productivity in the 1990s.

Table B2: Multifactor productivity growth accounting over MFP cycles in EGWWS

	1990–91 to 1997–98	1997–98 to 2000–01	2000–01 to 2012–13
LP growth contribution (pp)	2.4	0.3	-1.2
of which			
IT capital deepening (pp)	0.3	0.3	0.2
KP growth contribution (pp)	0.3	-1.1	-2.7
of which			
IT capital productivity (pp)	-0.62	-1.04	-0.72
Non-IT capital productivity (pp)	0.88	-0.07	-1.93
MFP growth (% pa)	2.7	-0.8	-3.9

Source: Author estimates. Numbers may not add up due to rounding.

C. Wholesale trade

Key Points

Wholesale's use of IT and productivity both grew rapidly in the 1990s. However, the rate of growth in both slowed in the 2000s. Growth in the use of Information Technology (IT) dropped after 2007–08 and growth in multifactor productivity (MFP) slowed after 2005–06.

Since 1989–90, there has been strong substitution of IT for labour. IT capital deepening accounted for 0.7 to 0.9 of a percentage point of labour productivity (LP) growth in the high growth period:

> IT capital deepening has accounted for around 15–25 per cent of LP growth since the early 1990s.

There is high correlation between greater use of IT and greater use of skills in the industry.

IT use may have enabled more productive use of some types of capital. The productivity of buildings and land has improved by 100 per cent since the early 1990s. Wholesalers were also able to economise on the use of industrial machinery and equipment, road vehicles and the need for inventories in the 1990s. However, the productivities of these assets declined in the 2000s.

There was a clear association between IT use and MFP growth in the high growth period up to the mid-2000s, after which growth in both has declined:

> Viewing MFP growth as an amalgam of LP growth and capital productivity growth, IT contributed between 0.4 and 1 percentage point to annual MFP growth for the sector up to the mid-2000s.

Wholesale trade is the distribution of goods from domestic producers and importers to domestic retailers and the distribution of domestic goods to export outlets.

The Australian Bureau of Statistics (ABS) identifies the following subdivisions of wholesale trade:

> basic material wholesaling

> machinery and equipment wholesaling

> motor vehicle and motor vehicle parts wholesaling

> grocery, liquor and tobacco product wholesaling

> other goods wholesaling, and

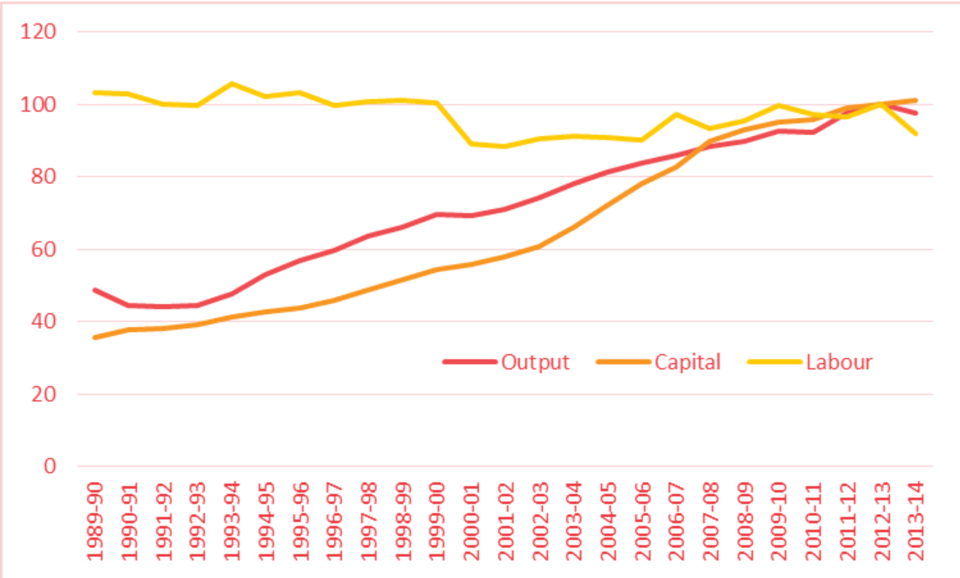
> commission-based wholesaling.

The sector has shown below-average growth of 2.9 per cent a year from 1989–90 to 2013–14. As a result, it fell as a proportion of GDP from 5.4 per cent to 4.2 per cent. Wholesaling did, however, have a period of very strong growth of 6.6 per cent a year between 1992–93 and 1999–00 (Figure C1).

Capital growth was quite strong at 4.4 per cent a year over the whole period. The strongest growth came between 2002–03 and 2007–08 (Figure C1), when the average annual rate reached 8.2 per cent.

Labour use changed little over the entire period. A sharp fall after 1999–00 was offset by a gradual rise from the early 2000s (Figure C1).

Figure C1: Capital, labour and output in wholesale trade (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002

Previous analysis showed that IT has brought productivity gains in wholesale trade. Johnston et al (2000) examined the link between IT use and productivity gains in wholesale trade and found the use of IT was helping to transform the industry from a storage-based system to a fast-flow distribution network. Wholesale trade was one of the major sources of productivity growth in the Australian economy in the productivity surge of the 1990s.[13]

C.1 Growth in IT capital

The rapid rate of growth in Information Technology (IT) capital is evident in The rate of growth in investment eased in the 2000s. Growth in software investment slowed from a very rapid 30 per cent a year in the decade before 2003–04 to 16 per cent a year in the decade after. Over the same periods, growth in hardware investment slowed from 13 to eight per cent a year.

[13] D. Parham (2004), 'Sources of Australia's Productivity Growth Revival', *The Economic Record*, vol.80, no.249, pp.239–57. Productivity Commission (2009), *Australia's Productivity Performance*, Productivity Commission Submission, Canberra.

Figure 3.1 shows investment in E&E equipment stalled in the mid-2000s, but then resumed growth in the 2010s. The average rate of growth in the two periods was 15 and six per cent a year respectively.

The rate of growth in hardware investment has been variable since the mid-2000s. It slowed considerably after a brief acceleration in 2007–08, which may have been prompted by the global financial crisis. There was a 40 per cent rise in hardware investment in 2013–14, which could possibly be catch-up after deferred investment.

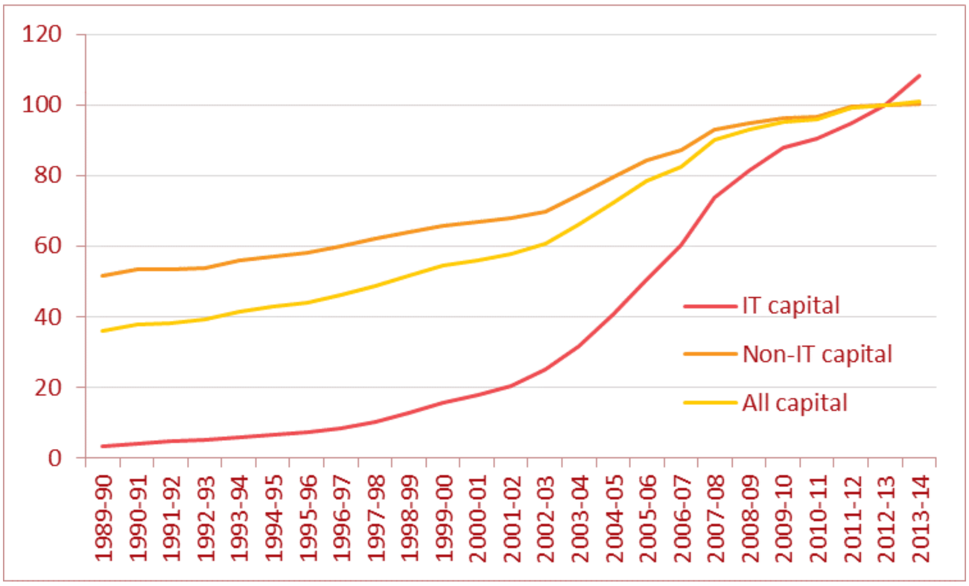
Figure 3.1. The annual rate of growth averaged 15.7 per cent. Annual rates of growth in IT capital were strongest through the late-1990s and early-2000s (Figure C3). Growth in IT use dropped off after 2007–08.

This strong growth in IT capital had a noticeable impact on total capital growth because of IT's importance in wholesale's use of capital. IT has absorbed between 10 and 15 per cent of capital income in the sector (Figure).

Figure C3 shows the annual rate of growth averaged 15.7 per cent. Annual rates of growth in IT capital were strongest through the late-1990s and early-2000s. Growth in IT use dropped off after 2007–08.

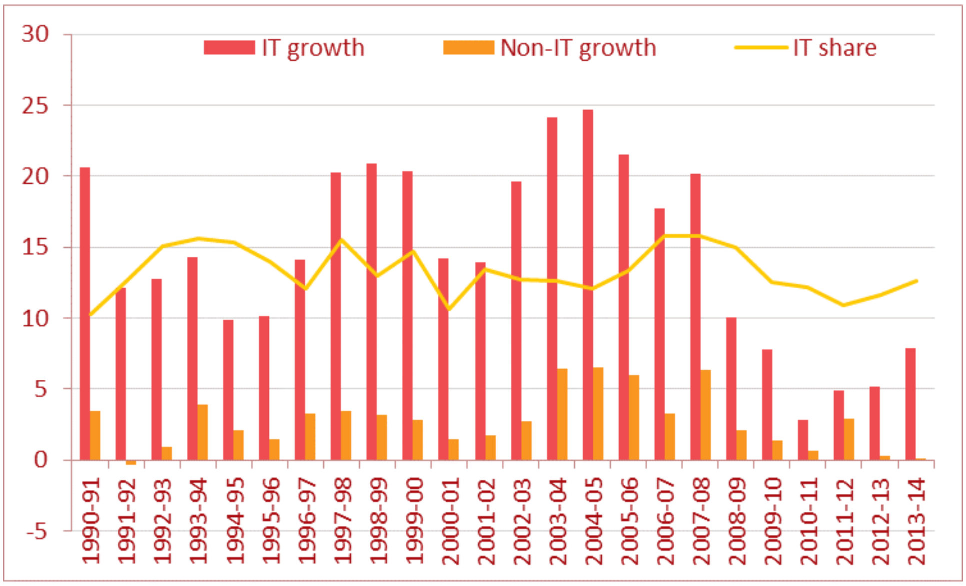
This strong growth in IT capital had a noticeable impact on total capital growth because of IT's importance in wholesale's use of capital. IT has absorbed between 10 and 15 per cent of capital income in the sector (Figure).

Figure C2: Capital, IT capital and non-IT capital in wholesale trade (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002 and author estimates

Figure C3: Annual growth in IT and non-IT capital (% per year) and the IT share of capital income (%) in wholesale trade

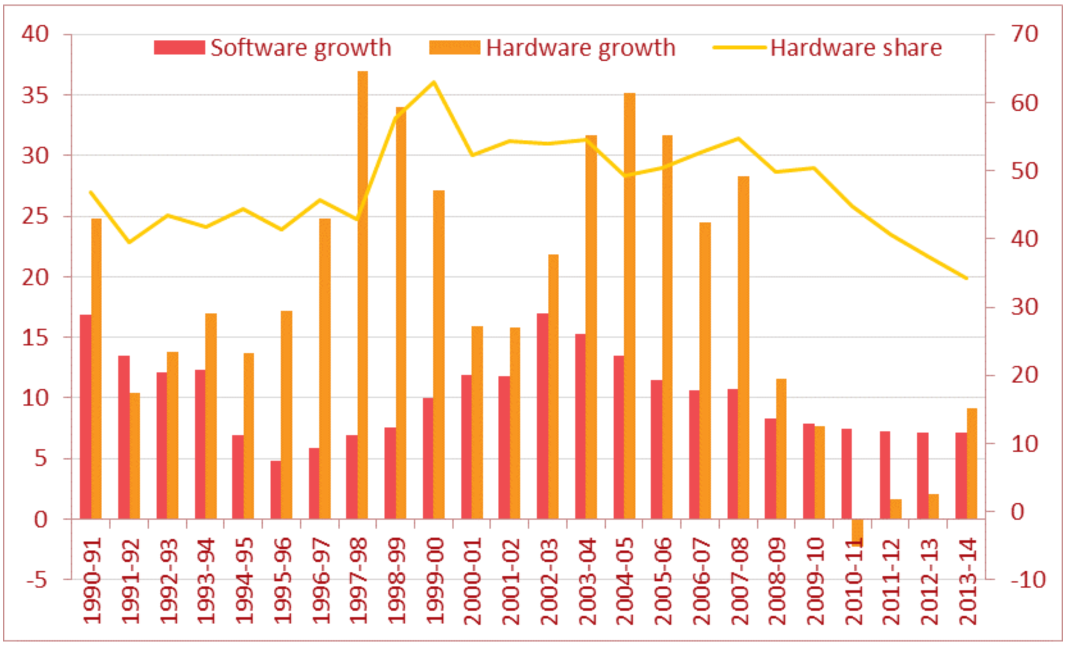


Source: Author estimates

The growth in IT stocks in the second half of the 1990s and first half of the 2000s was mainly in hardware (Figure C4). This made the sector hardware intensive for a while, as indicated by the hardware income share rising above 50 per cent. However, since the drop-off in IT use after 2007–08 was mostly in hardware, this intensity fell away rapidly.

Growth in software was reasonably steady by comparison. There was stronger growth in the early 1990s and the early 2000s.

Figure C4: Annual growth in software and hardware (% per year) and hardware share of IT capital income (%) in wholesale trade



Source: Author estimates

C.2 Labour productivity growth

Between 1989–90 and 2013–14, labour productivity growth in wholesale trade was strong, so that the level of labour productivity increased 125 per cent. The average annual rate of growth in trend labour productivity (LP) was 4.0 per cent.

Productivity growth was also reasonably steady, aside from the negative effects of the early-1990s recession and the global financial crisis in the late 2000s (Figure).

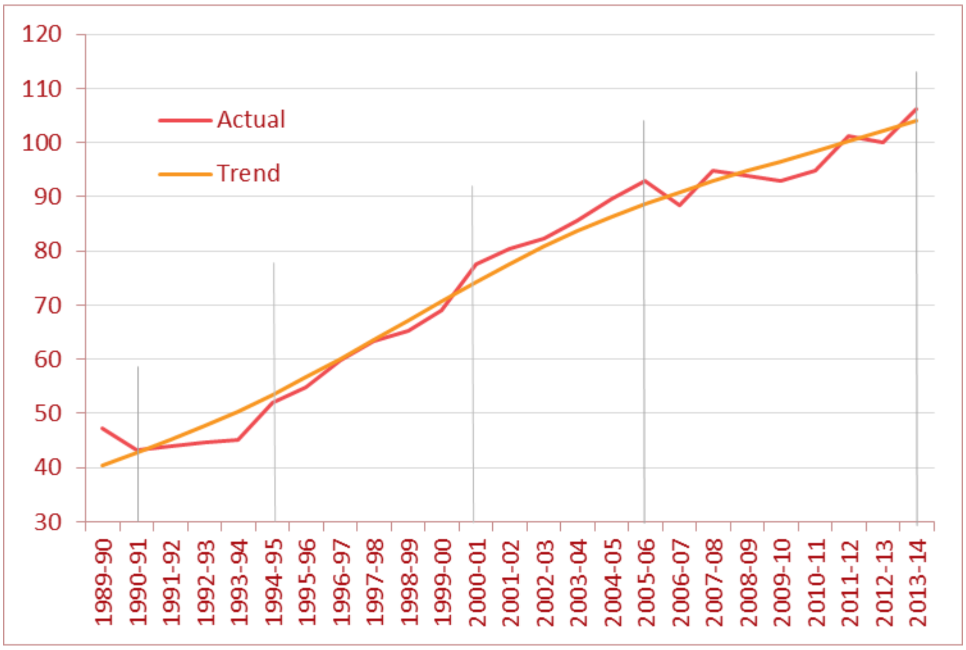
Peaks in LP cycles occurred in 1989–90, 2005–06, 2007–08 and 2013–14 according to the method set out in section 5.3. The peak in 1990–91 was used rather than the one in 1989–90 as it yields a growth rate to the next peak that is much closer in line with trend productivity growth.

Another peak was added at 2000–01, even though it escapes the formal decision rules. As Figure shows, 2000–01 was a local peak well above trend. The peak in 2007–08 was overlooked, as it was so close to the peak in 2005–06.

The average rates of growth in labour productivity over the resulting cycles were:

- 1990–91 to 2000–01: 6.0 per cent a year
- 2000–01 to 2005–06: 3.7 per cent a year, and
- 2005–06 to 2013–14: 1.7 per cent a year.[s]

Figure C5: Actual and trend labour productivity in wholesale trade[a] (indexes, actual 2012–13 = 100)



Note: a. Trend series formed with a Hodrick-Prescott filter λ = 100

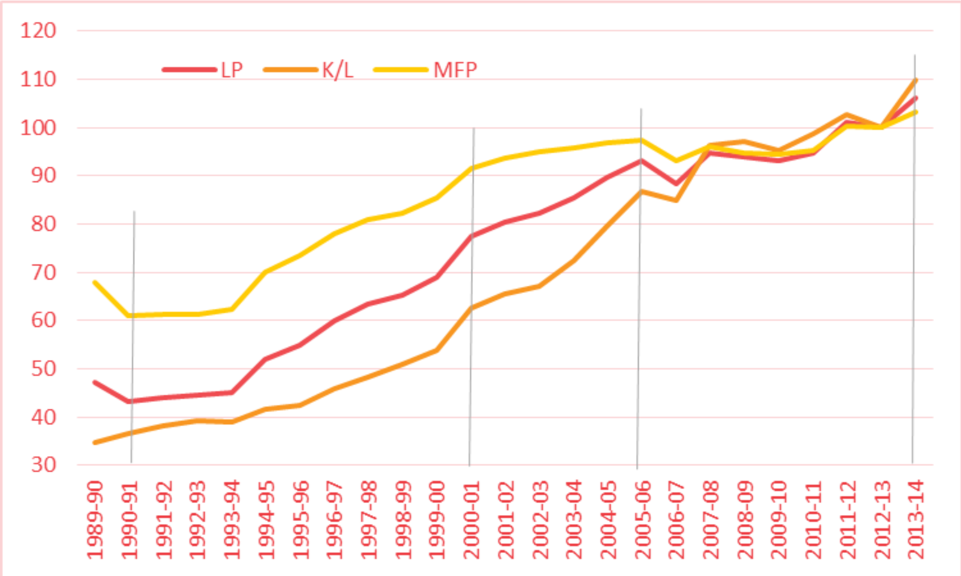
Source: ABS Cat. No. 5260.0.55.002 and author estimates

C.2.1 IT capital deepening and LP growth

The growth in labour productivity can be decomposed into contributions from capital deepening and multifactor productivity (MFP) growth. Capital deepening is growth in the capital-labour ratio, multiplied by the share of total industry income attributed to capital.

As previously noted, LP increased by 125 per cent over the period. The capital-labour ratio increased by over 210 per cent (Figure C6). This needs to be weighted by the capital share of income, which averaged about one-third to indicate its contribution to LP growth. MFP growth accounted for a little over 50 percentage points.

Figure C6: Labour productivity (LP), the capital-labour ratio (K/L) and multifactor productivity (MFP) in wholesale trade (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002

MFP growth was especially strong in the 1990s at 4.0 per cent a year, accounting for about two-thirds of the very strong growth in LP (Table C1). As MFP growth slowed in the 2000s and 2010s, capital deepening came to account for the majority of LP growth.

There are indications of substitution of IT capital for labour having a very strong effect on LP growth in wholesale. IT capital deepening contributed 0.7 of a percentage point to LP growth in the 1990s, rising to 0.9 of a percentage point in the first period in the 2000s. These contributions were divided approximately two-thirds to hardware and one-third to software.

The IT capital deepening contribution fell to 0.4 of a percentage point after 2005–06 in line with slower growth in IT use. The fall was greater in hardware, meaning it and software contributed equally to IT capital deepening after 2005–06.

Table C1: Labour productivity growth accounting (per cent per annum and percentage points)[a]

	1990–91 to 2000–01	2000–01 to 2005–06	2005–06 to 2013–14
Capital deepening (pp)	1.8 (31)	2.4 (65)	0.9 (57)
IT capital deepening (pp)	0.9 (16)	0.9 (25)	0.4 (24)
Hardware (pp)	*0.6*	*0.6*	*0.2*
Software (pp)	*0.3*	*0.3*	*0.2*
Non-IT capital deepening (pp)	0.9 (15)	1.5 (40)	0.6 (33)
MFP growth (pp)	4.0 (69)	1.3 (35)	0.7 (43)
Labour productivity growth (%pp)	5.8 (100)	3.7 (100)	1.7 (100)

Note: a. Figures in brackets refer to percentages of labour productivity growth.
Numbers may not add up due to rounding.

Source: Author estimates

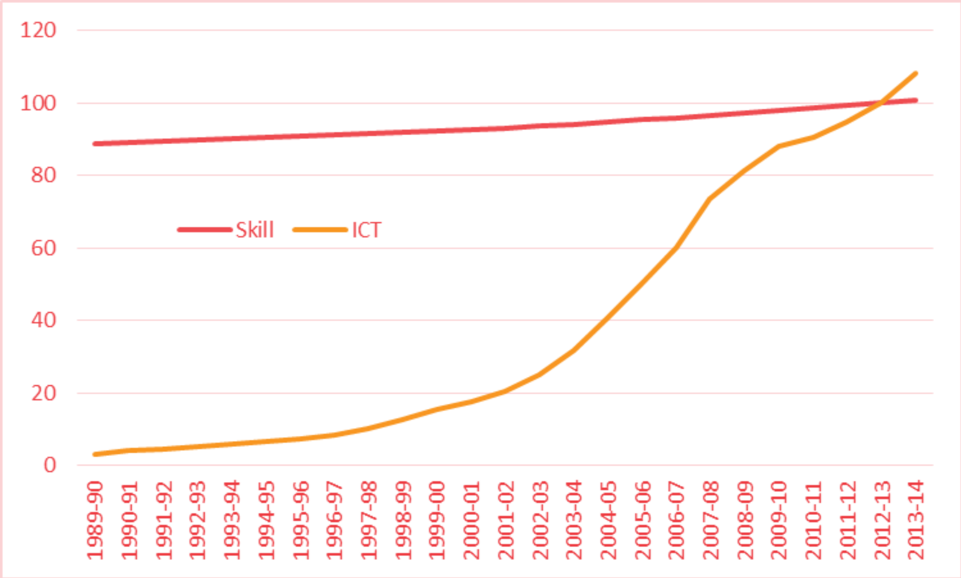
Any co-variation between the IT capital deepening contribution and LP growth across the cycles was swamped by variations in MFP growth and non-IT capital deepening.

C.2.2 IT use and skills

The average skill level of labour increased by 13 per cent over the entire period. Even though the use of IT increased by much more there was very high correlation (a coefficient of 0.98) between the increase in skill and the increase in IT use (Figure C7).

This co-variation could reflect, at least to some extent, a bias in IT use toward skill. If IT was helping wholesale to transform away from a storage-based system, the need for unskilled labour in storage-based loading and unloading activities could be reduced. Without further analysis, it is not possible to confirm whether or the extent to which the co-variation is causal or spurious.

Figure C7: IT capital and average skill in wholesale trade (index, 2012–13 = 100)



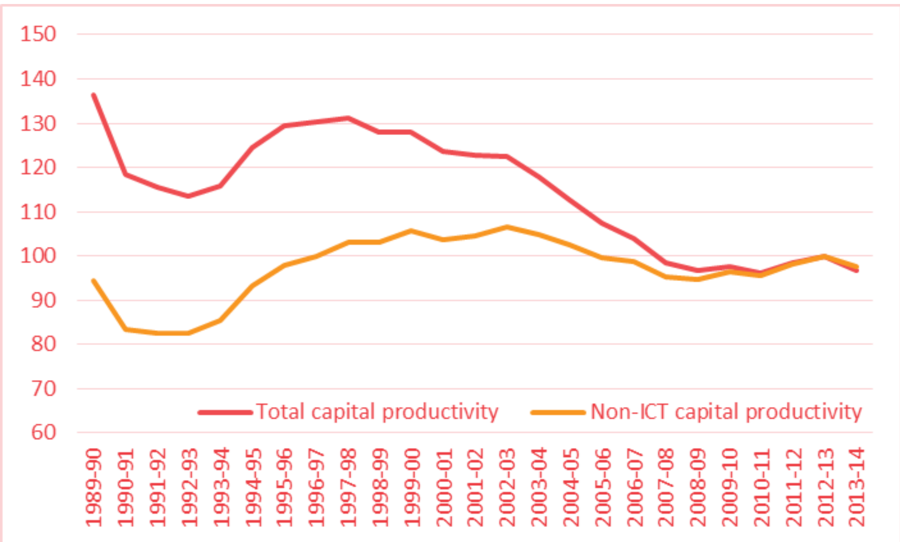
Source: Author estimates

C.3 IT, asset use, and capital productivity

IT can also enhance the productivity of other assets. For example, if IT enabled the industry to transform away from storage-based operations the unit requirements for various types of assets such as buildings and inventories may fall. That is, the productivity of non-IT assets may rise.

Figure C8 shows the productivity of total capital and non-IT capital. The difference between the two is the productivity of IT capital. Because IT capital has grown much more rapidly than value added in wholesaling, IT capital productivity has fallen steeply.

Figure C8: Capital productivity of all assets and non-IT assets in wholesale trade



Source: Author estimates

There is some association between IT use and the productivity of non-IT assets. The productivity of non-IT capital grew in the 1990s when there was steep growth in IT. However, it levelled out from the late-1990s when there was still strong growth in IT, and declined a little in the second half of the 2000s when there was little growth in IT.

The productivity of individual asset types was also investigated. The major capital inputs in wholesale are non-dwelling construction (average 26 per cent of capital costs), inventories (23 per cent), industrial machinery and equipment (13 per cent) and road vehicles (9 per cent). Non-dwelling construction is assumed to be mostly buildings.

Figure C9 shows the productivity of use of these major assets, along with the productivity of land use (2 per cent of capital income).

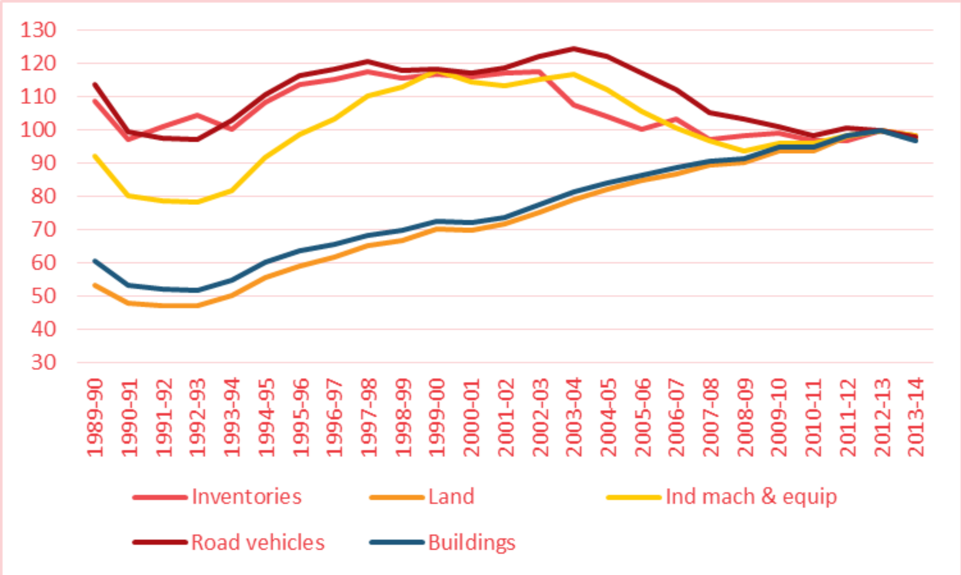
The productivity of buildings and of land has improved around 100 per cent from the mid-1990s to the early 2010s. That is, double the amount of output could be generated from the same amount of land and buildings. This is consistent with IT enabling the rationalisation of storage facilities and the transition away from a storage-based model of wholesale distribution. The correlation coefficients for IT use with land productivity and with building productivity are both 0.93.

The productivity of the other major assets improved in the 1990s. This was especially true of industrial machinery and equipment.

However, there were larger requirements for holding inventories and use of road vehicles and industrial machinery and equipment in the 2000s. This has not been investigated but may reflect a compositional shift within the industry associated with the mining boom. According to ABS data[14], the distribution of basic materials was the largest of wholesale's sub-industries in 2012–13.[t]

[14] ABS, Retail and Wholesale Industries, Cat. No. 8622.0 Canberra 31/07/2014

Figure C9: Asset productivity—the ratio of value added to use of selected assets in wholesale trade



Source: Author estimates

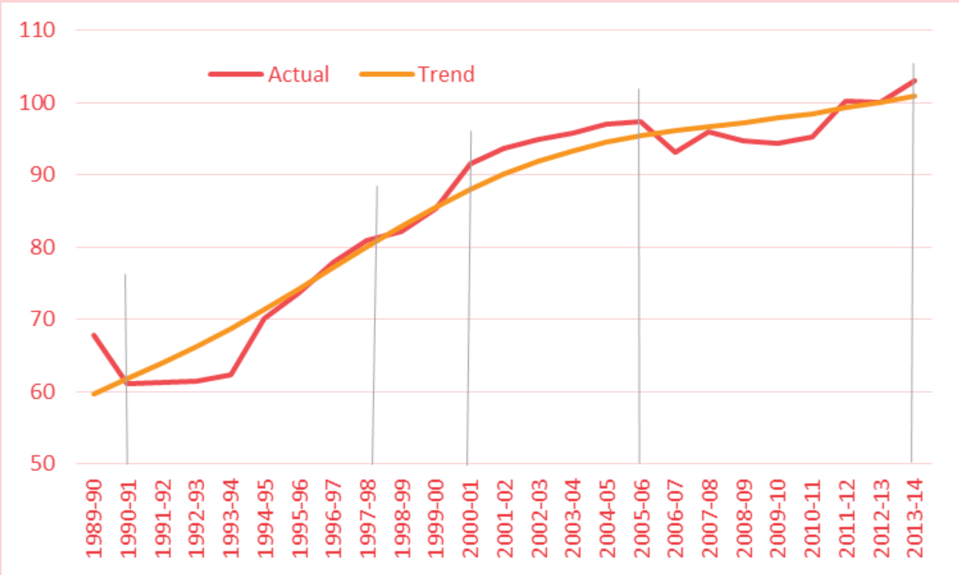
C.4 Use of intermediates

Another proposition is that IT could help improve the efficiency of use of intermediate inputs, that is, inputs of purchased materials, energy and services). However, over the period 1994–95 to 2012–13, the productivity of intermediate use, that is the ratio of gross output to intermediate input use, declined in wholesale trade.

C.5 MFP growth

The association between IT and MFP was examined in the context of MFP cycles. According to the method set out in section 5.3, MFP peaks in wholesale trade occurred in 1989–90, 1997–98, 2000–01, 2011–12 and 2013–14. As with LP, 1990–91 was used rather than 1989–90 and another peak in 2005–06 was imposed. The peak in 2011–12 was dropped as it only just qualifies and is close to the next peak. The resulting cycles are shown in Figure C10.

Figure C10: Actual and trend MFP in wholesale trade (indexes, actual 2012–13 = 100)



Source: Author estimates

From the above analysis, it would appear IT effects on MFP growth would come from a combination of labour productivity (labour substitution and complementary skill) effects and capital productivity effects. Accordingly, MFP growth is treated as a weighted average of labour productivity growth and capital productivity growth, where the weights are the shares of labour and capital in value added respectively.

Table C2 shows this treatment over MFP cycles. The labour productivity contribution (LP growth multiplied by the labour income share) plus the capital productivity contribution (capital productivity growth multiplied by the capital income share) equals MFP growth.

Table C2: Contributions to MFP growth in wholesale trade

	1990–91 to 1997–98	1997–98 to 2000–01	2000–01 to 2005–06	2005–06 to 2013–14
LP growth contribution (pp)	3.5	4.7	2.3	1.1
of which				
> IT capital deepening (pp)	*0.5*	*1.0*	*0.6*	*0.3*
> KP growth contribution (pp)	0.5	-0.6	-1.1	-0.4
of which				
> IT capital productivity (pp)	*0.26*	*-0.36*	*-0.25*	*-0.14*
> Non-IT capital productivity (pp)	*0.28*	*-0.24*	*-0.81*	*-0.30*
MFP growth	4.0	4.1	1.3	0.7

Source: Author estimates. Numbers may not add up due to rounding

The IT capital deepening contribution to MFP growth is shown as part of the labour productivity contribution.[u] This accounted for 0.4 to 0.7 percentage point of MFP growth up to 2005–06. This is quite large in the context of MFP growth averaging 1.7 per cent a year over the period reviewed (1989–90 to 2013–14).

Trends in major asset productivities are summarised for MFP cycles in Table C3. The growth in asset productivity over a cycle is shown first (unweighted) with another row showing asset productivity growth weighted by the asset's share in capital income. This provides an indication of the relative importance of the different asset productivities.

However, these values should not be regarded as contributions to MFP growth that can be added. To gain an indication of the contribution to MFP growth, take one third of the weighted increase in asset productivity (one third being the approximate capital income share.)

Table C3: Capital productivity for selected assets in wholesale trade over MFP cycles, unweighted and weighted[a] (per cent per year)

	1990–91 to 1997–98	1997–98 to 2000–01	2000–01 to 2005–06	2005–06 to 2013–14
Inventories productivity	2.73	-0.43	-2.92	-0.25
> Weighted	0.67	-0.10	-0.85	-0.05
Other P & E productivity	1.10	-1.90	-2.38	0.15
> Weighted	0.04	-0.09	-0.10	0.01
Road vehicles productivity	2.75	-0.98	-0.01	-2.23
> Weighted	0.22	-0.10	-0.00	-0.25
Construction productivity	3.54	1.77	3.65	1.42
> Weighted	0.90	0.50	0.82	0.31

Note: a. Weighted by the share of the asset in capital income

Source: Author estimates

From this purely accounting perspective, IT appears to have made a strong contribution to MFP growth. The IT capital deepening contribution accounts for 0.4 to 0.7 of a percentage point of annual MFP growth up to the mid-2000s. IT could have contributed more through the capital productivity of different assets.

In the case of better use of buildings, IT could have contributed up to 0.3 of a percentage of annual MFP growth. In the first MFP cycle IT could have contributed anywhere up to 0.4 of a percentage point if it was influential across all major asset categories.

D. Retail trade

Key points

Information Technology (IT) grew very rapidly in retail in the 1990s and 2000s, up until 2007-08, with annual rates of growth typically 15-20 per cent:

- Growth in hardware, in particular, dropped off after 2007-08.

Between 1989–90 and 2013–14, labour productivity (LP) growth was moderate to strong. While it was quite steady throughout this period, labour productivity growth was slower in the 2000s.

Multifactor productivity (MFP) growth was more important than capital deepening as a source of labour productivity growth over the observation period, even though MFP growth slowed in the 2000s.

The Information Technology (IT) capital deepening contribution to LP growth was quite strong at 0.6 of a percentage point up to the end of the 2000s. This represents roughly 20–25 per cent of LP growth over different cycles.

A slowdown in LP and MFP growth is associated with a slowdown in IT growth. A causal link, however, was not established in this analysis.

There has been little improvement in average skill in the industry.

IT has likely enabled MFP gains through labour and capital substitution effects.

Areas of substantial improvement in capital productivity that could be associated with IT use include:

- Efficiency in the use of land (80 per cent) and buildings (35 per cent).
- Productivity of road vehicles improved 60 per cent over the 1990s and early 2000s before falling back.
- Improvement of nearly 20 per cent in the productivity of other plant and equipment.
- Inventories productivity increased 20 per cent in the 2000s.

The efficiency of use of intermediate inputs increased by over 30 per cent up to 2006–07.

The Australian Bureau of Statistics (ABS) identifies the following subdivisions within retail trade:

- food retailing
- household goods retailing
- clothing, footwear and personal accessory retailing
- department stores

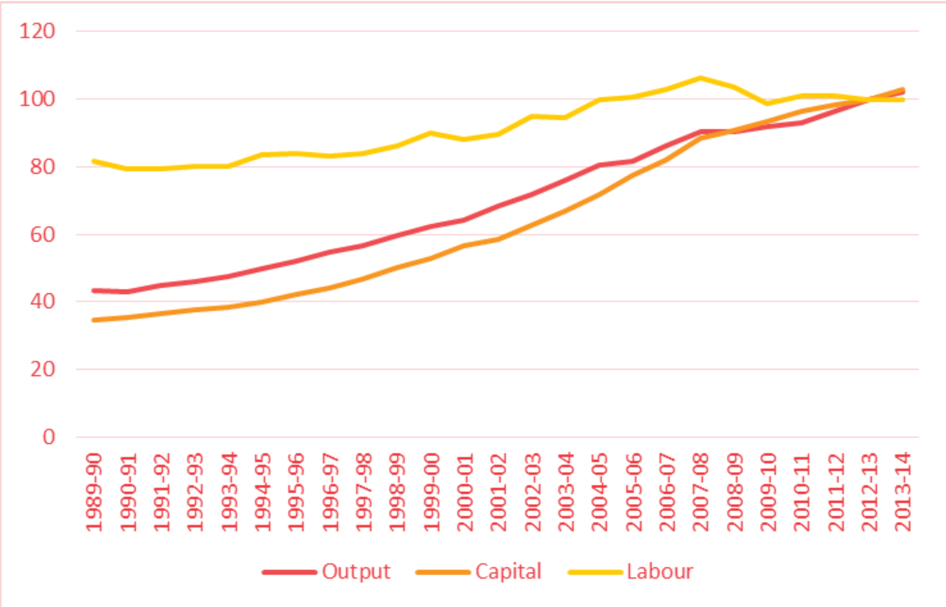
- other retailing, and
- cafes, restaurants and takeaway food services.

Retail trade grew at 3.9 per cent a year between 1989–90 and 2013–14. Since that was below the economy-wide average, retail fell as a proportion of GDP from 5.3 to 4.8 per cent over that period. Output growth dwindled after 2007–08, to an average 2.1 per cent a year.

There was a distinct slowdown in growth of the sector from 2007–08 (Figure D1). Growth in output and capital halved and growth in labour turned into shedding of labour (Table D1).

The sector is very labour intensive, with labour costs absorbing around 75 per cent of gross income between 1989–90 and 2013–14.

Figure D1: Capital, Labour and output in Retail trade (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002

Table D1: Rates of output, capital and labour growth in Retail trade (% pa)

	1989–90 to 2007–08	2007–08 to 2013–14	1989–90 to 2013–14
Output	4.2	2.1	3.6
Capital	5.4	2.5	4.6
Labour	1.5	-1.0	0.8

Source: Author estimates

D.1 Growth in IT capital

The rapid rate of growth in Information Technology (IT) capital since 1989–90 is evident in The rate of growth in investment eased in the 2000s. Growth in software investment slowed from a very rapid 30 per cent a year in the decade before 2003–04 to 16 per cent a year in the decade after. Over the same periods, growth in hardware investment slowed from 13 to eight per cent a year.

Figure 3.1 shows investment in E&E equipment stalled in the mid-2000s, but then resumed growth in the 2010s. The average rate of growth in the two periods was 15 and six per cent a year respectively.

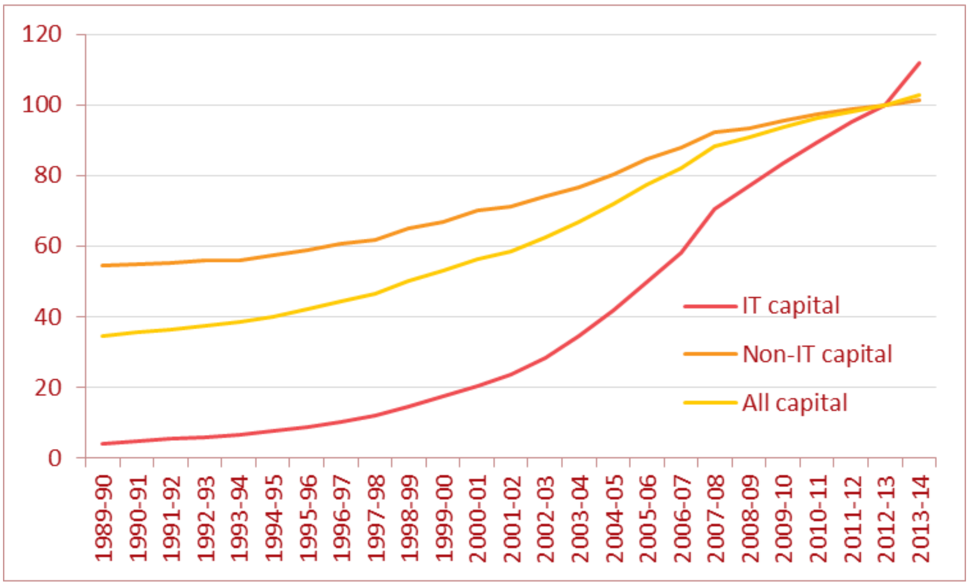
The rate of growth in hardware investment has been variable since the mid-2000s. It slowed considerably after a brief acceleration in 2007–08, which may have been prompted by the global financial crisis. There was a 40 per cent rise in hardware investment in 2013–14, which could possibly be catch-up after deferred investment.

Figure 3.1

With some variation, annual rates of growth in IT capital were strong through the 1990s and into the 2000s, up until 2007–08 (Figure D3).

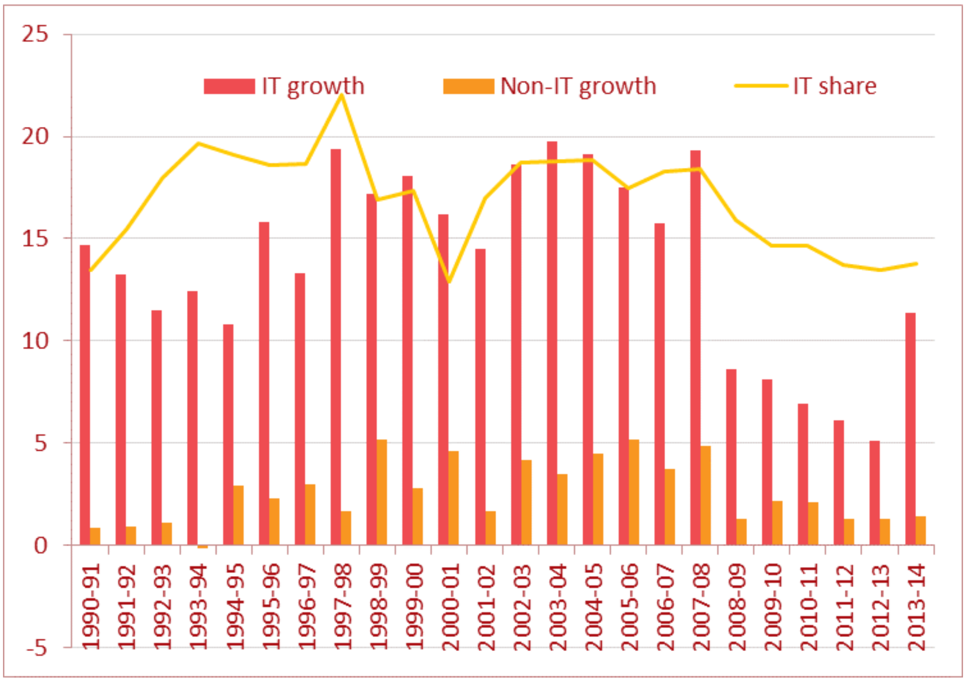
This strong growth in IT capital had an impact on total capital growth in the industry because of IT's importance in retail's use of capital. IT has accounted for 15–20 per cent of capital income in the sector for most of the period (Figure).

Figure D2: Capital, IT capital and non-IT capital in retail trade (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002 and author estimates

Figure D3: Annual growth in IT and non-IT capital (% per year) and the IT share of capital income (%) in retail trade

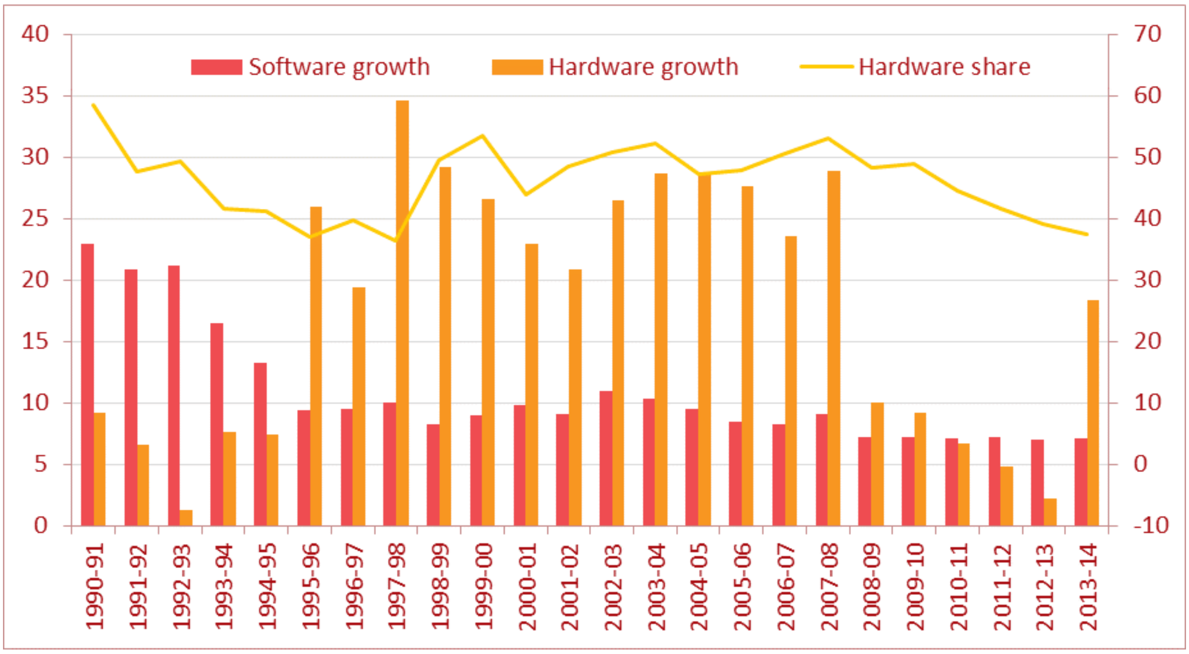


Source: Author estimates

The growth in hardware and software components of IT capital is shown in Figure . The figure also shows the share of hardware in capital income, which indicates the degree to which retail is hardware intensive.

The hardware share shows retail trade has generally been about equally divided between software and hardware use. There was strong growth in software—around 8–10 per cent per year—in the early 1990s. Hardware growth then took over from the mid-1990s. Annual growth in hardware varied between 10–15 per cent between 1995–96 and 2007–08.

Figure D4: Annual growth in software and hardware (% per year) and hardware share of IT capital income (%) in retail trade



Source: Author estimates

D.2 Labour productivity growth

In the period reviewed, IT brought business transformation and productivity gains in retail trade by enabling developments such as electronic payment, point of sale stock monitoring, just-in-time inventory management and internet marketing and sales.

Labour productivity (LP) growth in retail was moderate to strong. The level of LP increased 93 per cent between 1989–90 and 2013–14. The average annual rate of growth in trend LP was 2.8 per cent.

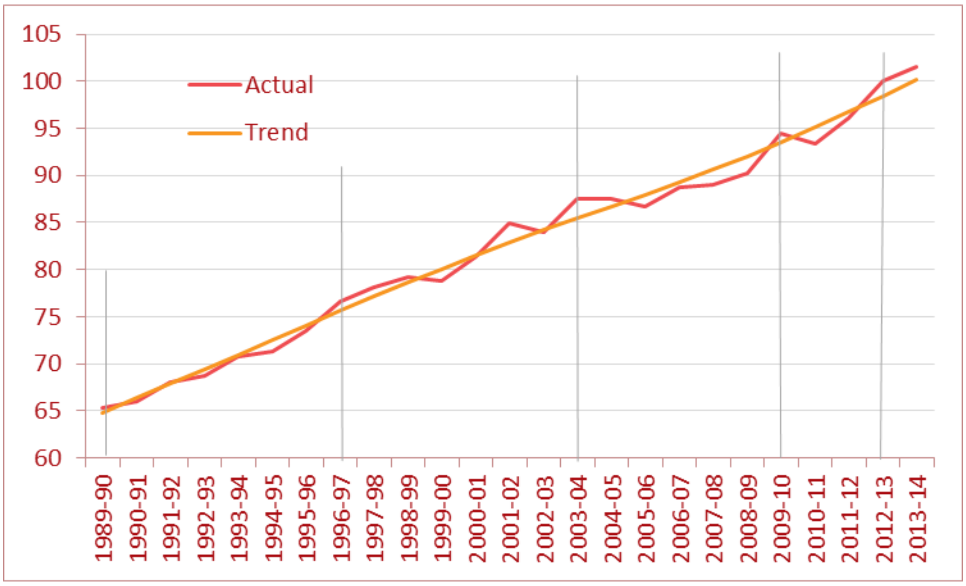
Productivity growth was reasonably steady, with no major movements above or below trend (Figure).

Peaks in LP cycles, according to the method set out in section 5.3, occurred 1989–90, 1997–98, 2001–02, 2003–04, 2009–10 and 2012–13. The peak in 2001–02 was overlooked, as it was close to the next peak in 2003–04 and unlikely to furnish much additional insight.

The underlying rate of growth in LP has slowed gradually over the entire period. Average rates of growth over the cycles were:

- 1989–90 to 1997–98: 3.1 per cent a year
- 1997–98 to 2003–04: 2.8 per cent a year
- 2003–04 to 2009–10: 2.5 per cent a year, and
- 2009–10 to 2012–13: 2.4 per cent a year.[v]

Figure D5: Actual and trend labour productivity in retail trade[a] (index, actual 2012–13 = 100)



Note: a. Trend series formed with a Hodrick-Prescott filter λ = 100

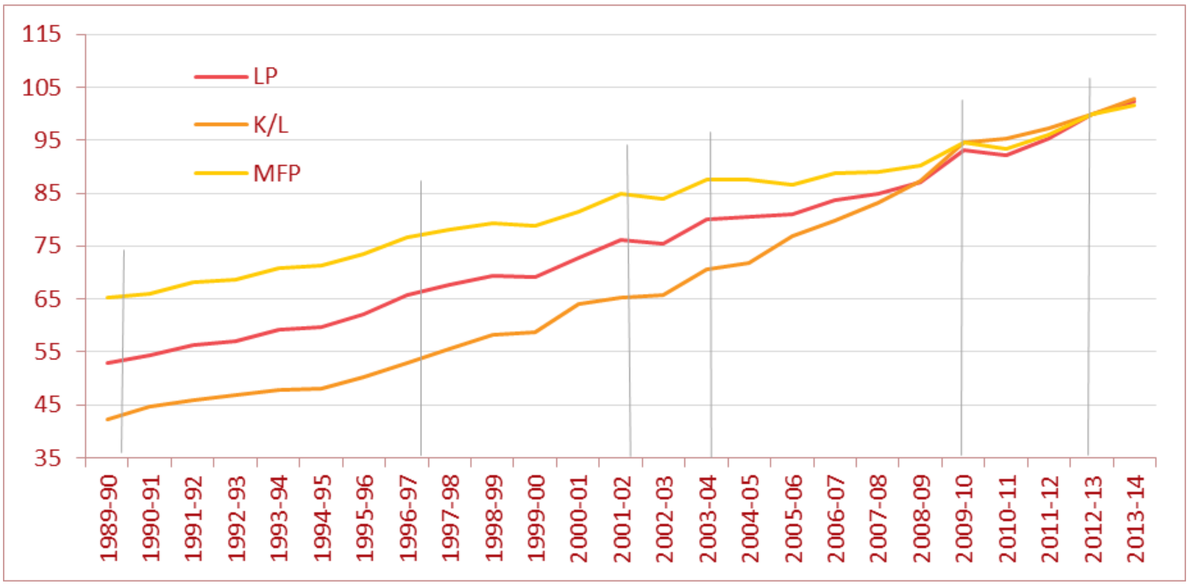
Source: ABS Cat. No. 5260.0.55.002 and author estimates

D.2.1 IT capital deepening and LP growth

The growth in labour productivity can be decomposed into contributions from capital deepening and multifactor productivity (MFP) growth. Capital deepening is growth in the capital-labour ratio, multiplied by the share of total industry income attributed to capital.

On a rough calculation, MFP contributed more than capital deepening to LP growth over the entire period. MFP grew 55 per cent. The capital-labour ratio grew over 140 per cent (Figure D6) which, with a capital share of total income of around 0.26, means capital deepening contributed roughly 37 percentage points to LP growth.

Figure D6: Labour productivity (LP), the capital-labour ratio (K/L) and multifactor productivity (MFP) in retail trade (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002

The strength of the MFP contribution is confirmed in the formal decomposition of LP growth over cycles as presented in Table D2. It shows the capital-deepening contribution strengthened over time, while the MFP contribution weakened up until the last cycle.

The IT contribution was reasonably strong and very steady at 0.6 of a percentage point up until the last cycle. It fell to 0.2 of a percentage point, more or less in line with the fall in contribution from capital-deepening as a whole. Up until the last cycle, IT capital deepening accounted for around 20–25 per cent of LP growth.

With the heavier uptake of hardware in the second half of the 1990s and up to 2007–08, hardware contributed more than software to IT capital deepening in the middle two cycles.

Table D2: Labour productivity growth accounting (per cent per annum and percentage points)[a]

	1989–90 to 1997–98	1997–98 to 2003–04	2003–04 to 2009–10	2009–10 to 2012–13
Capital deepening (pp)	0.8 (27)	0.9 (33)	1.2 (49)	0.5 (20)
IT capital deepening (pp)	0.6 (19)	0.6 (22)	0.6 (25)	0.2 (9)
Hardware	*0.3*	*0.5*	*0.5*	*0.1*
Software	*0.3*	*0.2*	*0.2*	*0.1*
Non-IT capital deepening (pp)	0.3 (8)	0.3 (11)	0.6 (24)	0.3 (11)
MFP growth (%pa)	2.2 (73)	1.9 (67)	1.3 (51)	1.9 (80)
Labour productivity growth (%pa)	3.1 (100)	2.8 (100)	2.5 (100)	2.4 (100)

Note: a. Figures in brackets refer to percentages of labour productivity growth.
Numbers may not add up due to rounding.

Source: Author estimates

There was only very weak co-variation between IT capital deepening and LP growth across the LP cycles. That is, changes in IT capital deepening contributions did not closely match changes in LP growth. There is stronger co-variation between MFP growth and LP growth.

D.2.2 IT use and skills

The average skill level of labour in the industry increased by 7 per cent over the entire period. The correlation with IT use was a very high 0.98.

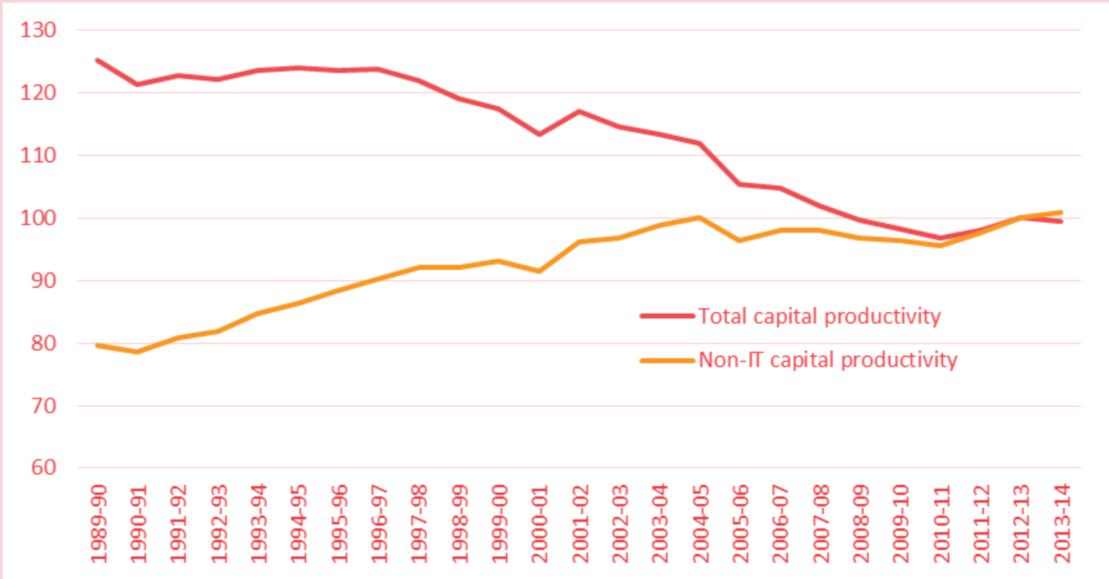
D.3 IT, asset use and capital productivity

IT can enhance the productivity of other assets.

The productivity of total capital and of non-IT capital is shown in Figure D7. The difference between the two is the productivity of IT capital. Because IT capital has grown much more rapidly than value added in retailing, IT capital productivity has fallen steeply.

The increase in non-IT productivity is somewhat correlated with IT use over the entire period (correlation coefficient of 0.74). However, there was higher correlation (0.90) up to 2004–05, when the productivity of non-IT capital increased by about 25 per cent. While there was some decline over the rest of the decade, there was very little change overall between 2004–05 and 2013–14.

Figure D7: Capital productivity of all assets and non-IT assets in retail trade (index, 2012–13 = 100)



Source: Author estimates

The period of growth in non-IT capital productivity corresponds broadly with the period of strongest growth in IT use, which ended in 2007–08. While there is strong correlation between IT use and non-IT capital productivity (correlation coefficient of 0.74), there is not necessarily a causal relationship between the two.

The productivity of individual assets was also investigated. The major capital inputs in retail trade are: construction assets (26 per cent of capital income)[w], inventories (17 per cent), road vehicles (13 per cent) and other plant and equipment (10 per cent). Non-dwelling construction assets are assumed to be mostly buildings. While not a major asset, land (4 per cent) was also included.

The productivity of all these assets increased over the period with some variation in the sub-periods in which they grew strongest (Figure D8):

> Land showed the strongest and steadiest increase in capital productivity at around 80 per cent for the whole period. (Correlation coefficient with IT use = 0.94.)

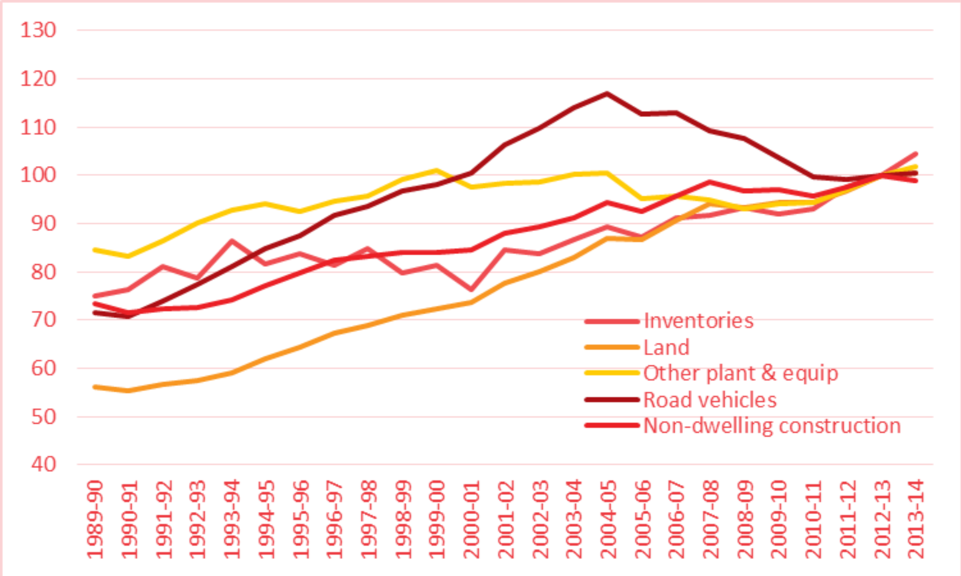
> The productivity of buildings increased by about 35 per cent over the whole period. (Correlation coefficient with IT use = 0.90.)

> The productivity of road vehicles increased over 60 per cent up to 2004–05 before falling back. (Correlation coefficient with IT use = 0.55.)

> The productivity of other plant and equipment increased in the 1990s, but was basically constant after that. (Correlation coefficient with IT use = 0.43.)

> There was little overall change in inventories productivity in the 1990s but it improved by around 20 per cent in the 2000s. (Correlation coefficient with IT use = 0.93.)

Figure D8: Asset productivity–the ratio of value added to use of selected assets in wholesale (index, 2012–13 = 100)



Source: Author estimates

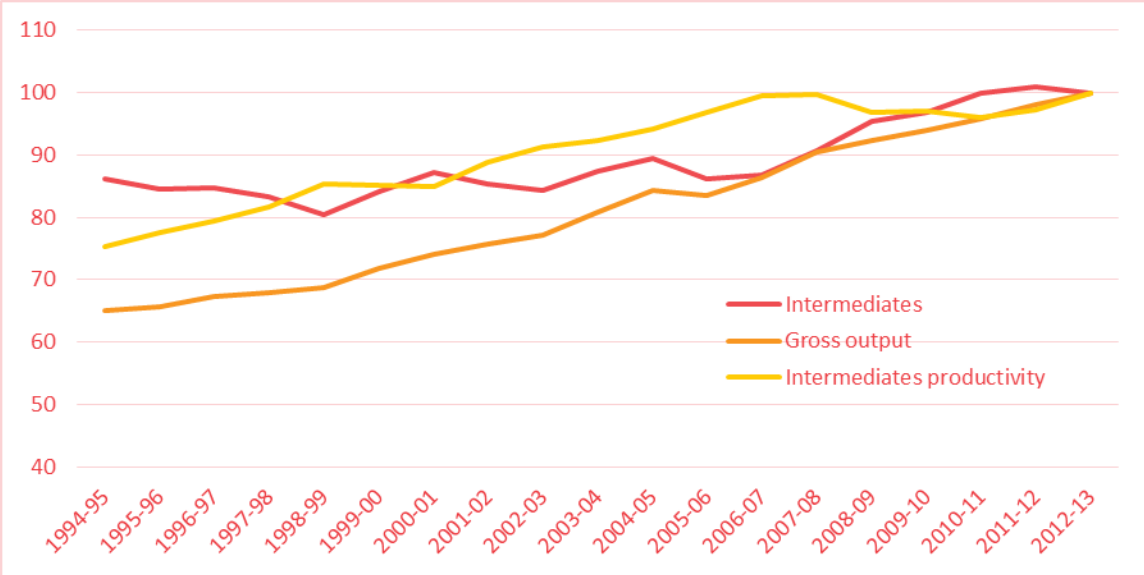
D.4 Use of intermediates

Whether IT could help improve the efficiency with which intermediate inputs (component materials, energy and purchased services) are used was another possibility examined. In the case of intermediate input use, productivity is determined in reference to the gross output rather than the value-added measure of output.

Retail is one industry where the efficiency of intermediates use did improve over the period (Figure D9). While gross output grew steadily over the period, intermediate input use remained flat until 2006–07. Intermediates productivity rose about 32 per cent up to that point. With the improvement in efficiency, the share of intermediate inputs in total costs fell from 55 per cent in 1994–95 to 41 per cent in 2004–05.

Intermediates cover the purchased materials, energy and other services used in the production of retail services.

Figure D9: Gross output, Intermediate input use and intermediate input productivity in retail trade



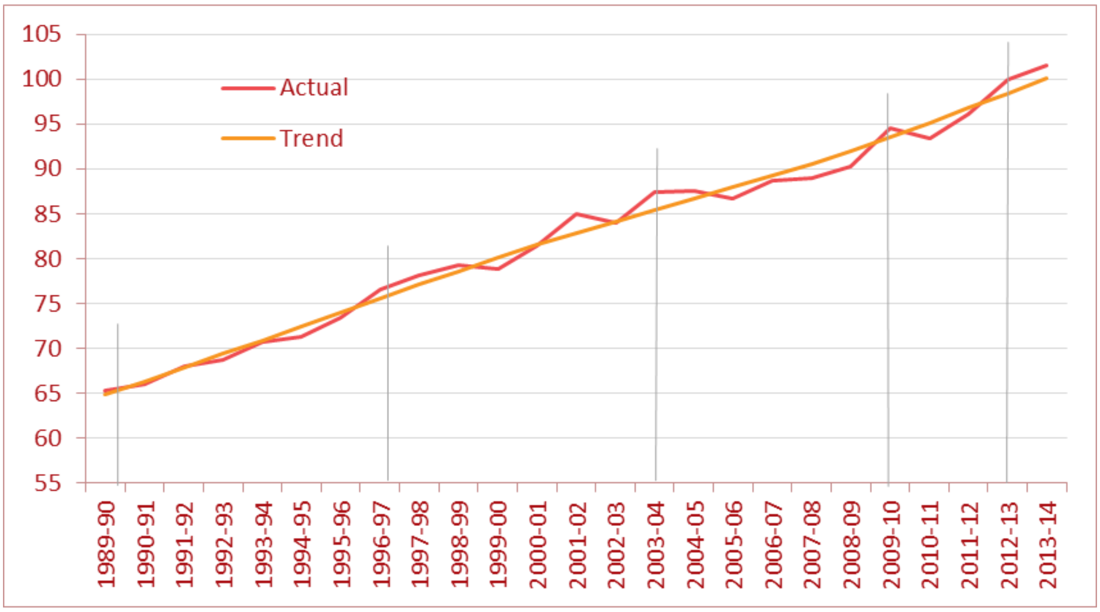
Source: Author estimates

D.5 MFP growth

The association between IT and MFP was examined in the context of MFP cycles. According to the method set out in Section 5.3, MFP peaks in retail trade took place in 1996–97, 2001–02, 2003–04, 2009–10, and 2012–13 (Figure). Because the early 1990s are of interest due to strong investment in software—a peak was also imposed at 1989–90. As with labour productivity, the 2001–02 peak was overlooked.

The only difference between LP and MFP cycles is that the 1990s peak in LP occurred in 1997–98, whereas the MFP peak occurred in 1996–97.

Figure D10: Actual and trend MFP in wholesale trade[a] (index, actual 2012–13 = 100)



Note: a. Trend series formed with a Hodrick-Prescott filter λ = 100

Source: ABS Cat. No. 5260.0.55.002 and author estimates

The average rates of growth over MFP cycles were:

- 1989–90 to 1996–97: 2.3 per cent a year
- 1996–97 to 2003–04: 1.9 per cent a year
- 2003–04 to 2009–10: 1.3 per cent a year, and
- 2009–10 to 2012–13: 1.9 per cent a year.

For current purposes, MFP growth is treated as a weighted average of LP growth and capital productivity growth, with the respective income shares as the weights. This allowed the influences of IT growth on MFP to be seen as a combination of substitution effects on labour and on capital.

MFP growth accounting is shown in Table D3. The labour productivity growth contribution plus the capital productivity contribution equals the MFP growth presented in the bottom row of the table.

Table D3: Multifactor productivity growth accounting over MFP cycles in retail trade

	1989–90 to 1996–97	1996–97 to 2003–04	2003–04 to 2009–10	2009–10 to 2012–13
LP growth contribution	2.3	2.2	1.9	1.7
of which				
> IT capital deepening	0.4	0.5	0.5	0.2
> KP growth contribution	0.0	-0.3	-0.6	0.2
of which				
> IT capital productivity	-0.40	-0.53	-0.51	-0.12
> Non-IT capital productivity	0.37	0.25	-0.07	0.28
MFP growth	2.3	1.9	1.3	1.9

Source: Author estimates

Labour productivity growth accounts for most of the MFP growth in each cycle (see Table D3). This is as expected, given that capital productivity tends to show relatively small movements over short periods.

The IT capital deepening contribution is shown as part of the labour productivity contribution.[x] A value of 0.4 to 0.5 of a percentage point up to the end of the 2000s decade is quite strong, in the context of MFP growth rates of the order of 2 per cent a year.

The capital productivity contribution is split into IT and non-IT contributions. The IT capital productivity contribution is negative as IT capital has grown faster than output.

Non-IT productivity grew positively in all cycles, except the third cycle for the late 2000s, raising the possibility of an association with IT use.

The trends in asset productivities examined in the previous section are summarised for MFP cycles in Table D4. The growth in asset productivity over a cycle is shown first, with another row showing asset productivity growth weighted by the asset's share in capital income. This provides an indication of the relative importance of the different asset productivities. However, these values should not be regarded as contributions that can be added.

Table D4: Capital productivity for selected assets over MFP cycles, unweighted and weighted[a] (per cent per year) in Retail trade

	1989–90 to 1996–97	1996–97 to 2003–04	2003–04 to 2009–10	2009–10 to 2012–13
Inventories productivity	1.17	0.90	1.00	2.76
> Weighted	0.11	0.15	0.19	0.43
Land productivity	2.58	3.01	2.14	1.91
> Weighted	0.10	0.09	0.03	0.06
Other plant & equip prody	1.61	0.84	-1.04	1.97
> Weighted	0.14	0.08	-0.11	0.22
Road vehicles productivity	3.55	3.10	-1.58	-1.22
> Weighted	0.39	0.44	-0.23	-0.15
Buildings productivity	1.64	1.47	1.02	0.99
> Weighted	0.43	0.34	0.21	0.31

Note: a. Weighted by the share of the asset in capital income

Source: Author estimates

As previously noted, the strongest and steadiest improvements were in land and buildings productivity (Table D4). The improvement in the productivity of use of road vehicles was both large (3-3.5 per cent a year) and of strong relative importance up to the mid-2000s. The productivity of other plant and equipment improved over the same period, but at a slower rate and a lower weighting.

E. Transport, postal and warehousing

Key Points

From 1989–90, there was about average growth in transport, postal and warehousing (TPW). From 2007–08, the growth of this sector slowed and growth in labour turned to labour shedding. There was strong and steady growth in capital through the 2000s and into the 2010s. This sector is labour intensive with a capital income share averaging about 36 per cent.

While growth in Information Technology (IT) averaged 12.4 per cent a year, IT represented only about 7.7 per cent of capital costs.

Most of the growth in IT in the 2000s was in hardware. Nevertheless, the sector remained software intensive.

IT capital deepening contributed between 0.2 and 0.4 of a percentage point to labour productivity (LP) growth.

Average skill level increased by 8 per cent over the period, with a correlation coefficient with IT use of 0.93.

There were two distinct periods of movement in non-IT capital productivity. Growth in the 1990s was largely offset by decline in the 2000s and beyond.

Nevertheless, there were periods in which the productivity of major assets improved:

> The productivity of construction assets, which includes road and rail infrastructure, land and other transport equipment improved up to 2007–08.

> The productivity of road vehicles improved in the early 1990s.

The productivity of intermediate input usage improved by 8 per cent up to 2002–03.

IT contributed about 0.2 of a percentage point to annual multifactor productivity growth through the capital deepening effect on LP growth. It may also have made some contribution through improvement in non-IT capital productivity in the 1990s.

According to the Australian Bureau of Statistics (ABS), the transport, postal and warehousing (TPW) sector covers transport of both passengers and goods in the following industries:

- road transport
- water transport
- air and space transport
- other transport
- postal and courier pick-up and delivery services, and

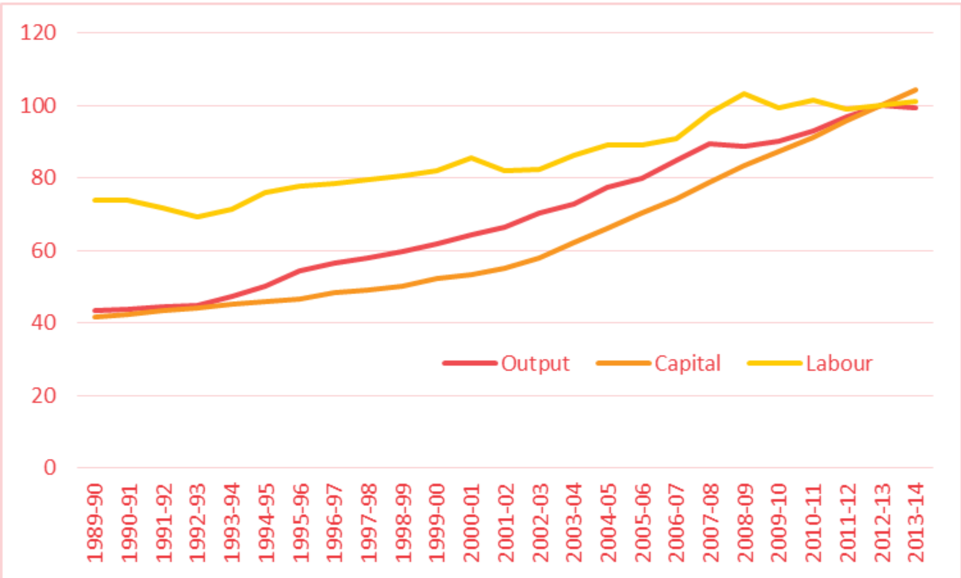
> transport support services.

Transport, postal and warehousing grew steadily through the 1990s and 2000s, up to 2007–08 (Figure E1). Its annual growth in output averaged 3.5 per cent from 1989–90 to 2013–14, which was about the average for GDP. Consequently, the sector hovered close to 5 per cent of GDP throughout the period reviewed (1989–90 to 2013–14).[y]

There was solid growth in capital, which averaged 3.9 per cent a year over the whole period (Figure E2). However, there was more-rapid growth after 2001–02 (at .5 per cent a year compared with 2.4 per cent a year before 2001–02. Growth in labour averaged 1.3 per cent a year over the period reviewed.

The sector is labour-intensive with the capital income share averaging 36 per cent.

Figure E1: Capital, labour and output in PST services (index, 2012–13 = 100)



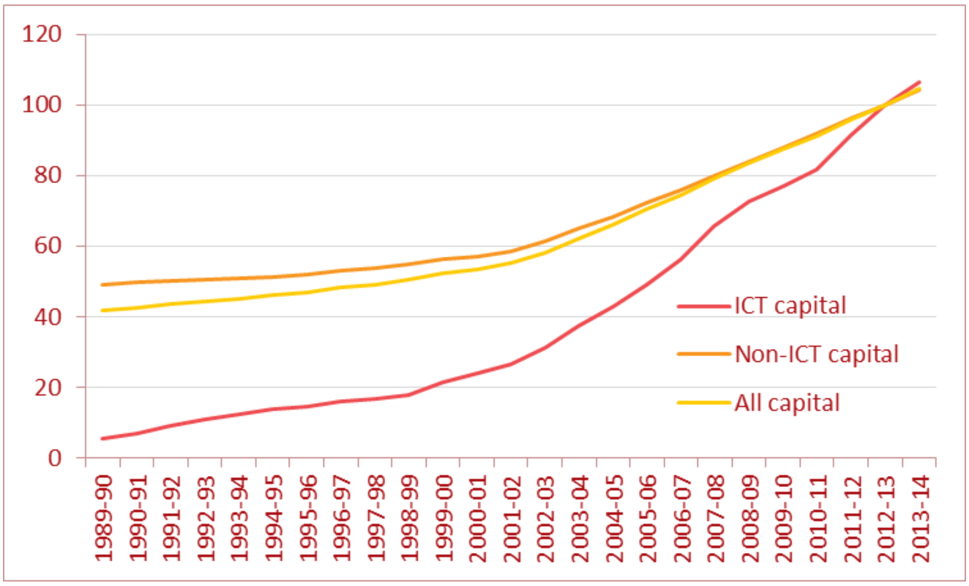
Source: ABS Cat. No. 5260.0.55.002

E.1 Growth in IT capital

TPW is not an intensive user of Information Technology (IT). IT has accounted for between 5-15 per cent of capital costs, at an average of 7.7 per cent (Figure E3). The sector accounts for about 4 per cent of hardware use in the economy and a sizeable 10 per cent of software use.

While the growth in IT capital was strong, that growth did not have a big influence on growth in total capital because IT has a small share of TPW's use of capital (Figure V2). Growth in IT capital grew at 12.4 per cent a year from 1989–90 and non-IT capital at 3.1 per cent a year.

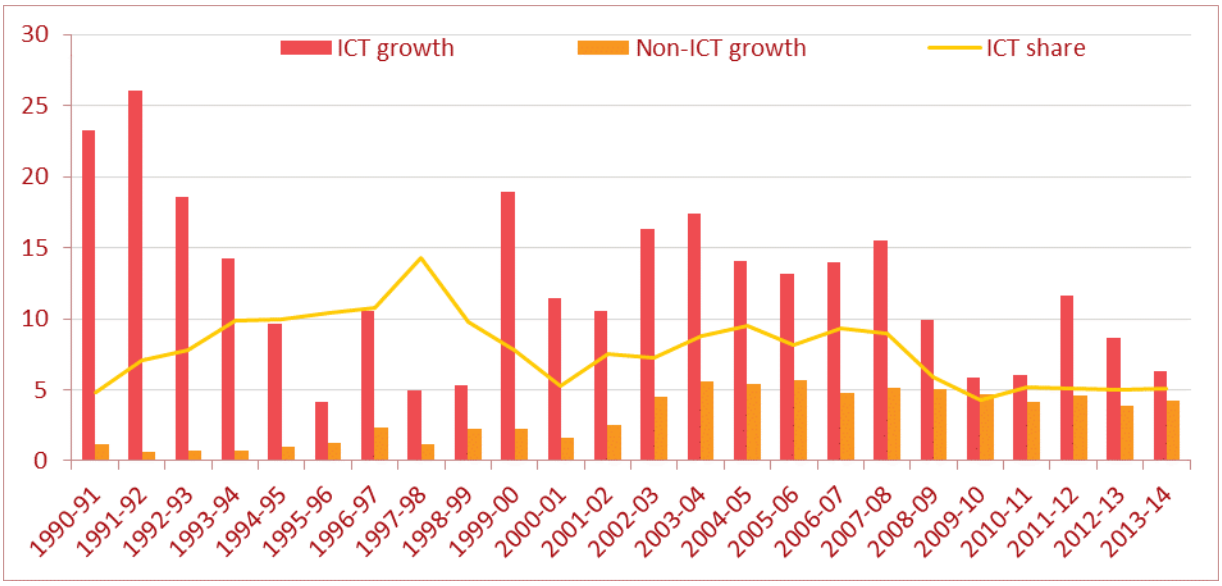
Figure E2: Capital, IT capital and non-IT capital in TPW (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002 and author estimates

The rates of growth in IT were strongest in the early 1990s and the 2000s (Figure E3). There was a slowdown after 2007–08 but this was not as prominent as in other industries.

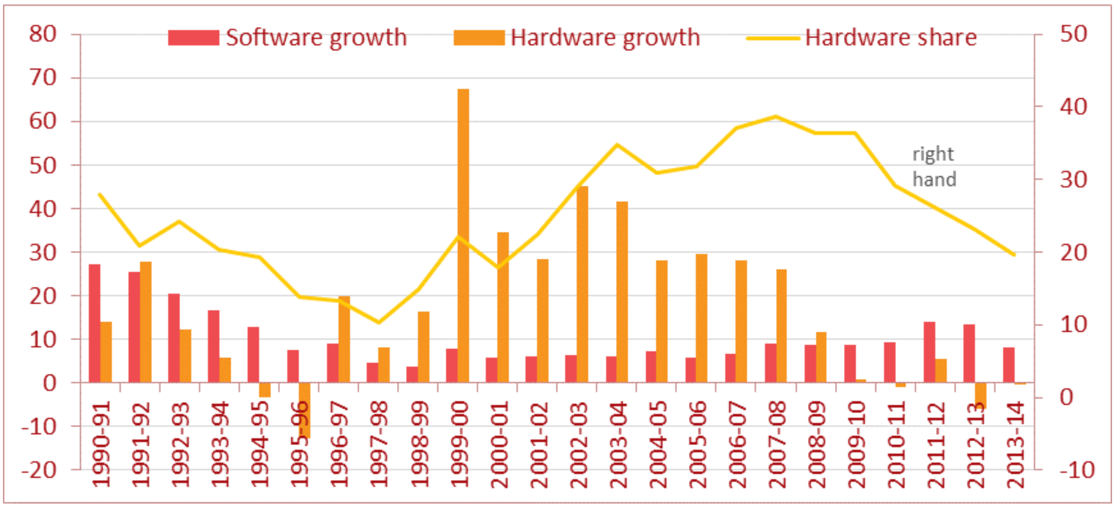
Figure E3: Annual growth in IT and non-IT capital (% per year) and the IT share of capital income (%) in TPW



Source: Author estimates

Most of the growth in IT in the 2000s was in hardware (Figure E4). Nevertheless, the sector remained software intensive, which is indicated by a hardware share of less than 50 per cent in Figure E4.

Figure E4: Annual growth in software and hardware (% per year) and hardware share of IT capital income (%) in TPW



Source: Author estimates

E.2 Labour productivity growth

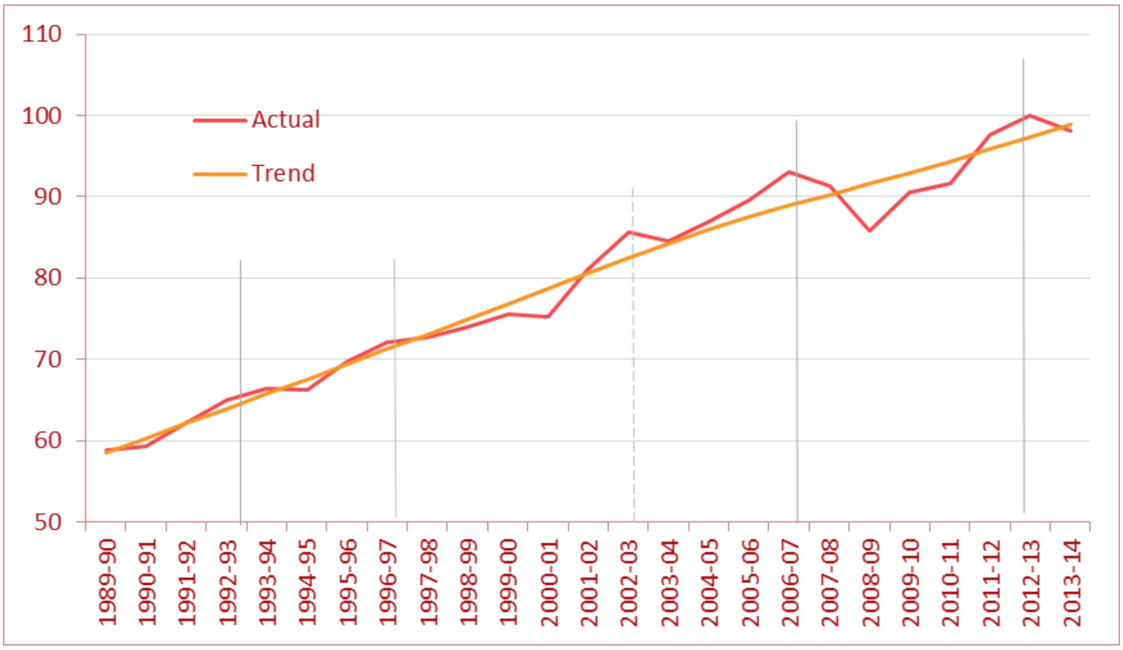
With relatively weak growth in labour, growth in labour productivity (LP) was reasonably strong. The level of labour productivity increased 67 per cent between 1989–90 and 2013–14. The average annual rate of growth in trend LP was 2.2 per cent.

Peaks in LP cycles occurred in 1992–93, 1996–97, 2006–07 and 2012–13 according to the method set out in section 5.3 (Figure). A peak at 2002–03 was imposed.

Productivity growth over these LP cycles was:

- 1992–93 to 1996–97: 2.7 per cent a year
- 1996–97 to 2002–03: 3.6 per cent a year
- 2002–03 to 2006–07: 2.1 per cent a year, and
- 2006–07 to 2012–13: 1.2 per cent a year.[z]

Figure E5: Actual and trend labour productivity in TPW[a] (index, actual 2012–13 = 100)



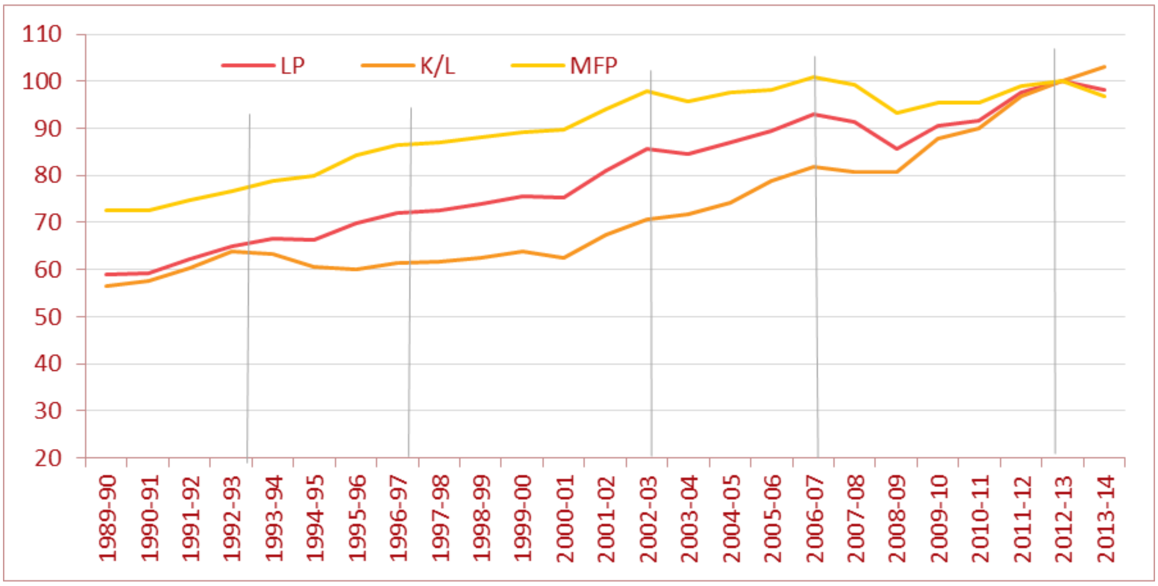
Note: a. Trend series formed with a Hodrick-Prescott filter λ = 100
Source: ABS Cat. No. 5260.0.55.002 and author estimates

E.2.1 IT capital deepening and LP growth

The growth in labour productivity can be decomposed into contributions from capital deepening and multifactor productivity (MFP) growth (section 4). Capital deepening is growth in the capital-labour ratio, multiplied by the share of total industry income attributed to capital.

Labour productivity, the capital-labour ratio and MFP are illustrated in Figure E6. MFP increased 34 per cent and the capital-labour ratio grew 83 per cent. (The later needs to be weighted by the capital share of total income, which averaged 0.36, to indicate its contribution to LP growth).

Figure E6: Labour productivity (LP), the capital-labour ratio (K/L) and multifactor productivity (MFP) in TPW (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002

The decomposition of LP growth over the cycles is presented in Table E1.

Table E1: Labour productivity growth accounting in TPW (per cent per annum and percentage points)[a]

	1992–93 to 1996–97	1996–97 to 2002–03	2002–03 to 2006–07	2006–07 to 2012–13
Capital deepening (pp)	-0.4	0.8 (28)	1.3 (64)	1.3
IT capital deepening (pp)	-0.2	0.2 (6)	0.0 (0)	-0.1
Hardware (pp)	*-0.3*	*0.1*	*0.1*	*-0.1*
Software (pp)	*0.0*	*0.1*	*-0.1*	*0.0*
Non-IT capital deepening (pp)	-0.1	0.6 (22)	1.3 (64)	1.4
MFP growth (pp)	3.0	2.1 (72)	0.8 (36)	-0.1
Labour productivity growth (%pa)	2.6	2.9 (100)	2.1 (100)	1.2

Note: a. Figures in brackets refer to percentages of labour productivity growth. Numbers may not add up due to rounding

Source: Author estimates

The contribution of IT capital deepening is small, and even negative, in this sector.

E.2.2 IT use and skills

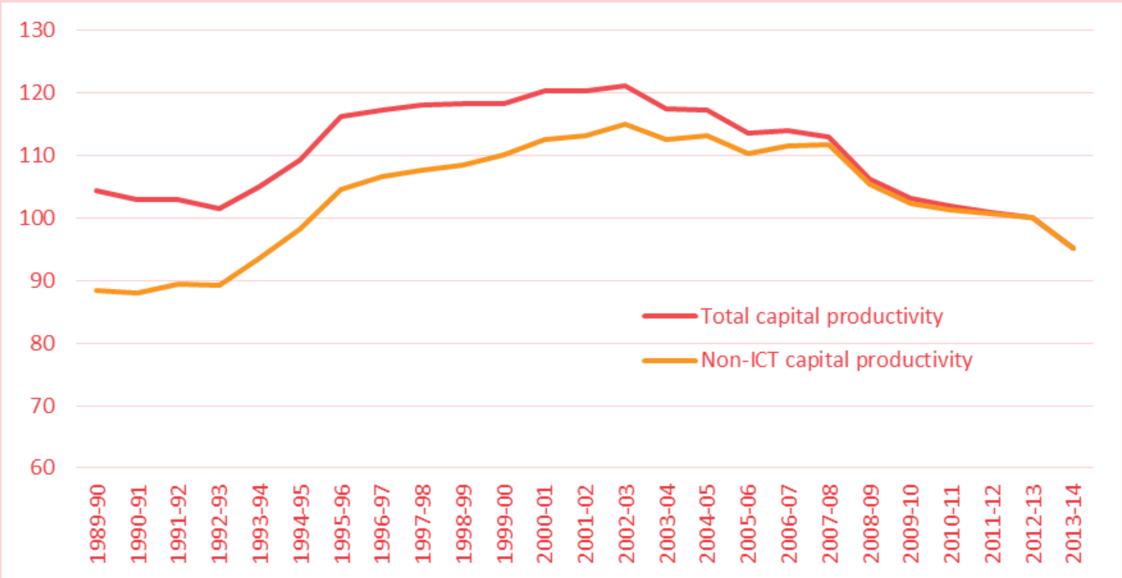
The average skill level increased by 8 per cent between 1989–90 and 2013–14. Even though the stock of IT capital increased a lot more, there was a high degree of correlation between the two. The correlation coefficient between IT capital and the index of skill composition is 0.93.

E.3 IT, asset use and capital productivity

The productivity of total capital and of non-IT capital is shown Figure E7.

Non-IT capital productivity can be divided into two contrasting periods. It grew by 8 per cent overall, with 25 percentage points of growth before 2002–03 offset by 17 percentage points of decline after this. IT growth was correlated with non-IT productivity in the earlier period to produce a coefficient of 0.92, but not in the later period.

Figure E7: Capital productivity of all assets and non-IT assets in TPW (index, 2012–13 = 100)



Source: Author estimates

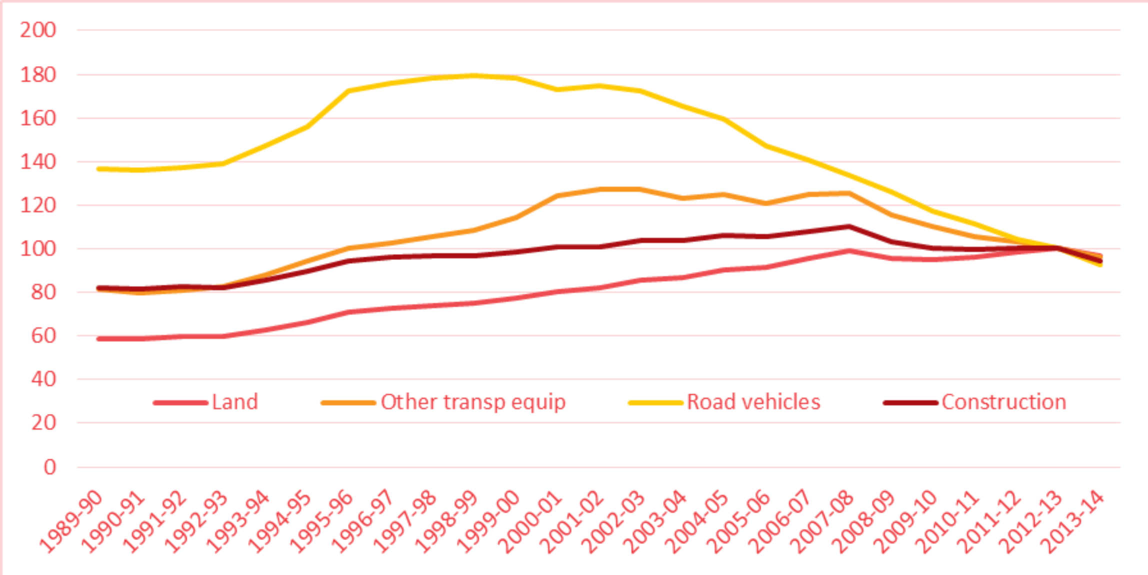
The major non-IT assets in TPW are: construction (50 per cent of capital income)[aa], other transport equipment (15 per cent), road vehicles (8 per cent) and land (7 per cent). Construction is such a large proportion of capital use because it includes the transport infrastructure of roads and rail.

The productivity of these major assets improved over at least part of the period (Figure E8):

- construction: 2.0 per cent a year 1992–93 to 2007–08
- other transport equipment: 3.5 per cent a year 1990–91 to 2002–03
- road vehicles: 3.5 per cent a year 1990–91 to 1998–99, and
- land: 3.4 per cent a year 1992–93 to 2007–08.

The correlation with IT use over the identified periods was high. Correlation coefficients are respectively: 0.87, 0.97, 1.00 and 0.95.

Figure E8: Asset productivity--the ratio of value added to use of selected assets in TPW



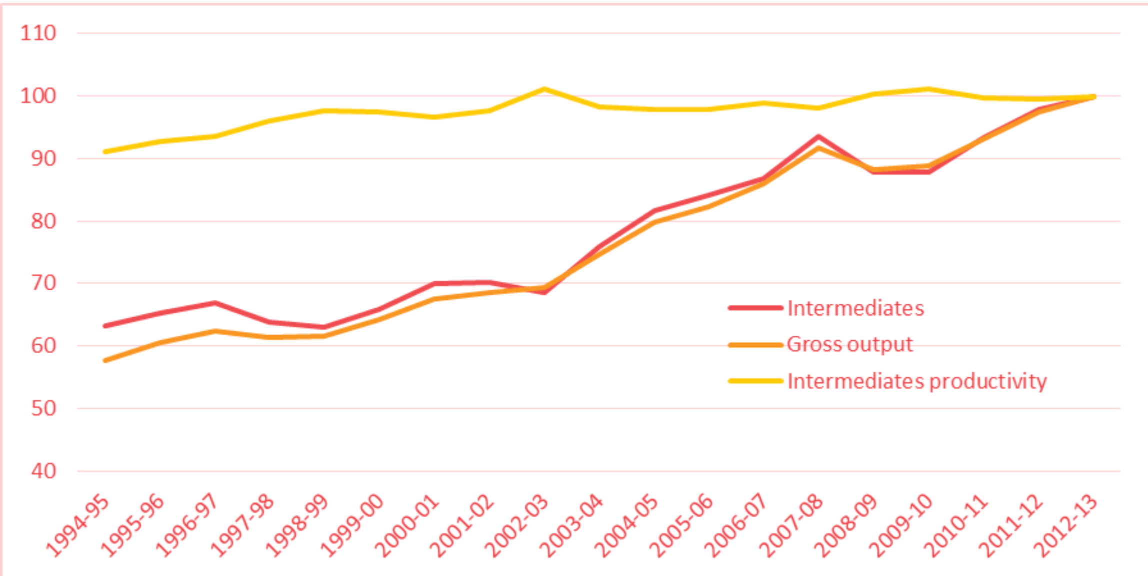
Source: Author estimates

E.4 Use of intermediates

In the case of intermediate input use, which refers to inputs of materials, energy and services to production, productivity is determined with reference to the gross output rather than the value added measure of output.

The productivity of intermediates use increased by 9 per cent over the entire period (Figure E9). This improvement took place between 1989–90 and 2002–03, after which intermediates productivity was flat.

Figure E9: Gross output, Intermediate input use and intermediate input productivity in TPW

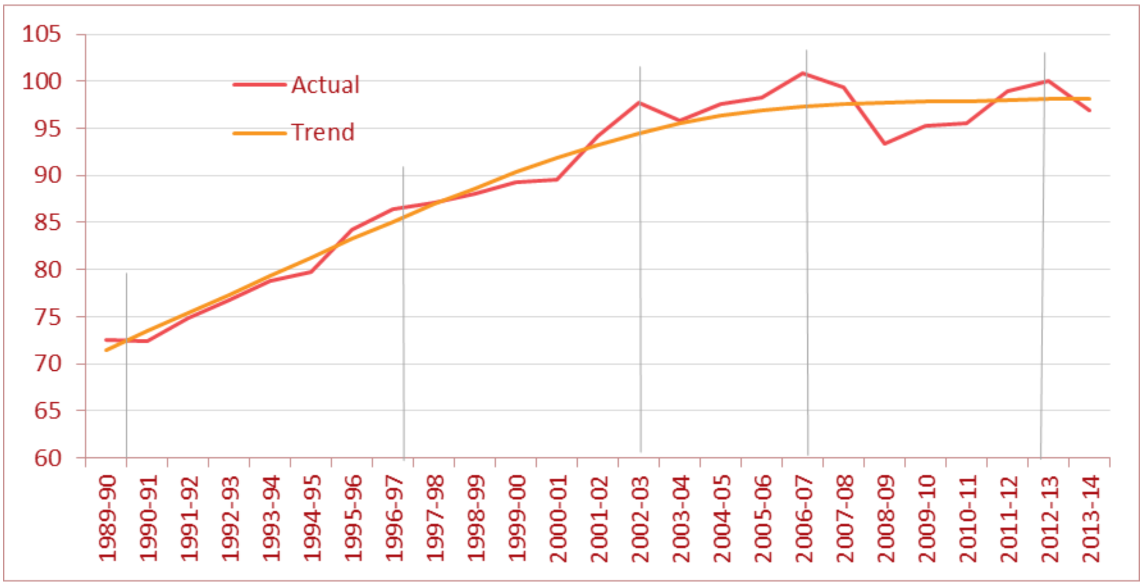


Source: Author estimates

E.5 MFP growth

The association between IT and MFP was examined in the context of MFP cycles (Figure E10). The peak in 2006–07 does not strictly satisfy the criteria for a peak and was imposed. The MFP and LP peaks coincide, except for the initial one—1992–93 for LP and 1989–90 for MFP.

Figure E10: Actual and trend MFP in TPW[a] (index, actual 2012–13 = 100)



Note: a. Trend series formed with a Hodrick-Prescott filter λ = 100

Source: ABS Cat. No. 5260.0.55.002 and author estimates

The MFP growth accounting is presented in **Error! Reference source not found.**Table E2. The labour productivity growth contribution plus the capital productivity contribution equals the MFP growth presented in the bottom row.

The IT contribution through IT capital deepening and LP growth was minor. There may have been some link between IT use and improvements in productivity of some assets and perhaps in particular, land and transport equipment.

Table E2: Multifactor productivity growth accounting over MFP cycles in TPW

	1989–90 to 1996–97	1996–97 to 2002–03	2002–03 to 2006–07	2006–07 to 2012–13
LP growth contribution (pp)	**1.9**	**1.9**	**1.3**	**0.7**
of which				
> IT capital deepening (pp)	0.1	0.1	0.0	0.0
KP growth contribution (pp)	**0.6**	**0.2**	**-0.6**	**-0.9**
of which				

> IT capital productivity (pp)	0.28	0.31	0.39	0.30
> Non-IT capital productivity (pp)	0.31	-0.13	-0.95	-1.15
MFP growth (% pa)	**2.5**	**2.1**	**0.8**	**-0.1**

Source: Author estimates. Numbers may not add up due to rounding.

F. Information, media and telecommunications (IMT)

Key points

The use of Information Technology (IT) in information, media and telecommunications (IMT) services has grown rapidly since the early 1990s, with the annual rate of growth in stocks of IT averaging 16.5 per cent. The rate was higher after 2011–12.

The industry was more software-intensive during the 1990s and 2000s.

There has been very strong labour productivity growth of 200 per cent over the 1990s and 2000s, largely due to the strong substitution of capital for labour (capital deepening).

IT capital deepening has been strong to very strong:

- It accounted for around 1.4 percentage points of annual labour productivity growth in the 1990s.
- It contributed half of that in the 2000s.
- These contributions represented between 10–20 per cent of the very strong growth in labour productivity.

Average skills increased 12 per cent with very strong correlation with IT stocks.

It does not appear IT has contributed to growth in the productivity of non-IT assets as a group. Nevertheless, there are some positive associations for individual assets.

- The strongest growth and associations are in regard to other transport equipment, industrial plant and equipment, and land. There was also some positive growth in the productivity of construction assets in the 1990s.

The IT capital deepening effects made strong contributions to multifactor productivity growth through the labour productivity channel. However, the significance of possible capital productivity effects was diminished by the low importance of the affected assets in IMT capital stocks.

Information, media and telecommunications (IMT) services are engaged in creating, enhancing and storing information that allows for its dissemination and transmission, using analogue and digital signals, providing transmission services, and operating the infrastructure to allow the transmission and storage of information.

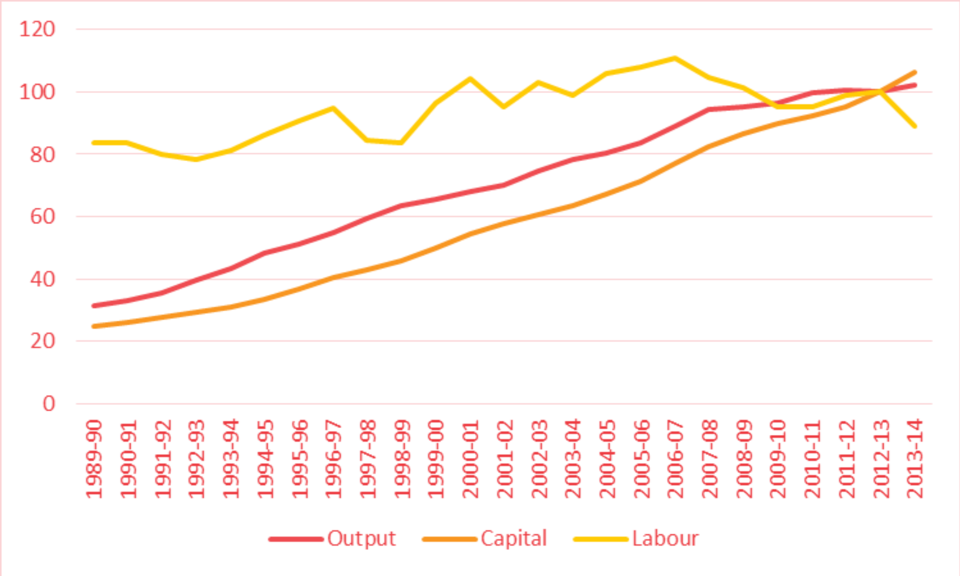
The ABS identifies the following subdivisions of IMT:

- publishing (except internet and music)
- motion picture and sound recording activities
- broadcasting (except internet)
- internet publishing and broadcasting

- telecommunications services
- internet service providers, web search portals and data processing services, and
- library and other information services.

The sector's value added expanded rapidly up until 2007–08 (Figure F1). Growth from 1989–90 to 2013–14 averaged 5.1 per cent a year. At basic prices, the sector slipped from 3.4 per cent of GDP in 1989–90 to 3 per cent in 2013–14.[15]

Figure F1: Capital, labour and output in information, media and telecommunications (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002

Growth in capital was strong and steady at 6.3 per cent a year on average. Labour was somewhat volatile but trended upward until 2007–08, before falling back. Average growth over the whole period was just 0.3 per cent a year.

F.1 Growth in IT capital

The rapid rate of growth in Information Technology (IT) capital in this sector over the period reviewed, 1989–90 to 2013–14, is evident in Figure F2. It has grown at an annual average of 16.5 per cent since 1989–90. Annual rates of growth have slowed in the 2000s, although the rate has picked up again since 2011–12 (Figure F3).

The importance of IT in total assets has varied in a fairly wide range at an average of 12.4 per cent (Figure F3).

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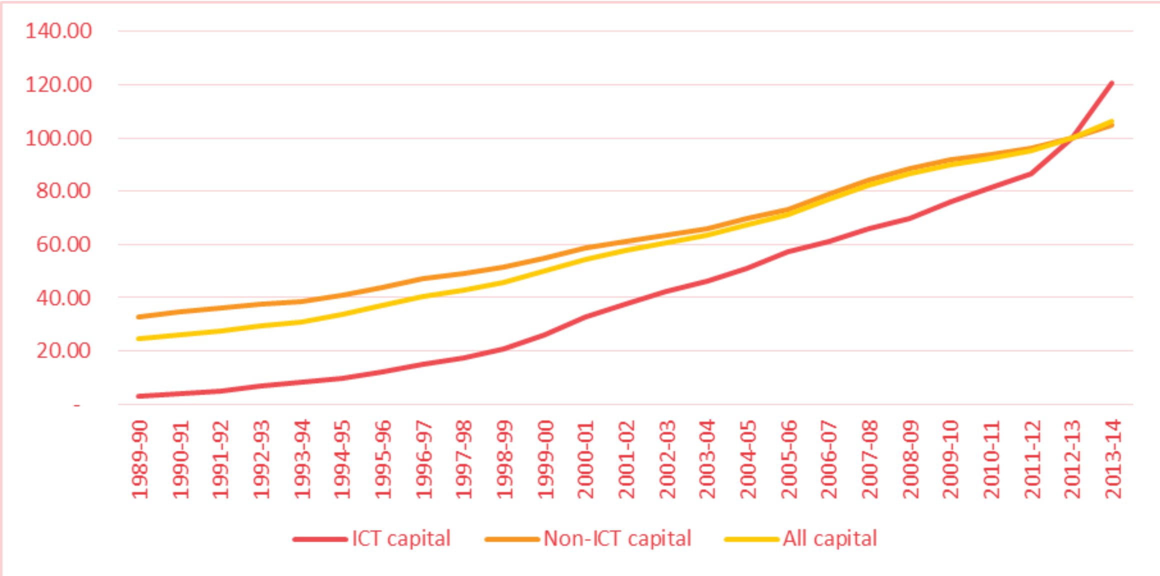
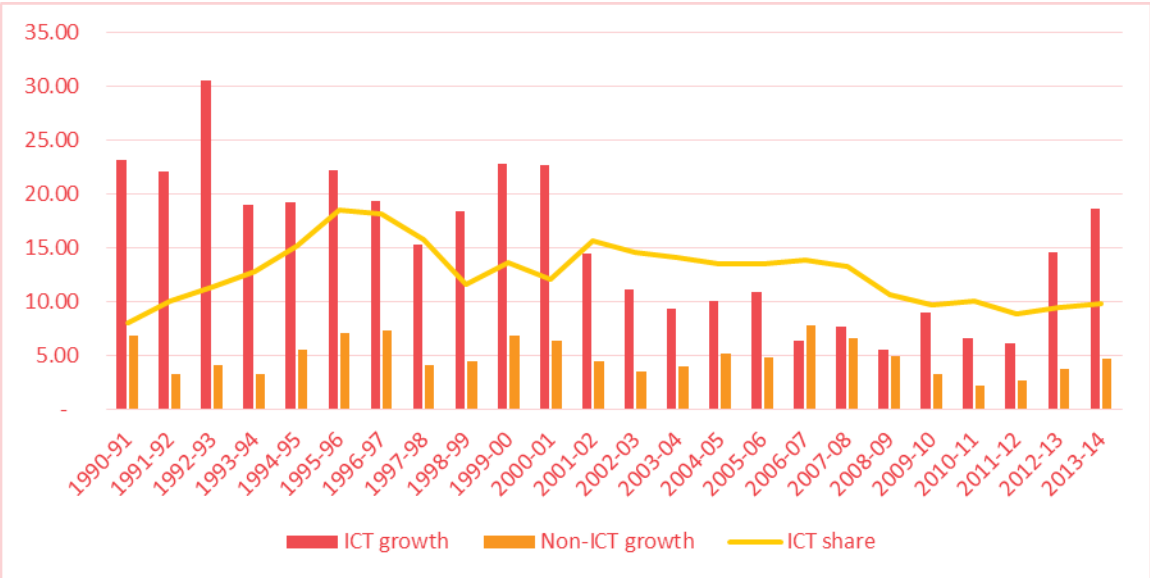
[15] ABS, *Australian System of National Accounts*, Cat. No. 5204.0, Table 5, Canberra, 31/10/2014

Figure F2: Capital, IT capital and non-IT capital (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002 and author estimates

Figure F3: Annual growth in IT and non-IT capital (% per year) and the IT share of capital income (%)

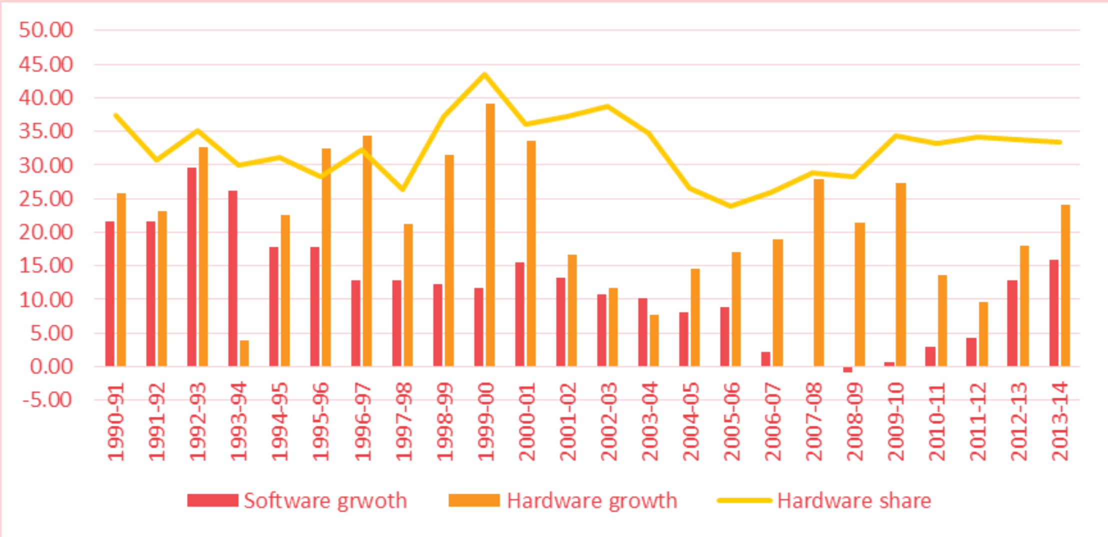


Source: Author estimates

The growth in hardware and software components of IT capital is shown in Figure F4. The figure also shows the share of hardware in IT capital income, which indicates the extent to which the industry is hardware (as opposed to software) intensive.

IMT services have generally been divided about two-thirds software and one-third hardware. There has been fluctuation in both software and hardware growth; there was strong growth in both software and hardware in the 1990s and in hardware from 2004–05.

Figure F4: Annual growth in software and hardware (% per year) and hardware share of IT capital income (%)



Source: Author estimates

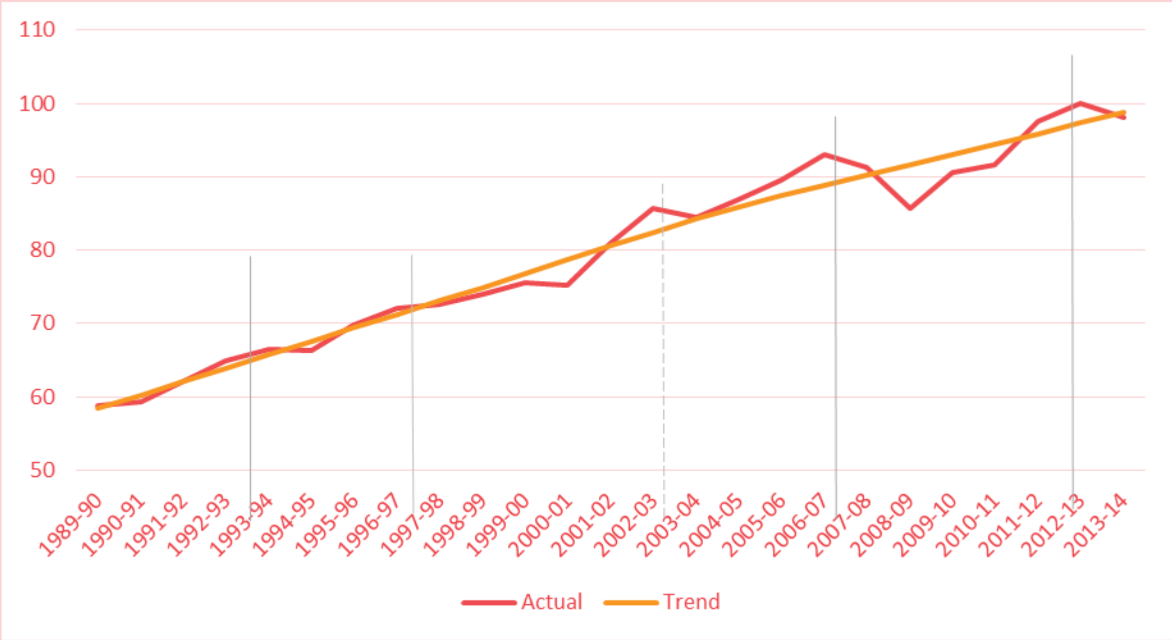
F.2 IT, labour use, and labour productivity

Labour productivity (LP) growth in IMT has been very strong. Labour productivity increased 208 per cent between 1989–90 and 2013–14 (Figure F5). The average annual rate of growth in trend LP was 4.5 per cent.

Peaks in LP cycles took place in 1992–93, 1998–99, 2001–02, 2003–04, and 2009–10 according to the method set out in section 5.3. The peak at 2001–02 was not used as it was close to a very high peak in 1998–99 and would have exaggerated the fall in productivity growth.

The year 2013–14 has been added, even though it escapes the formal decision rules, in order to investigate the most recent experience.

Figure F5: Actual and trend labour productivity in information, media and telecommunications[a] (index, actual 2012–13 = 100)



Note: a. Trend series formed with a Hodrick-Prescott filter λ = 100

Source: ABS Cat. No. 5260.0.55.002 and author estimates

Average growth rates in actual LP over cycles were:[bb]

- 1992–93 to 1998–99: 7.2 per cent a year
- 1998–99 to 2003–04: 0.8 per cent a year
- 2003–04 to 2009–10: 4.2 per cent a year, and
- 2009–10 to 2013–14: 3.1 per cent a year.

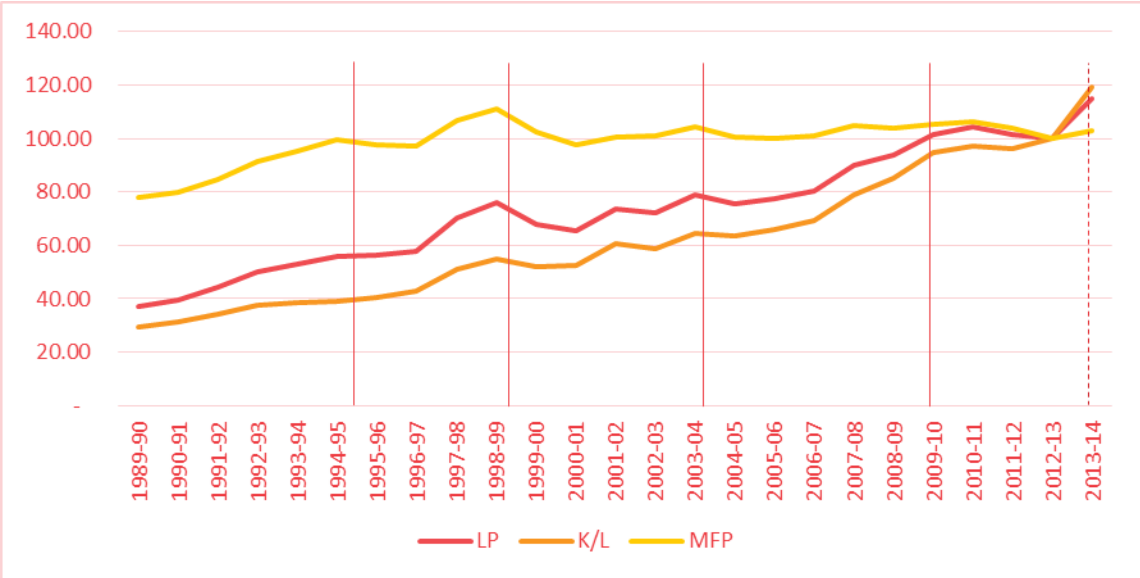
Note that the high peak in 1998–99 exaggerates the variation in productivity growth over the first two cycles.

F.2.1 IT capital deepening and LP growth

The growth in LP can be decomposed into contributions from capital deepening and multifactor productivity (MFP) growth (section 4). Capital deepening is growth in the capital-labour ratio, multiplied by the share of total industry income attributed to capital.

LP, the capital-labour ratio and MFP are illustrated in Figure F6. Capital deepening contributed more than MFP to LP growth. The capital-labour ratio increased more than 300 per cent.[cc] MFP grew 33 per cent.

Figure F6: Labour productivity (LP), the capital-labour ratio (K/L) and multifactor productivity (MFP) in IMT (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002

The dominance of the capital deepening contribution to LP growth, especially after the first cycle, is confirmed in the growth accounting in Table F1. The IT capital contribution was a very strong 1.1-1.6 percentage points in the first two cycles. After that it dropped to 0.7 of a percentage point.

Table F1: Labour productivity growth accounting in IMT services[a]

	1992–93 to 1998–99	1998–99 to 2003–04	2003–04 to 2009–10	2009–10 to 2013–14
Capital deepening (pp)	3.7 (53)	2.0	4.0 (96)	3.6
IT capital deepening (pp)	1.6 (23)	1.1	0.7 (16)	0.8
Hardware (pp)	*0.7*	*0.6*	*0.5*	*0.4*
Software (pp)	*1.0*	*0.5*	*0.2*	*0.4*
Non-IT capital deepening (pp)	2.1 (30)	0.9	3.3 (80)	2.8
MFP growth (pp)	3.2 (47)	-1.2	0.1 (4)	-0.5
Labour productivity growth (%pa)	6.9 (100)	0.8	4.2 (100)	3.1

Note: a. Figures in brackets refer to percentages of labour productivity growth. Numbers may not add up due to rounding

Source: Author estimates

Software made the stronger contribution in the first cycle, but its contribution slowed more than software's over following cycles (Table F3).

The pace of growth in non-IT capital deepening picked up in the last cycle, which may well have been due to investment in new telecommunications infrastructure.

F.2.2 IT use and skills

The average skill level increased 12 per cent between 1989–90 to 2013–14. Even though the stock of IT capital increased by much more, there was a high degree of correlation between the two. The correlation coefficient between IT capital and the index of skill composition is 0.98.

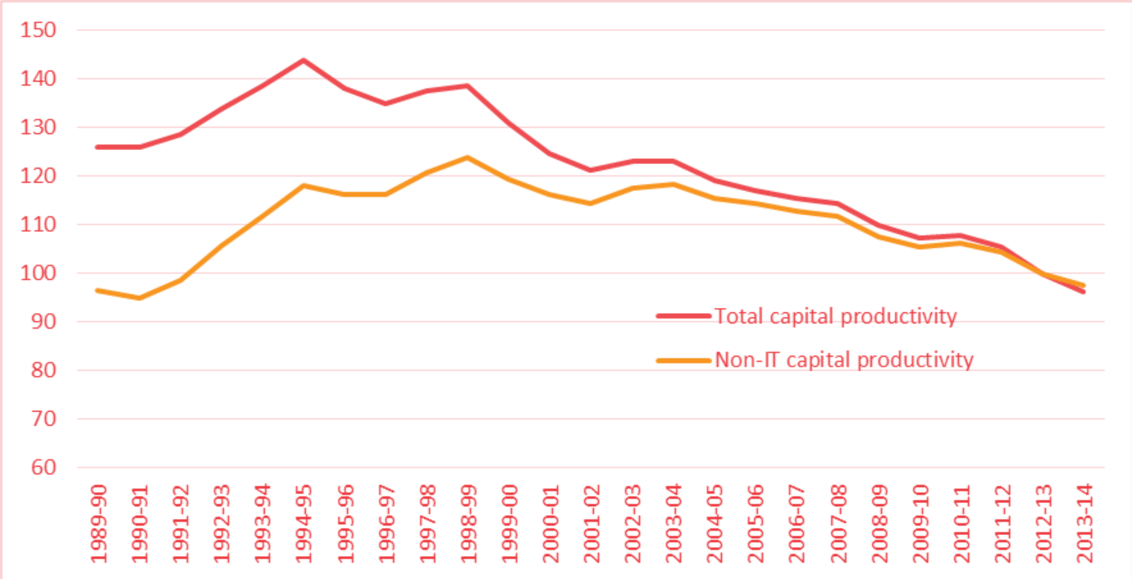
F.3 IT, asset use and capital productivity

IT can also enhance the productivity of other assets. For example, if IT enabled the industry to transform away from physical printing and publishing operations to publishing over the internet and digital channels, the unit requirements for various types of assets such as machinery and equipment may fall. That is, the productivity of non-IT assets may rise.

The productivity of total capital and of non-IT capital is shown in Figure F7. The difference between the two is the productivity of IT capital. Because IT capital has grown much more rapidly than value added in IMT, IT capital productivity has fallen.

The productivity of non-IT capital increased substantially—by 28.6 per cent—from the early to the late-1990s. However, nearly all of this increase has been lost in a steady decline since 1998–99.

Figure F7: Capital productivity of all assets and non-IT assets in IMT (index, 2012–13 = 100)



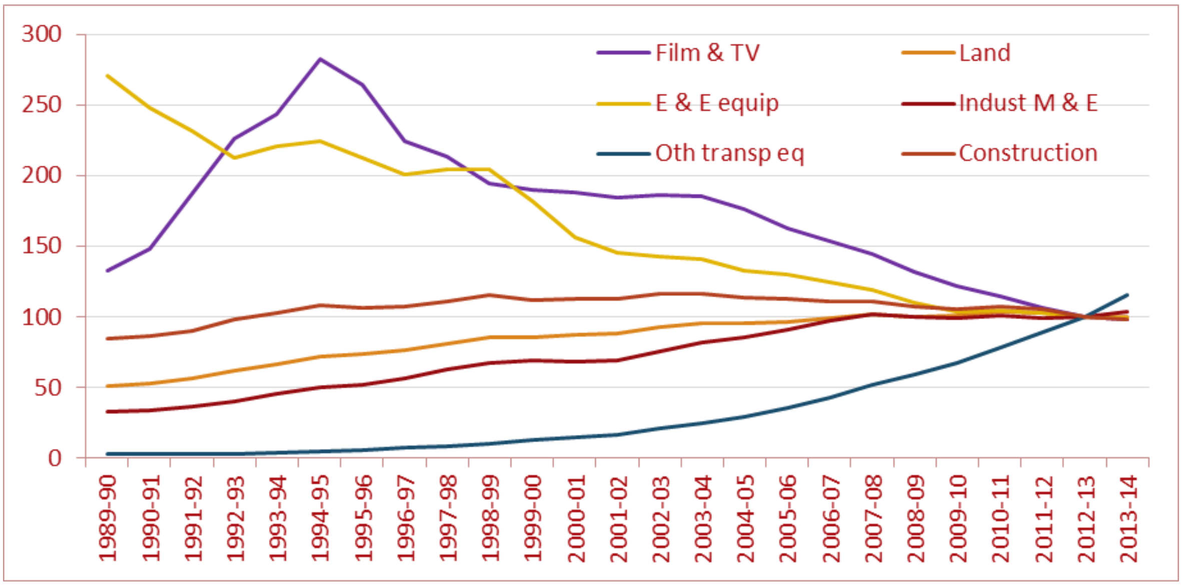
Source: Author estimates

The productivity of individual assets was investigated. The major capital inputs in IMT are: non-dwelling construction (46 per cent of capital income), electrical and electronic equipment (15 per cent), land (7 per cent) and film and TV (5 per cent).

Non-dwelling construction includes not only buildings but also communications infrastructure. While not major assets at 2 per cent of capital income each, other transport equipment, and industrial machinery and equipment were also included, as these assets had the highest average growth in capital productivity over the period.

The productivity of most of these assets increased over the entire period, apart from electrical and electronic equipment which decreased by 63 per cent and film and TV which decreased by 26 per cent (Figure F8).

Figure F8: Asset productivity–the ratio of value added to use of selected assets in IMT



Source: Author estimates

- Industrial machinery and equipment showed strong and steady increase in capital productivity of more than 200 per cent for the whole period. (Correlation coefficient with IT use = 0.93.)
- Non-dwelling construction showed an increase of 31 per cent up until 1998–99 but then reversed most of that gain by 2013–14. (Correlation coefficient with IT use = 0.21.)
- Land showed an increase of 52 per cent until 2010–11. (Correlation coefficient with IT use = 0.86.)
- Other transport equipment showed a very large increase from a small base. (Correlation coefficient with IT use = 0.97.)

There were varying degrees of correlation between IT use and the different asset productivities, as the above figures in brackets indicate.

The decline in construction productivity needs to be interpreted with some care. This may reflect additional expenditure on communications infrastructure. To the extent that is true, it cannot be inferred from the decline in asset productivity in this industry that it is bad for national productivity or a poor investment.

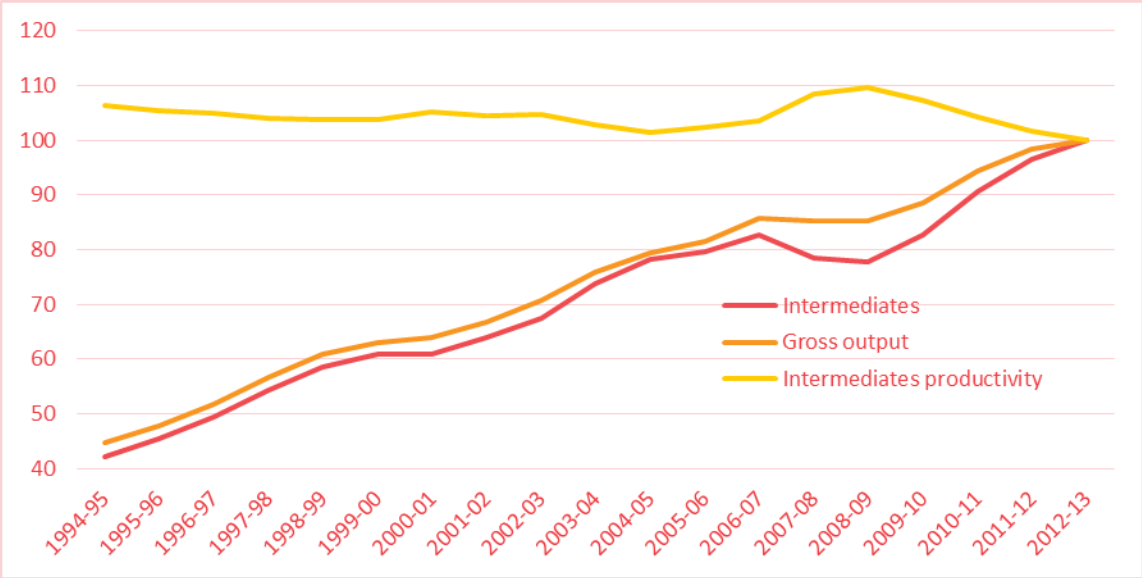
The communications infrastructure serves all industries, not just IMT, and may well provide productivity benefits over a range of them. These spill over benefits to other industries are not taken into account in the information presented here.

F.4 Use of intermediates

In the case of intermediate input use (purchased inputs of materials energy and services), productivity is determined with reference to the gross output rather than the value added measure of output.

The productivity of intermediates use decreased 6 per cent over the entire period (Figure F9). While gross output and intermediate input use grew steadily, intermediate input use did decline after 2006–07, before recovering to grow 20 per cent to 2012–13.

Figure F9: Gross output, intermediate input use and intermediate input productivity in IMT



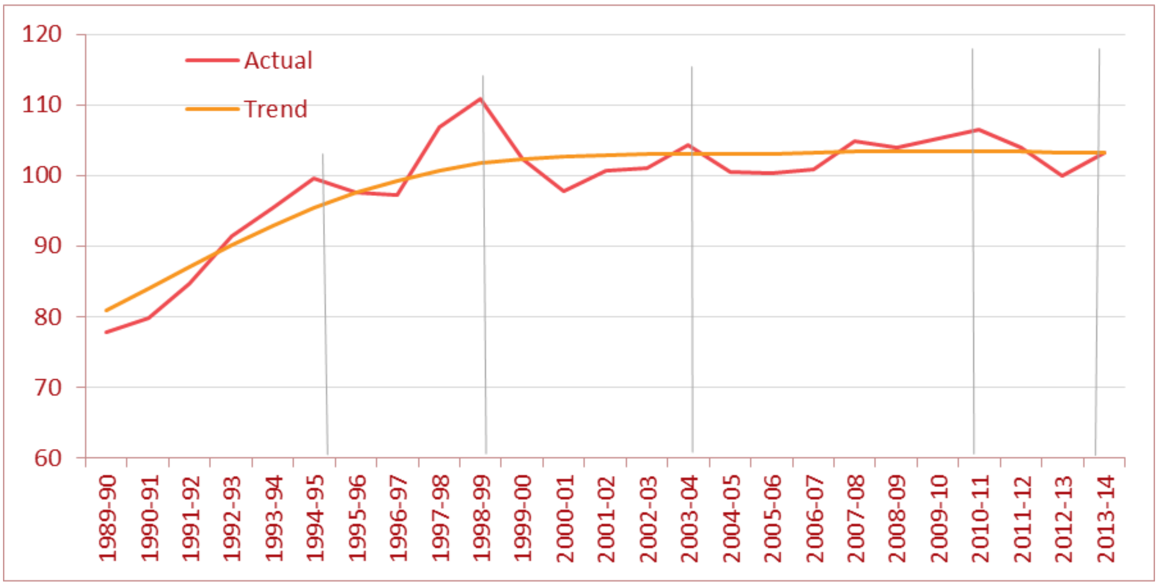
Source: Author estimates

F.5 MFP growth

The association between IT and MFP was examined in the context of MFP cycles. According to the method set out in section 5.3, MFP peaks in IMT took place in 1994–95, 1998–99, 2003–04 and 2010–11 (Figure F10). Another peak was imposed in 2013–14 (a point meeting the trend and a year corresponding to an LP peak).

The difference between LP and MFP cycles is that the 1990s peak in LP took place in 1992–93 and the 2000s peak in 2009–10, whereas the MFP peaks occurred in 1994–95 and 2010–11.

Figure F10: Actual and trend MFP in IMT[a] (index, actual 2012–13 = 100)



Note: a. Trend series formed with a Hodrick-Prescott filter λ = 100

Source: ABS Cat. No. 5260.0.55.002 and author estimates

Table F2 shows the MFP growth accounting. The labour productivity growth contribution plus the capital productivity contribution equals the MFP growth presented in the bottom row.

Labour productivity growth accounts for all of the MFP growth in each cycle, while the capital productivity contribution is negative in each cycle.

The IT capital deepening contribution is shown as part of the labour productivity contribution. Values in the range 0.4–0.8 of a percentage point in the first two periods were quite strong, especially in the context of an average annual MFP growth rate over the whole period of 1.2 per cent.

There is limited evidence that increased IT use may have enabled MFP growth through the capital productivity channel. The only positive growth in capital productivity contributions was from non-IT in the first cycle. However, as indicated above, there may have been some link between IT use and improvements in productivity of some individual assets.

Table F2: Multifactor productivity growth accounting over MFP cycles in IMT

	1994–95 to 1998–99	1998–99 to 2003–04	2003–04 to 2010–11	2010–11 to 2013–14
LP growth contribution (pp)	**3.2**	**0.2**	**1.5**	**1.2**
of which				
> IT capital deepening (pp)	0.8	0.4	0.2	0.3
KP growth contribution (pp)	**-0.5**	**-1.4**	**-1.2**	**-2.3**
of which				
> IT capital productivity (pp)	-1.13	-0.97	-0.35	-0.71
> Non-IT capital productivity (pp)	0.62	-0.46	-0.85	-1.60
MFP growth (% pa)	**2.7**	**-1.2**	**0.3**	**-1.1**

Source: Author estimates. Numbers may not add up due to rounding.

Trends in asset productivities examined in section F.3 are summarised for MFP cycles in Table F3. The growth in asset productivity over a cycle is shown first (unweighted), with another row showing asset productivity growth, weighted by the asset's share in capital income. This provides an indication of the relative importance of the different asset productivities. However, these values should not be regarded as contributions that can be added.

The improvement in productivity of other transport equipment stands out. However, its significance is reduced by its small weighting. The improvement in construction productivity in the first cycle is of major significance, generating weighted growth of 0.8 of a percentage point per annum. (See section J3 on the interpretation of construction productivity.)

Table F3: Capital productivity for selected assets over MFP cycles, unweighted and weighted[a] (per cent per year)

	1994–95 to 1998–99	1998–99 to 2003–04	2003–04 to 2010–11	2010–11 to 2013–14
Film and TV productivity	-9.4	-1.0	-6.9	-5.2
> Weighted	-0.2	-0.1	-0.5	-0.5
Land productivity	4.2	2.2	1.2	-1.0
> Weighted	0.2	0.2	0.0	0.0
E & E equip productivity	-2.4	-7.5	-4.3	-1.8
> Weighted	-0.5	-1.2	-0.7	-0.2
Indust M & E productivity	7.2	4.0	3.0	0.9
> Weighted	0.2	0.1	0.1	0.0
Other transp equip prody	19.4	17.4	16.3	13.1
> Weighted	0.5	0.2	0.1	0.0
Construction productivity	1.6	0.3	-1.2	-3.0
> Weighted	0.8	0.1	-0.5	-1.5

Source: Author estimates

G. Financial and insurance services

Key points

Information Technology (IT) stock grew very rapidly in financial and insurance services (FIS) in the 1990s and up until 2007–08, with annual growth rates typically 20–25 per cent. Growth in hardware, in particular, dropped off after 2007–08.

The increased use of IT in financial and insurance services had large effects on labour productivity and, most likely, on non-IT capital productivity.

Labour productivity growth was strong over the period reviewed (1989–90 to 2013–14). It slowed from being very strong in the early 1990s to strong through to 2007–08, after which it was moderate.

Multifactor productivity (MFP) growth followed a similar pattern and was more important than capital deepening as a source of labour productivity growth.

The IT capital deepening contribution to labour productivity growth was very strong at 1.3 to 1.9 of a percentage point up to 2007–08, and 0.8 of a percentage point after that. Aside from the early 1990s when MFP growth was especially strong, IT capital deepening has accounted for 40–50 per cent of labour productivity growth.

Non-IT capital deepening contributed little to labour productivity growth after the early 1990s, which is probably associated with the growth in productivity of non-IT assets, meaning fewer of them are required.

The average skill level in FIS has increased by 22 per cent since the late 1980s and the increase has been highly correlated with IT use.

Areas of substantial improvement in capital productivity, which is likely associated with increased IT use include:

> land productivity increased 200 per cent
> vehicles productivity by over 40 per cent, and
> buildings productivity by 160 per cent.

Because of the importance of buildings in capital costs, the improvement in buildings productivity is the most significant development for this sector. It contributed about 2 percentage points to annual growth in capital productivity.

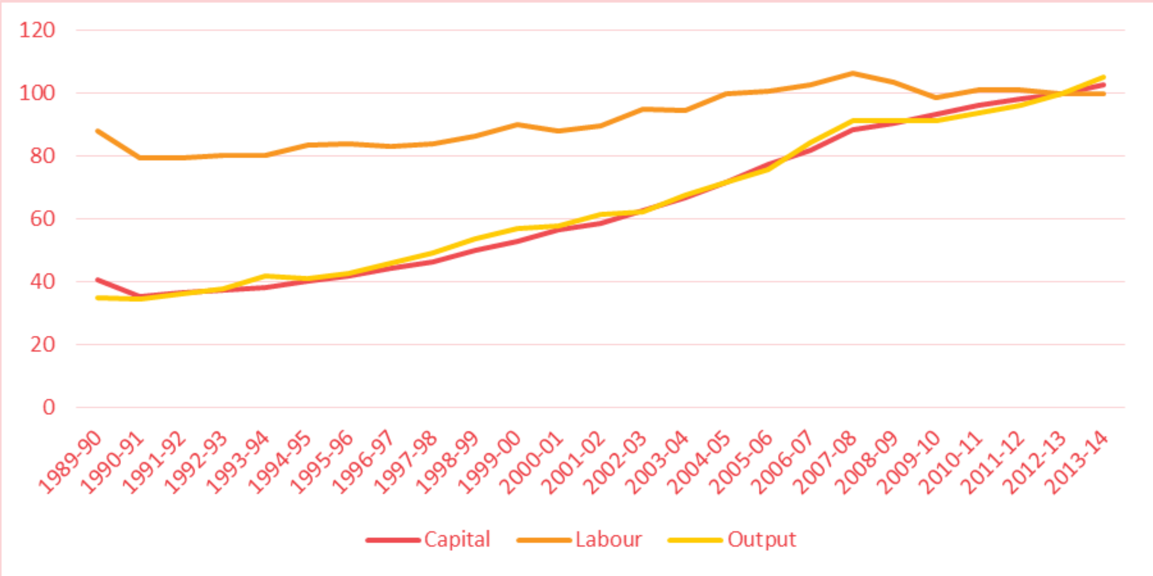
Financial and insurance services (FIS) covers financial intermediation, insurance and superannuation. The Australian Bureau of Statistics (ABS) identifies the following subdivisions within this sector:

> finance
> insurance and superannuation funds, and

- auxiliary insurance and superannuation services.

Output and capital grew rapidly and in conjunction from 1989–90 to 2007–08, after which there was a slowdown in growth, especially in output (Figure G1). Use of labour also grew until 2007–08, after which there was some labour shedding.

Figure G1: Capital, labour and output in financial and insurance services (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002

With its rapid growth, financial and insurance services has increased from 5.8 per cent of GDP in 1989–90 to 9.0 per cent in 2013–14. The annual rate of growth in output has averaged 4.7 per cent over that period. Growth in capital and labour have averaged 3.9 and 0.5 per cent a year respectively.

G.1 Growth in Information Technology capital

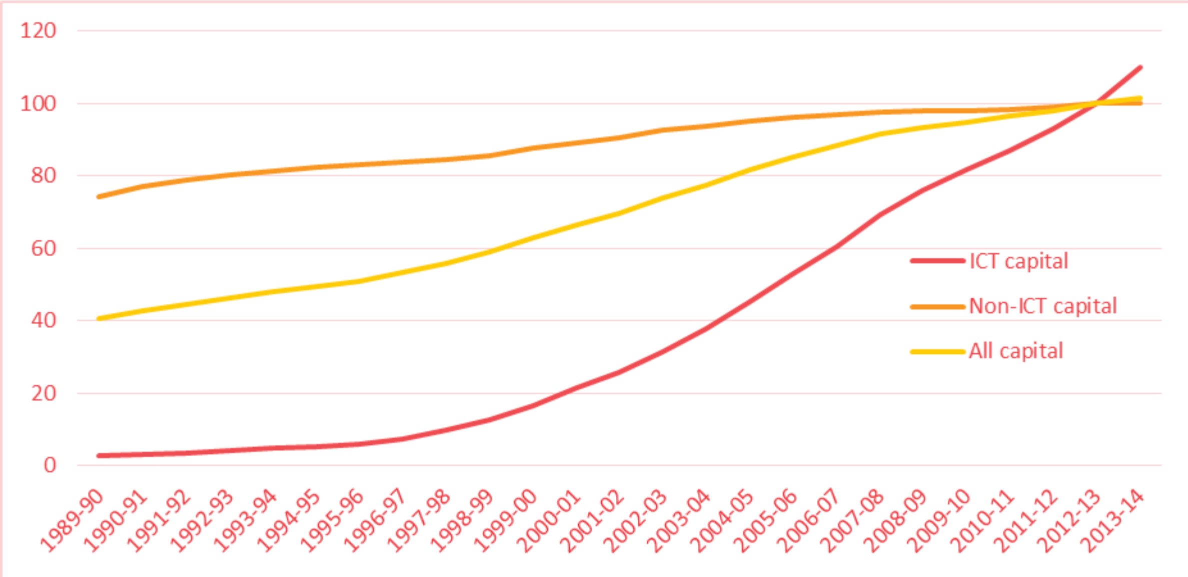
The FIS industry began investing more in Information Technology (IT) in the 1980s.[16] Even with that early start, the growth through the 1990s and the 2000s was rapid.

Annual rates of growth in IT capital were in the region of 20–25 per cent from the mid-1990s to the mid-2000s. As with other industries, there was a drop off in growth after 2007–08 (Figure G3).

[16] D. Parham, P. Roberts and H. Sun (2001), *Information Technology and Australia's Productivity Surge*, Staff Research Paper, Productivity Commission, Canberra.

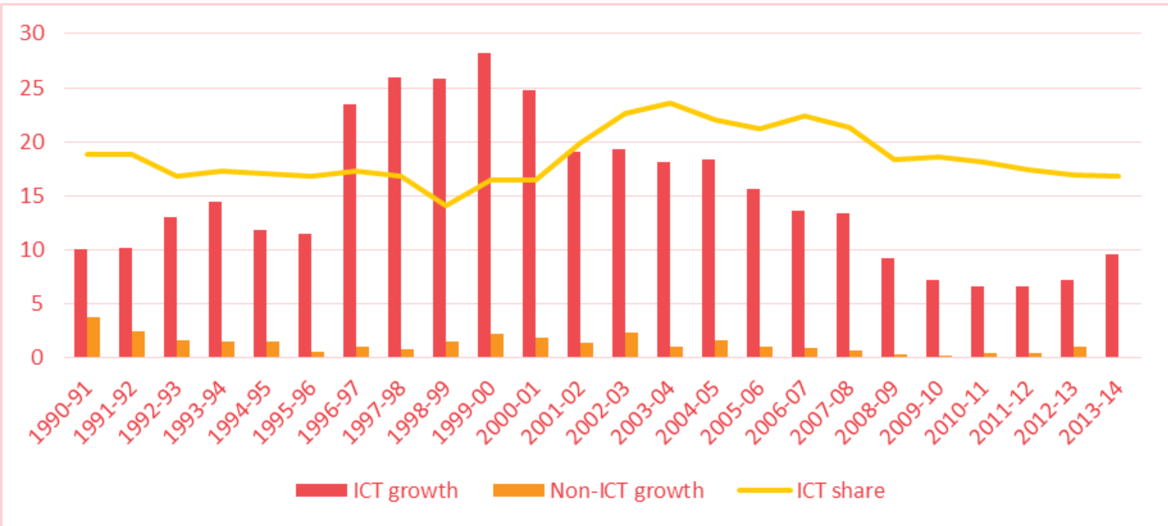
IT has been an important part of total capital in the sector. It has accounted for between 15-25 per cent of capital income for most of the period reviewed (Figure). The overall average was 19 per cent, with software accounting for 11 percentage points and hardware 8 percentage points.

Figure G2: Capital, ICT capital and non-IT capital in financial and insurance services (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002 and author estimates

Figure G3: Annual growth in IT and non-IT capital (% per year) and the IT share of capital income (%) in FIS

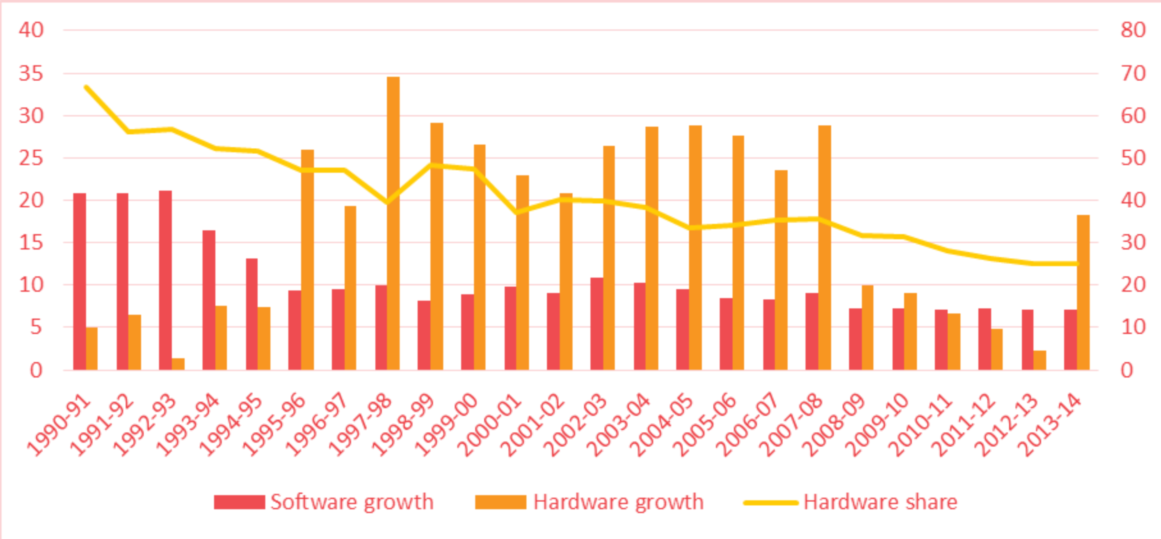


Source: Author estimates

The growth in IT between the mid-1990s and mid-2000s was mainly in hardware (Figure G4). Despite this growth, the sector has become more software intensive over time, as indicated by the declining share of IT income attributed to hardware (Figure G4).

Growth in hardware dropped heavily after 2007–08.

Figure G4: Annual growth in software and hardware (% per year) and hardware share of IT capital income (%) in FIS



Source: Author estimates

G.2 Labour productivity growth

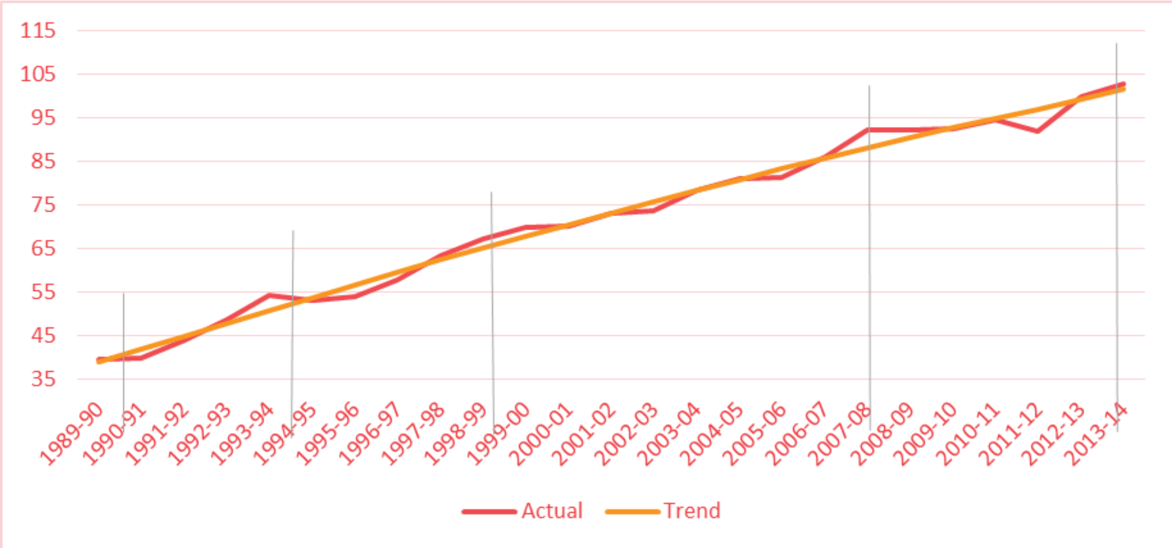
Labour productivity (LP) growth in FIS was strong for the period reviewed. The level of labour productivity increased 160 per cent between 1989–90 and 2013–14. The average annual rate of growth in trend LP was 4.1 per cent.

Peaks in LP cycles took place in 1989–90, 1993–94, 1998–99, 2007–08 and 2013–14 according to the method set out in section 5.3 (Figure).

Productivity growth over the LP cycles slowed considerably between 1989–90 and 2013–14. Average growth rates in actual LP over cycles were:

- 1989–90 to 1993–94: 8.3 per cent a year
- 1993–94 to 1998–99: 4.4 per cent a year
- 1998–99 to 2007–08: 3.6 per cent a year, and
- 2007–08 to 2013–14: 1.8 per cent a year.[dd]

Figure G5: Actual and trend labour productivity in finance and insurance services[a] (index, actual 2012–13 = 100)



Note: a. Trend series formed with a Hodrick-Prescott filter λ = 100

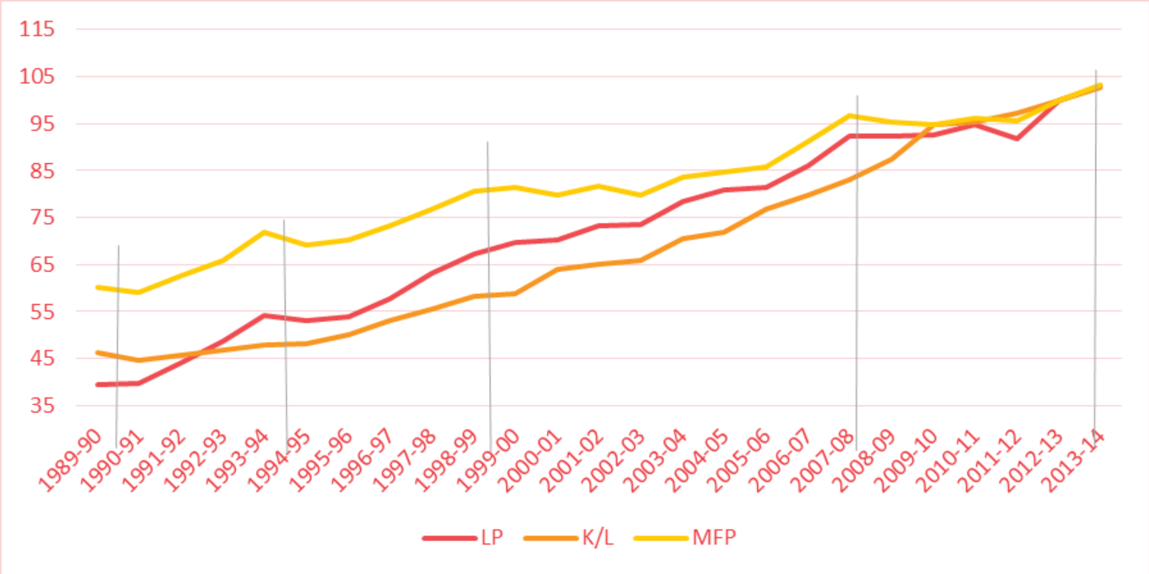
Source: ABS Cat. No. 5260.0.55.002 and author estimates

G.2.1 IT capital deepening and LP growth

The growth in labour productivity can be decomposed into contributions from capital deepening and multifactor productivity (MFP) growth. Capital deepening is growth in the capital-labour ratio, multiplied by the share of total industry income attributed to capital.

The growth in LP, the capital-labour ratio and MFP are illustrated in Figure G6. MFP increased 72 per cent and the capital-labour ratio grew by more than 120 per cent. (The latter needs to be weighted by the capital share of total income, which averaged 0.57, to indicate its contribution.)

Figure G6: Labour productivity (LP), the capital-labour ratio (K/L) and multifactor productivity (MFP) in financial and insurance services (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002

MFP growth had greater influence in each cycle, accounting for between 52–61 per cent of LP growth (Table G1). MFP growth did, however, weaken in absolute value over time.

The capital-deepening contribution also weakened in absolute value over time (Table G1). However, that weakening came mostly from non-IT capital deepening, which effectively disappeared in the 2000s.

The IT capital deepening contribution was very strong. It stayed in the 1.3–1.9 percentage point range up until 2007–08, after which it fell back to 0.8 of a percentage point in line with the low growth in IT investment previously noted.

Apart from the very early 1990s, when MFP made a particularly strong contribution, IT capital deepening accounted for 40–50 per cent of LP growth in each cycle for the period reviewed.

In summary, substitution of IT capital for labour had strong and fairly steady effects on LP growth.

Table G1: Labour productivity growth accounting in FIS (per cent per annum and percentage points)[a]

	1989–90 to 1993–94	1993–94 to 1998–99	1998–99 to 2007–08	2007–08 to 2013–14
Capital deepening	3.4 (43)	2.1 (48)	1.5 (42)	0.7 (39)
IT capital deepening	1.3 (17)	1.9 (43)	1.9 (54)	0.8 (44)
Hardware	*0.6*	*0.9*	*1.0*	*0.3*
Software	*0.7*	*1.0*	*0.9*	*0.5*
Non-IT capital deepening	2.1 (27)	0.2 (5)	-0.4	-0.1
MFP growth	4.5 (57)	2.3 (52)	2.0 (58)	1.1 (61)
Labour productivity growth	7.9 (100)	4.4 (100)	3.5 (100)	1.8 (100)

Note: a. Figures in brackets refer to percentages of labour productivity growth

Source: Author estimates

G.2.2 IT use and skills

Between 1989–90 and 2013–14, the average skill level in the industry increased steadily by 22 per cent. Even though the stock of IT capital increased by much more, there was a high degree of correlation between the two. The correlation coefficient between IT capital and the index of skill composition is 0.94.

G.3 IT, asset use and capital productivity

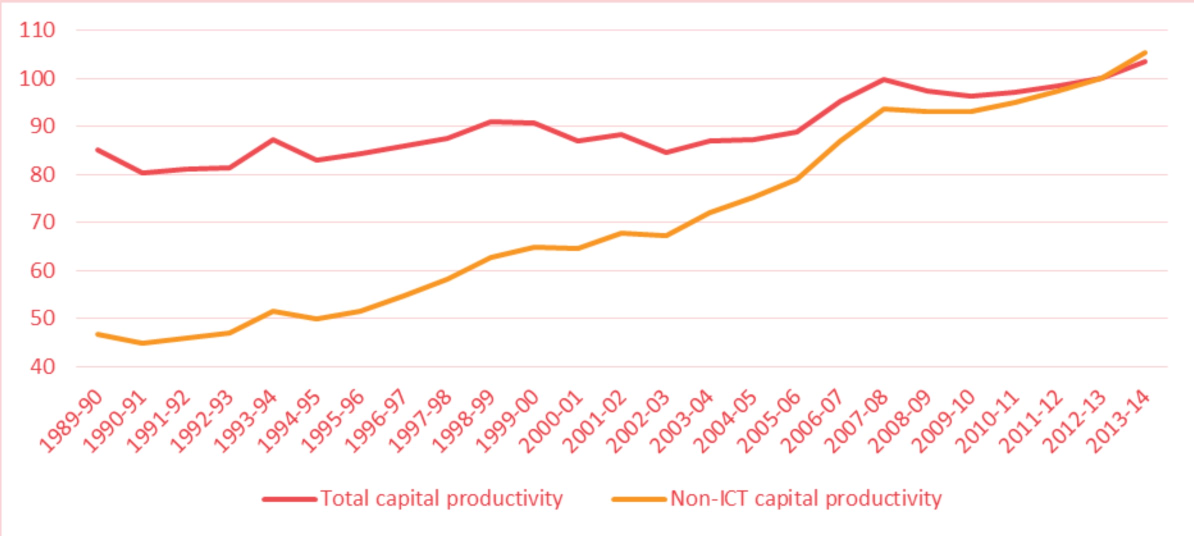
The use of IT can enhance the productivity of other assets—the productivity of total capital and of non-IT capital is shown Figure G7.

There was very strong growth in non-IT capital productivity that coincided with strong uptake of IT. Non-IT capital rose 80 per cent from 1993–94 to 2007–08 at an annual average rate of growth of 4.4 per cent. This rate of increase then slowed at the same time that growth in IT use slowed.

The entire non-IT capital productivity and IT capital series have a correlation coefficient of 0.98.

Total capital productivity grew positively but at a much slower rate than non-IT capital productivity. A sharp fall in IT capital productivity offset the rise in non-IT capital productivity, but not completely. IT capital productivity fell because IT capital grew much more rapidly than value added.

Figure G7: Capital productivity of all assets and non–IT assets in FIS (index, 2012–13 = 100)



Source: Author estimates

The productivity of individual assets was also investigated. The major non-IT capital inputs in FIS are: buildings (51 per cent of capital income)[ee], land (11 per cent) and road vehicles (7 per cent).

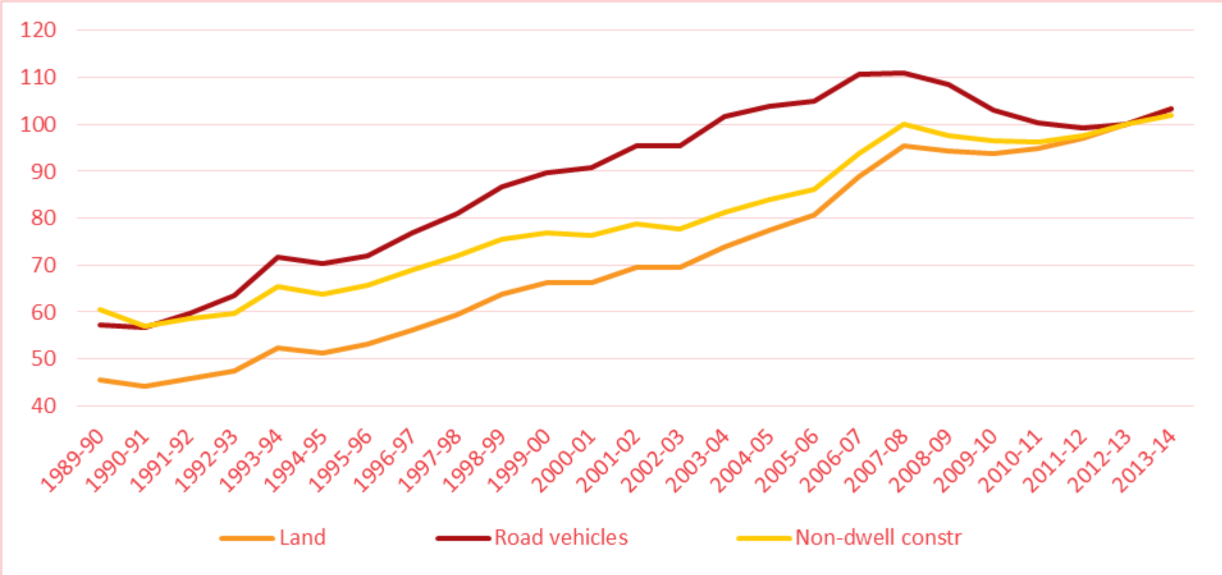
The productivity of these assets increased over the period (Figure G8).There was strong to very strong correlation between IT use and the different asset productivities, as the figures in brackets below indicate. The increases in capital productivity were large:

> Land showed the strongest increase at 200 per cent for the whole period. (Correlation coefficient with IT use = 0.99.)

> Road vehicles productivity increased 60 per cent up to 2007–08 before falling back to an overall 43 per cent increase. (Correlation coefficient with IT use = 0.73.)

> Buildings productivity increased by 160 per cent over the whole period. (Correlation coefficient with IT use = 0.99.)

Figure G8: Asset productivity—the ratio of value added to use of selected assets in FIS



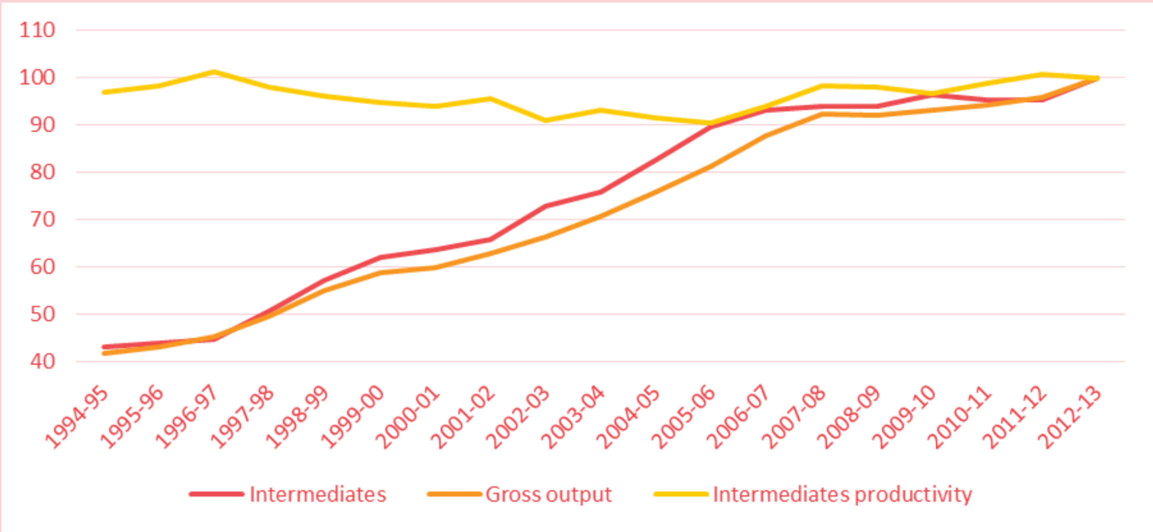
Source: Author estimates

G.4 Use of intermediates

The possibility that IT could help improve the efficiency with which intermediate inputs (materials, energy and services) are used was also examined. In the case of intermediate input use, productivity is determined with reference to the gross output, rather than the value added, measure of output.

The efficiency of intermediates use did not change much over the entire period, although a rise after 2005–06 offset a prior decline (Figure G9).

Figure G9: Gross output, intermediate input use and intermediate input productivity in FIS

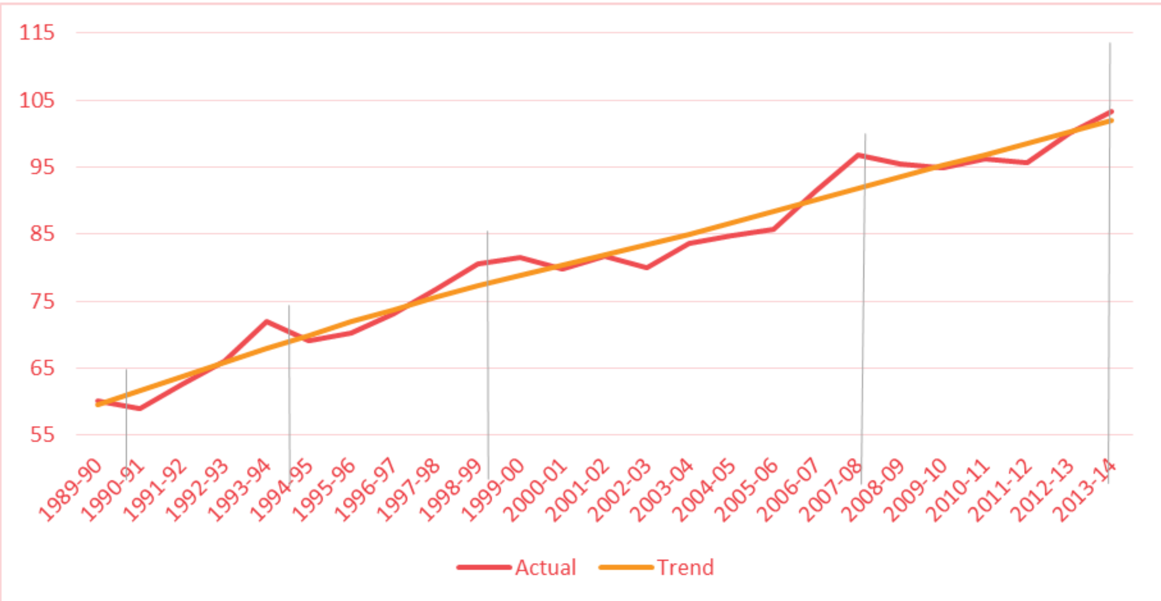


Source: Author estimates

G.5 MFP growth

The association between IT and MFP is examined in the context of MFP cycles (Figure G10). The timing of MFP cycles and LP cycles coincide.

Figure G10: Actual and trend MFP in FIS[a] (index, actual 2012–13 = 100)



Note: a. Trend series formed with a Hodrick-Prescott filter λ = 100

Source: ABS Cat. No. 5260.0.55.002 and author estimates

For the purposes of this paper, MFP growth was treated as a weighted average of LP growth and capital productivity growth, with the respective income shares as the weights. This allowed the influences of IT growth on MFP to be seen as a combination of substitution effects on labour and on capital.

The MFP growth accounting is presented in Table G2. The labour productivity growth contribution plus the capital productivity contribution equals the MFP growth presented in the bottom row of the table.

Labour productivity growth accounts for most of the MFP growth in each cycle. This was as expected, given capital productivity tends to show relatively small movements over short periods.

The IT capital deepening contribution is shown as part of the labour productivity contribution.[ff] Values around 0.8 of a percentage point up to 2007–08 are very strong.

The capital productivity contribution was split into IT and non-IT contributions. The IT capital productivity contribution was negative as IT capital grew faster than output. The non-IT contribution was positive and increased up to 2007–08. The overall average was around 1.6 per cent a year.

While it does not establish causality, the improvement in non-IT capital is strongly associated with increased use of IT. The correlation coefficient between the two series is 0.98.

Table G2: Multifactor productivity growth accounting over MFP cycles in FIS

	1989–90 to 1993–94	1993–94 to 1998–99	1998–99 to 2007–08	2007–08 to 2013–14
LP growth contribution	4.0	1.8	1.5	0.7
of which				
> IT capital deepening	0.7	0.8	0.8	0.3
KP growth contribution	0.5	0.5	0.6	0.4
of which				
> IT capital productivity	-0.62	-1.45	-1.47	-0.59
> Non-IT capital productivity	1.14	1.93	2.04	0.97
MFP growth	4.5	2.3	2.0	1.1

Source: Author estimates. Numbers may not add up due to rounding.

The trends in asset productivities examined in the previous section are summarised for MFP cycles in Table G8. The growth in asset productivity over a cycle is shown first (unweighted), with another row showing asset productivity growth weighted by the asset's share in capital income. This provides an indication of the relative importance of the different asset productivities. However, these values should not be regarded as contributions that can be added.

Table G3: Capital productivity for selected assets over MFP cycles, unweighted and weighted[a] (per cent per year)

	1989–90 to 1993–94	1993–94 to 1998–99	1998–99 to 2007–08	2007–08 to 2013–14
Land productivity	3.54	4.92	5.88	3.17
> Weighted	0.40	0.49	0.57	0.36
Road vehicles productivity	3.97	2.83	1.86	-1.79
> Weighted	0.19	0.22	0.13	-0.12
Buildings productivity	1.89	4.23	5.27	3.20
> Weighted	1.24	2.32	2.60	1.58

Note: a. Weighted by the share of the asset in capital income

Source: Author estimates

There was strong growth in all three asset productivities, especially over the first three cycles (Table G3). Because of the importance of buildings in total asset costs, however, the improvement in buildings productivity had greater significance. Over the whole period, it contributed about 2 percentage points to overall capital productivity. The improvement in capital productivity was much weaker for each asset after 2007–08.

H. Rental, hiring and real estate services

Key points

The analysis of productivity growth in the rental, hiring and real estate services sector is difficult to interpret. The capital equipment the industry leases to other industries is counted as part of the capital stock of this industry. That is, assets are attributed to industries on the basis of ownership rather than use in production. As a result, the industry has relatively large stocks of Information Technology (IT) hardware, as well as other leased assets such as vehicles and buildings.

Because of this asset allocation, productivity trends in the industry are dominated by the growth in leasing assets.

Overall trends include:

> Capital deepening has a large effect on labour productivity. Growth in the entire capital stock, including leasing assets, is referenced to growth in labour used within the industry.

> Multifactor productivity (MFP) growth is strongly negative, being dominated by growth in capital.

> To a large extent, the decline in MFP offsets the capital deepening effect on LP. LP growth in the industry has been weak on average.

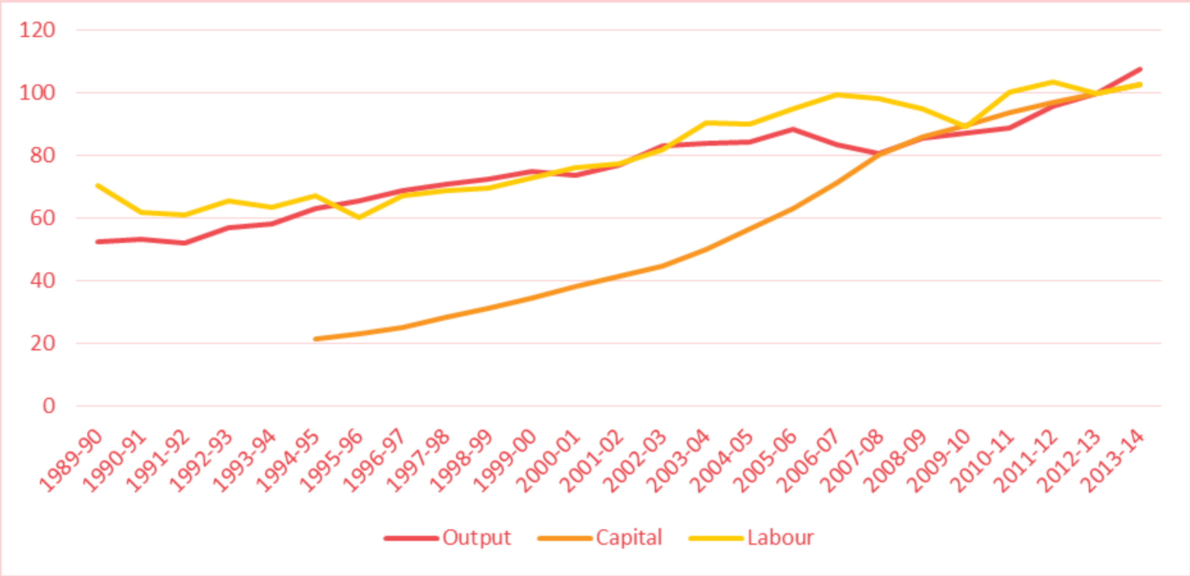
The slowdown in use of IT after 2007–08 is strongly reflected in the industry's ownership of IT assets.

The rental, hiring and real estate (RHRE) services sector showed moderate growth in output (Figure H1) between 1989–90 and 2013–14. Because growth was below average at 3.0 per cent a year, it declined from 3.4 per cent of GDP in 1989–90 to 2.8 per cent in 2013–14.[gg]

There was very strong growth in capital from 1994–95, which averaged 8.6 per cent a year. The sector falls on the side of capital intensity, with an average capital income share of 56 per cent.

Growth in labour averaged 1.6 per cent a year from 1989–90.

Figure H1: Capital, labour and output in RHRE services (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002

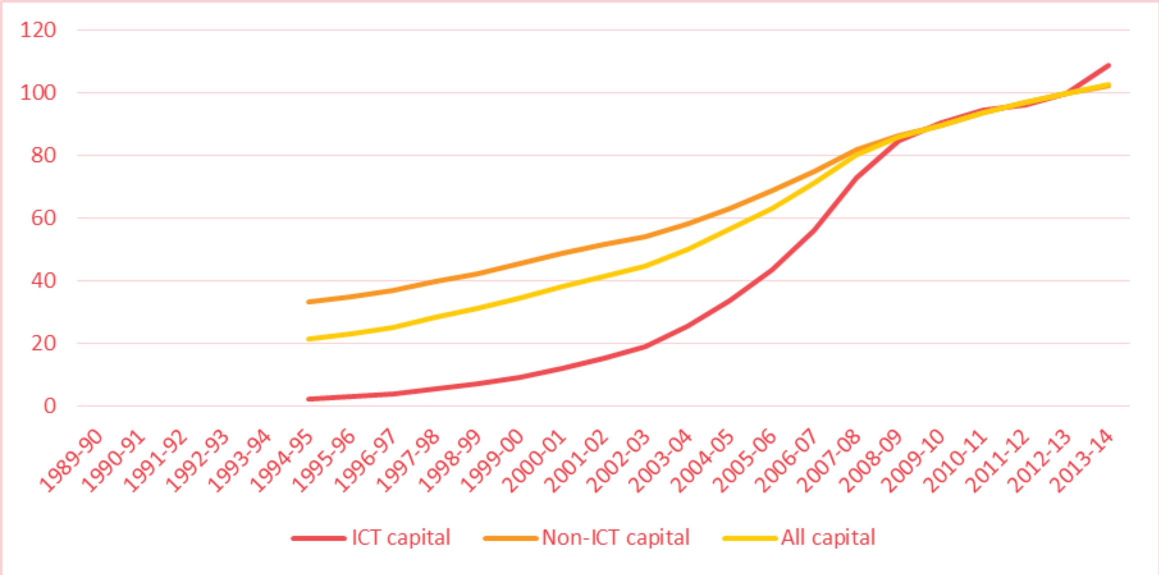
H.1 Growth in Information Technology capital

Growth in Information Technology (IT) capital was very rapid (Figure H2) and averaged 22.4 per cent a year from 1994–95.

Like other industries, it experienced a slowdown in growth in IT stocks after 2007–08. Growth of 30.3 per cent a year gave way to growth of 7.0 per cent a year—which is still healthy, but much lower. Growth in individual years is shown in Figure H3. IT capital accounted for an average 15 per cent of capital income.

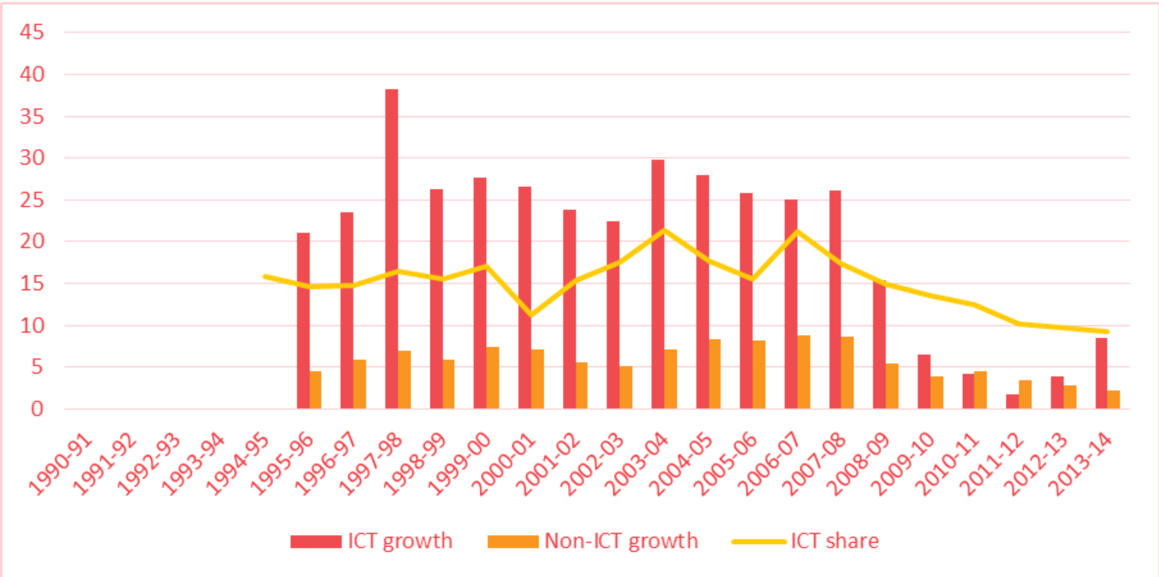
Growth in non-IT capital grew at 6.1 per cent a year from 1994–95 and IT capital at 16.5 per cent a year.

Figure H2: Capital, IT capital and non-IT capital in RHRE services (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002 and author estimates

Figure H3: Annual growth in IT and non-IT capital (% per year) and the IT share of capital income (%) in RHRE services

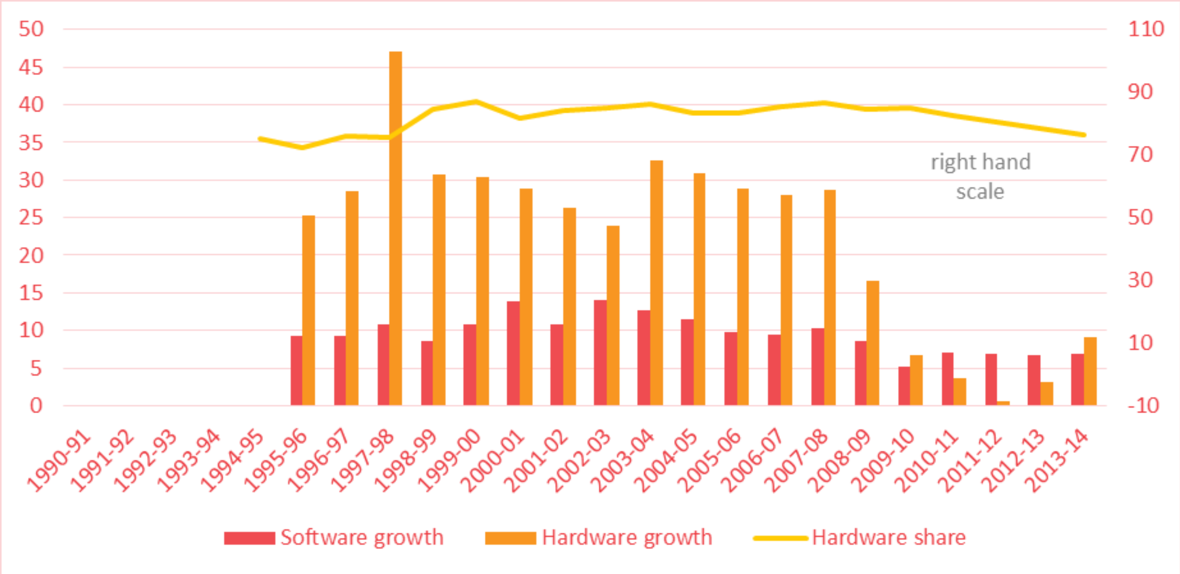


Source: Author estimates

Hardware featured in both the strong growth in the 1990s and the drop off in growth in late 2000s (Figure H4).

These data are consistent with large holdings of IT hardware for leasing purposes. IT accounted for 15–20 per cent of capital income up to 2007–08 (Figure H3) and hardware accounted for between 72 and 86 per cent of IT income (Figure H4).

Figure H4: Annual growth in software and hardware (% per year) and hardware share of IT capital income (%) in RHRE services



Source: Author estimates

H.2 Labour productivity growth

With similar growth in labour and output (Figure H1), growth in labour productivity (LP) was relatively weak. The average annual rate of growth in trend LP between 1989–90 and 2013–14 was 0.7 per cent.

Peaks in LP cycles took place in 1990–91, 1995–96, 2002–03, 2009–10 and 2013–14 according to the method set out in section 5.3 (Figure). The Bureau of Communications Research did not include the peak at 1989–90 as IT data for this sector did not go back that far.

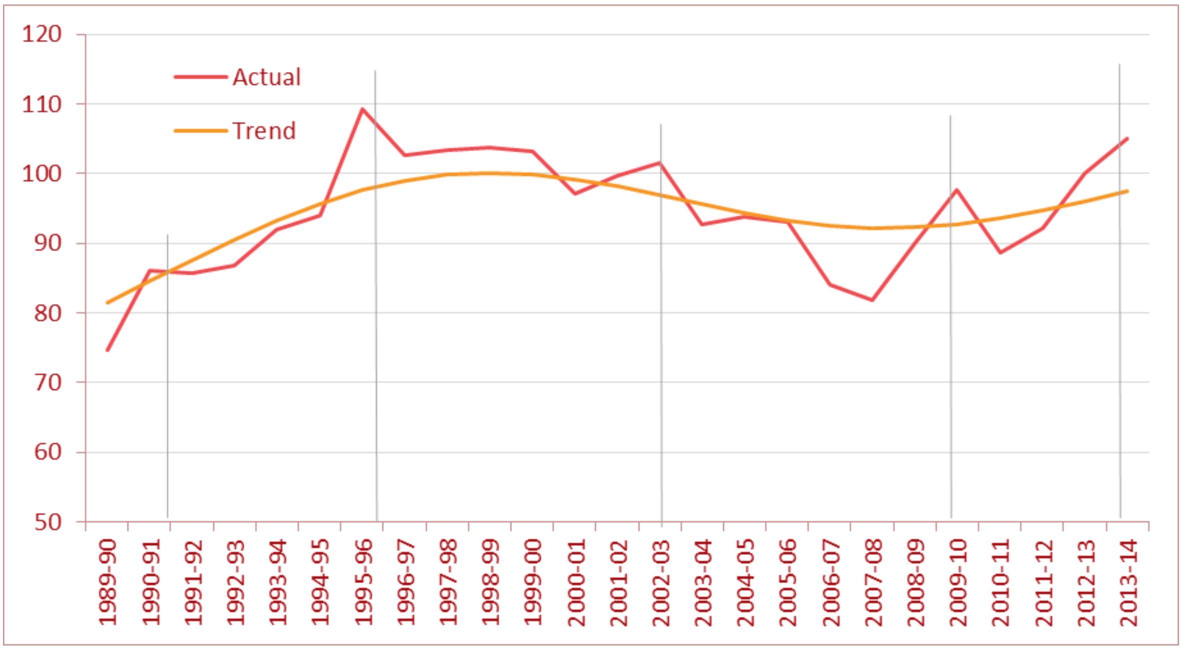
Average growth rates in actual LP over these cycles were:

> 1995–95 to 2002–03: -1.0 per cent a year

> 2002–03 to 2009–10: -0.5 per cent a year, and

> 2009–10 to 2013–14: 1.8 per cent a year.[hh]

Figure H5: Actual and trend labour productivity in RHRE services[a] (index, actual 2012–13 = 100)



Note: a. Trend series formed with a Hodrick-Prescott filter λ = 100

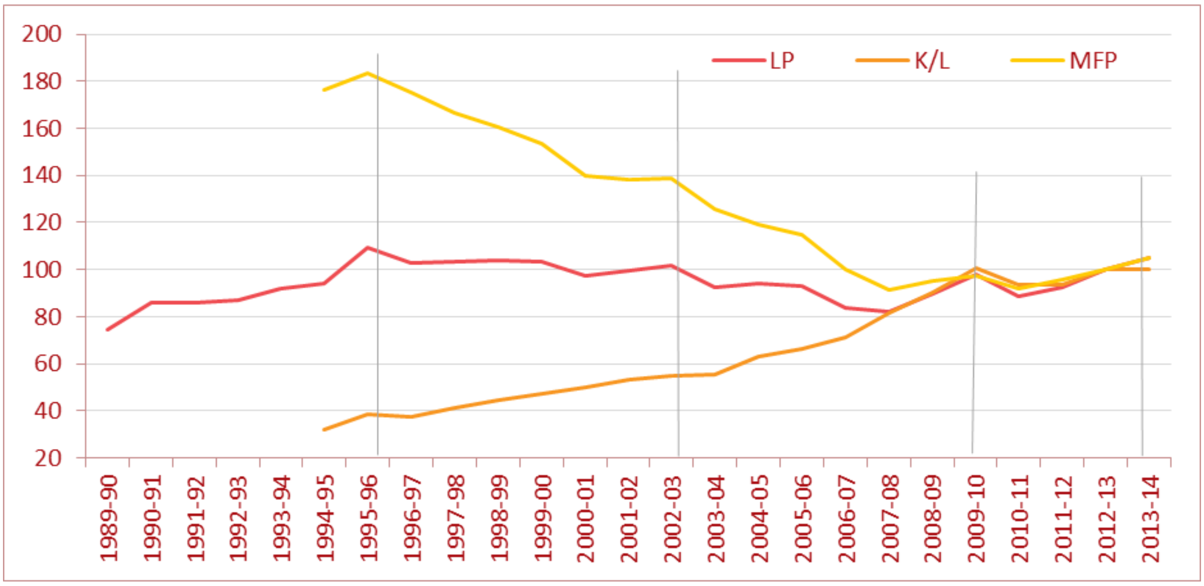
Source: ABS Cat. No. 5260.0.55.002 and author estimates

H.2.1 IT capital deepening and LP growth

The growth in labour productivity can be decomposed into contributions from capital deepening and multifactor productivity (MFP) growth (section 4). LP, the capital-labour ratio and MFP are illustrated in Figure H6.

All the LP growth came from capital deepening. MFP worked in the other direction, by falling 40 per cent. The capital-labour ratio grew over 200 per cent from 1994–95.

Figure H6: Labour productivity (LP), the capital-labour ratio (K/L) and multifactor productivity (MFP) in RHRE services (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002

Capital deepening was dominant in the first two cycles from the mid-1990s to the late-2000s (Table H1). IT made a very strong contribution of 2 percentage points. Hardware dominated the capital deepening, again in keeping with the growth in IT being a leased asset.

Strongly negative MFP growth more than offset the positive effect of capital deepening on LP growth.

There was a completely different picture in the last cycle. There was no capital deepening of any kind. MFP growth turned positive and so did LP growth.

Table H1: Labour productivity growth accounting in RHRE services (per cent per annum and percentage points)[a]

	1995–96 to 2002–03	2002–03 to 2009–10	2009–10 to 2013–14
Capital deepening (pp)	2.9	4.5	0.0
IT capital deepening (pp)	1.1	1.8	-0.7
Hardware (pp)	*1.6*	*1.8*	*-0.3*
Software (pp)	*-0.5*	*0.0*	*-0.4*
Non-IT capital deepening (pp)	1.8	2.7	0.7
MFP growth (pp)	-4.0	-5.0	1.8
Labour productivity growth (%pa)	-1.1	-0.5	1.8

Note: a. Figures in brackets refer to percentages of labour productivity growth. Numbers may not add up due to rounding.

Source: Author estimates

H.2.2 IT use and skills

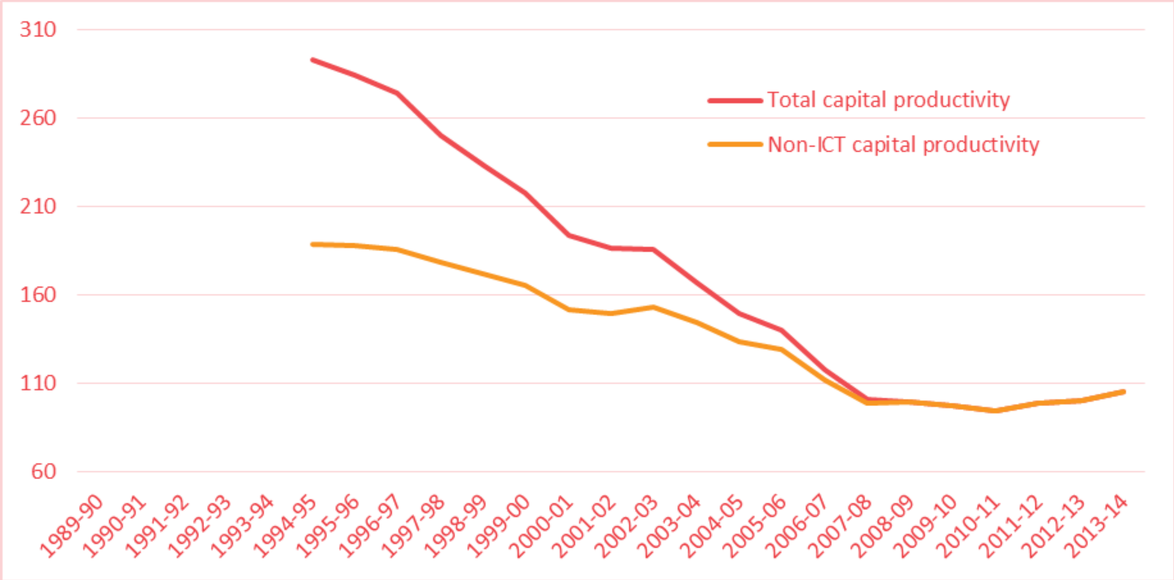
The average skill level in the industry increased by 12 per cent from 1989–90 to 2013–14 and 9 per cent from 1994-95. Even though the stock of IT capital increased by much more, there was a high degree of correlation between the two. The correlation coefficient between IT capital and the index of skill composition from 1994-95 to 2013-14 is 0.97.

H.3 IT, asset use and capital productivity

The productivity of total capital and of non-IT capital is shown Figure H7.

Non-IT capital productivity fell by around 45 per cent from 1994–95 so there was no positive association between IT use and non-IT capital productivity.

Figure H7: Capital productivity of all assets and non-IT assets in RHRE services (index, 2012–13 = 100)

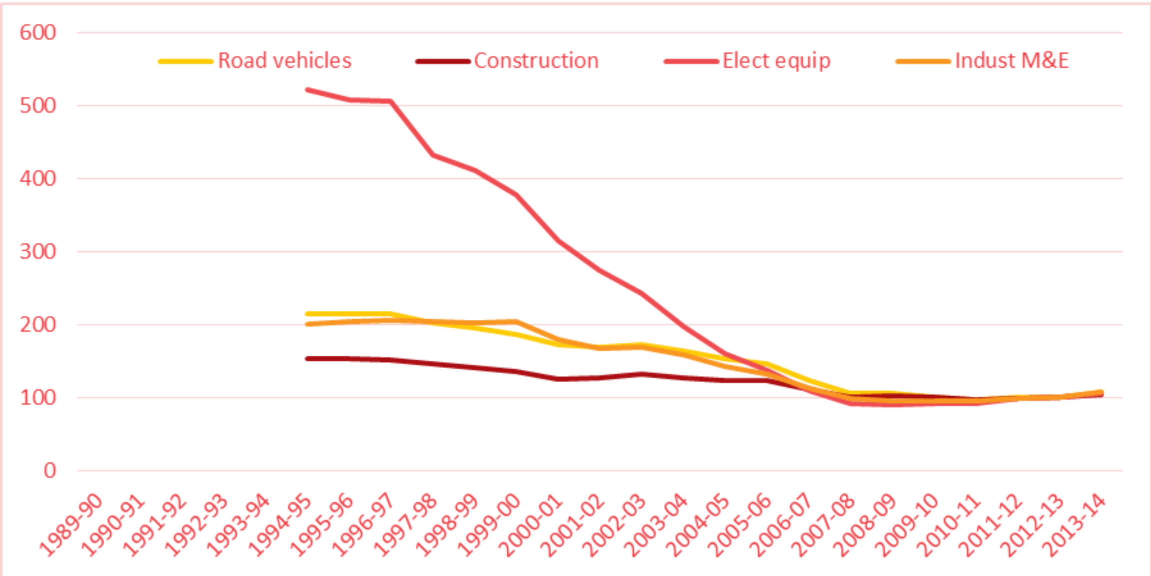


Source: Author estimates

The productivity of individual assets was also investigated. The major non-IT capital inputs in RHRE services are: construction assets (38 per cent of capital income)[ii], road vehicles (23 per cent), industrial machinery and equipment (7 per cent), and electrical and electronic equipment (7 per cent).

The productivity of the major assets declined (Figure H8).

Figure H8: Asset productivity—the ratio of value added to use of selected assets in RHRE services



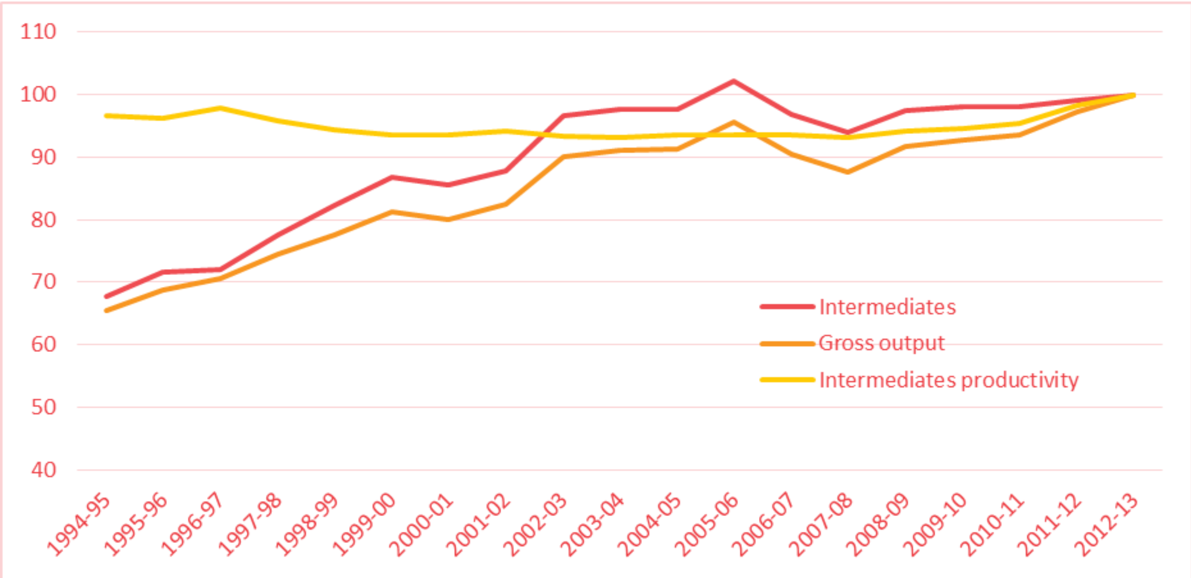
Source: Author estimates

H.4 Use of intermediates

Whether IT could help improve the efficiency with which intermediate inputs (materials, energy and services used in production) are used was another possibility that was examined. In the case of intermediate input use, productivity is determined in reference to the gross output, rather than the value added, measure of output.

The efficiency of intermediates use did not change much over the entire period (Figure H9).

Figure H9: Gross output, intermediate input use and intermediate input productivity in FIS

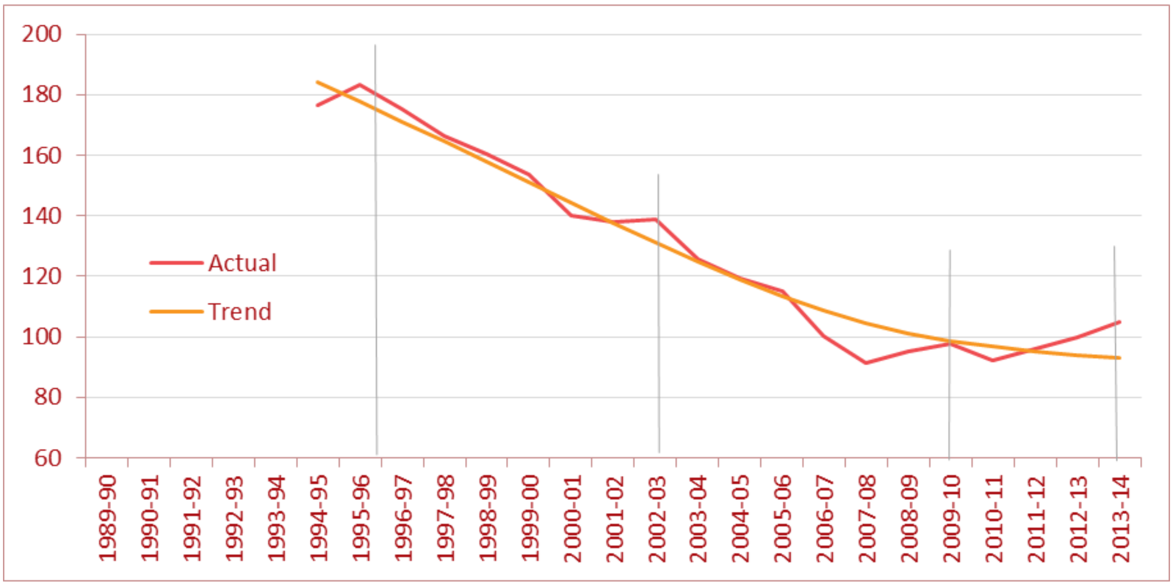


Source: Author estimates

H.5 MFP growth

The association between IT and MFP was examined in the context of MFP cycles (Figure H10).

Figure H10: Actual and trend MFP in RHRE services[a] (index, actual 2012–13 = 100)



Note: a. Trend series formed with a Hodrick-Prescott filter λ = 100

Source: ABS Cat. No. 5260.0.55.002 and author estimates

Peaks in MFP, according to the method set out in section 5.3, took place in 1995–96, 2002–03, 2005–06 and 2013–14. However, 2009–10 rather than 2005–06, was chosen. This allowed for the possibility there was a turning point in the late 2000s. It also brought the MFP cycles into line with the LP cycles. Capital deepening and its role in LP growth, and not the declining MFP, is the prominent feature of this industry.

MFP growth was treated as a weighted average of LP growth and capital productivity growth, with the respective income shares as the weights. The MFP growth accounting is presented in H2.

The IT contribution through IT capital deepening and LP growth is as expected from the LP growth accounting. Because of the declines in asset productivities, it does not appear IT had a positive effect on non-IT capital productivity. The only individual asset with positive productivity growth was land in the first cycle for the period reviewed.

Table H2: Multifactor productivity growth accounting over MFP cycles in RHRE services

	1995–96 to 2002–03	2002–03 to 2009–10	2009–10 to 2013–14
LP growth contribution (pp)	-0.4	-0.2	0.7
of which			
> IT capital deepening (pp)	0.5	0.9	-0.3

KP growth contribution (pp)	-3.6	-4.8	1.1
of which			
> IT capital productivity (pp)	-1.42	-1.93	1.25
> Non-IT capital productivity (pp)	-2.14	-2.85	-0.11
MFP growth (% pa)	-4.0	-5.0	1.8

Source: Author estimates. Numbers may not add up due to rounding.

I. Professional, scientific and technical services

Key points

Professional, scientific and technical services (PST) have expanded rapidly, with relatively strong growth in output, labour and capital. The sector is labour intensive.

Information Technology (IT) has accounted for a quarter to a third of capital costs.

Growth in IT has been a strong 16.5 per cent a year since 1994-95. Interesting points to note include:

- the drop off in growth from 2007–08; especially in hardware, and
- the sector is software intensive.

IT capital deepening has accounted for 0.3–0.4 of a percentage point of labour productivity growth, which compares with a long term rate of LP growth of 1.0 per cent a year.

The average skill level of the industry increased 12 per cent, with a correlation coefficient of 0.98 with IT use.

There was no positive association between IT and non-IT productivity as non-IT capital productivity *fell* over the period.

This was true of individual assets, although there was some improvement in the productivity of buildings and research and development at times between 1994-95 and 2013-14.

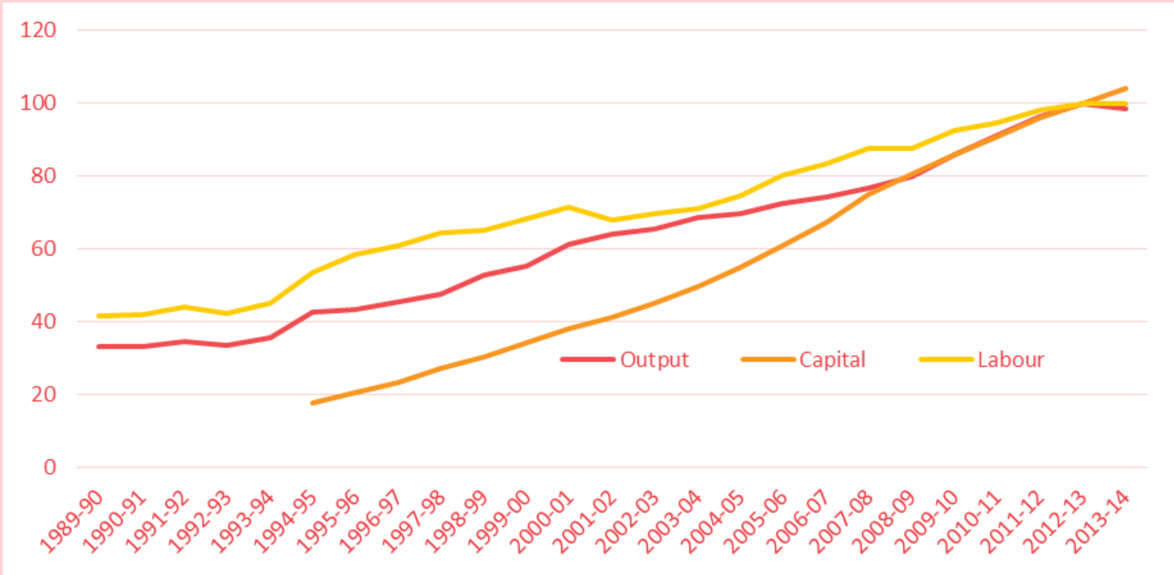
According to the Australian Bureau of Statistics (ABS), professional scientific and technical (PST) services apply common processes where labour inputs are integral to the production or service delivery.

They involve specialisation and sale of expertise: in most cases, equipment and materials are not major inputs. The activities carried out generally require a high level of expertise and training and formal (usually tertiary level) qualifications.

These services include scientific research, architecture, engineering, computer systems design, law, accountancy, advertising, market research, management and other consultancy, veterinary science and professional photography.

PST services expanded rapidly from the mid-1990s (Figure I1). With annual growth in output averaging 4.7 per cent, they increased from 4.3 per cent of GDP in 1989–90 to 6.8 per cent in 2013–14.[jj] Growth in labour averaged 3.7 per cent a year. There was very strong growth in capital which, from 1994–95, averaged 9.8 per cent a year. The sector is, however, quite labour-intensive.

Figure I1: Capital, labour and output in PST services (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002

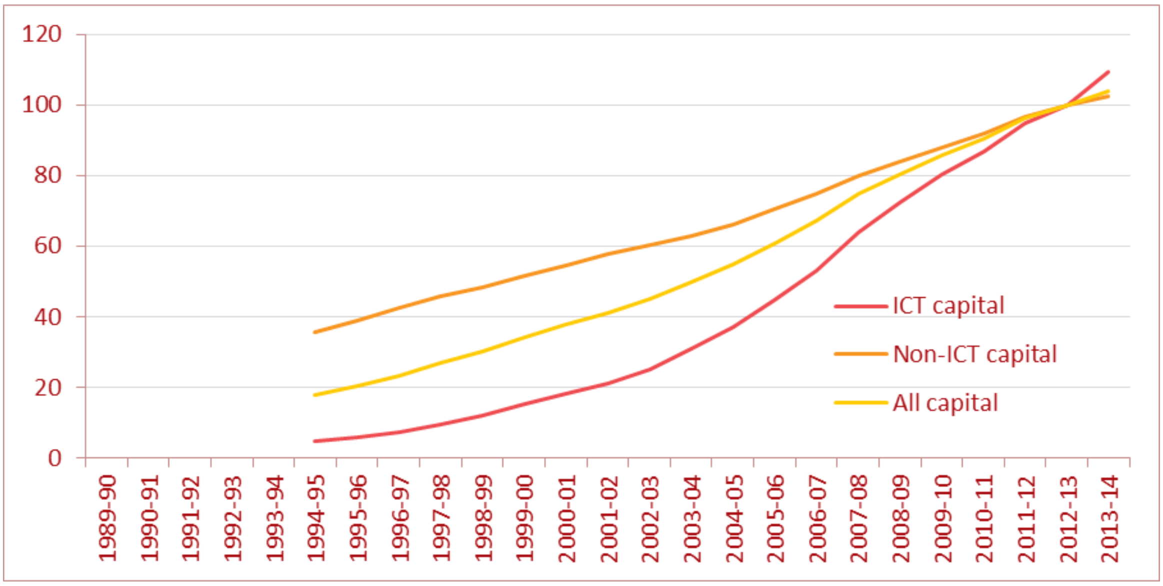
I.1 Growth in Information Technology Capital

From 1994-95, the growth in Information Technology (IT) capital was especially strong at 16.5 per cent a year. The growth in non-IT capital was much weaker at 5.6 per cent a year. (Figure I2)

The rates of growth in IT were strongest in the 1990s (Figure I3), but as with other industries, this rate of growth fell away after 2007–08. IT has been an important part of the total capital stock in the sector and accounted for about a third of capital income up to 2007–08, after which it drifted down to a quarter (Figure I3).

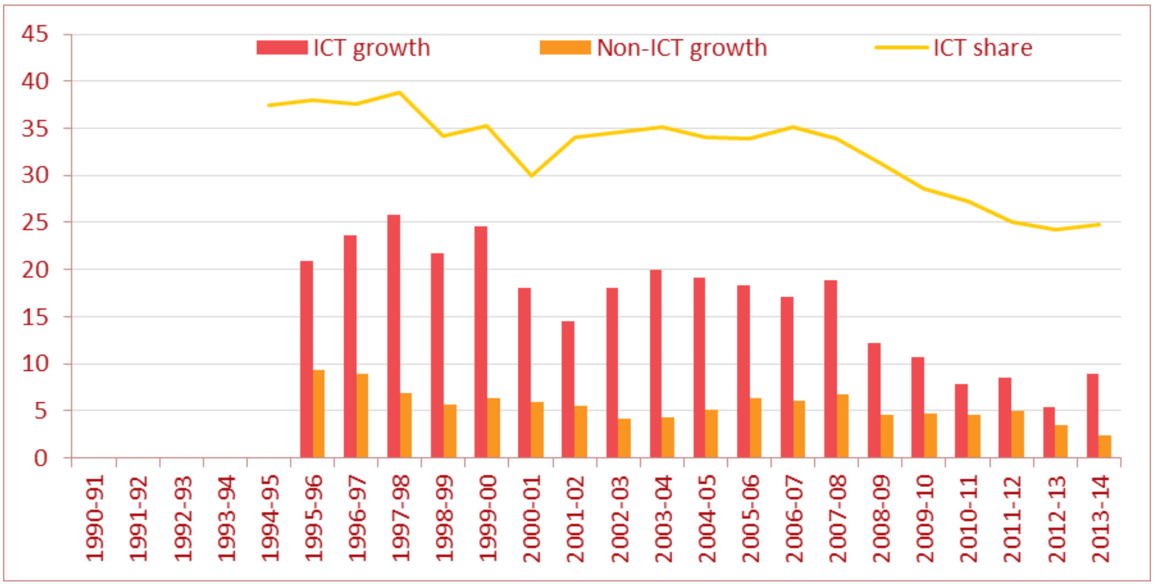
Hardware featured in both the strong growth in the 1990s and in the drop off in the late 2000s (Figure I4). Despite the strong growth in hardware, the sector has remained software intensive, (indicated by a hardware share of less than 50 per cent in Figure I4).

Figure I2: Capital, IT capital and non-IT capital in PST services (index, 2012–13 = 100)



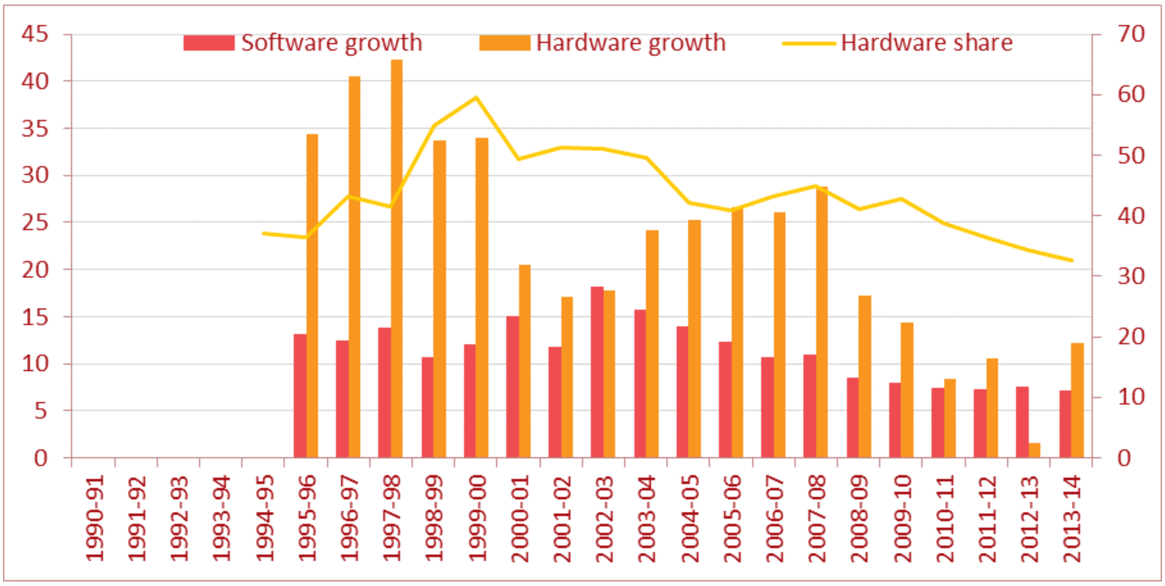
Source: ABS Cat. No. 5260.0.55.002 and author estimates

Figure I3: Annual growth in IT and non-IT capital (% per year) and the IT share of capital income (%) in PST services



Source: Author estimates

Figure I4: Annual growth in software and hardware (% per year) and hardware share of IT capital income (%) in PST services



Source: Author estimates

I.2 Labour productivity growth

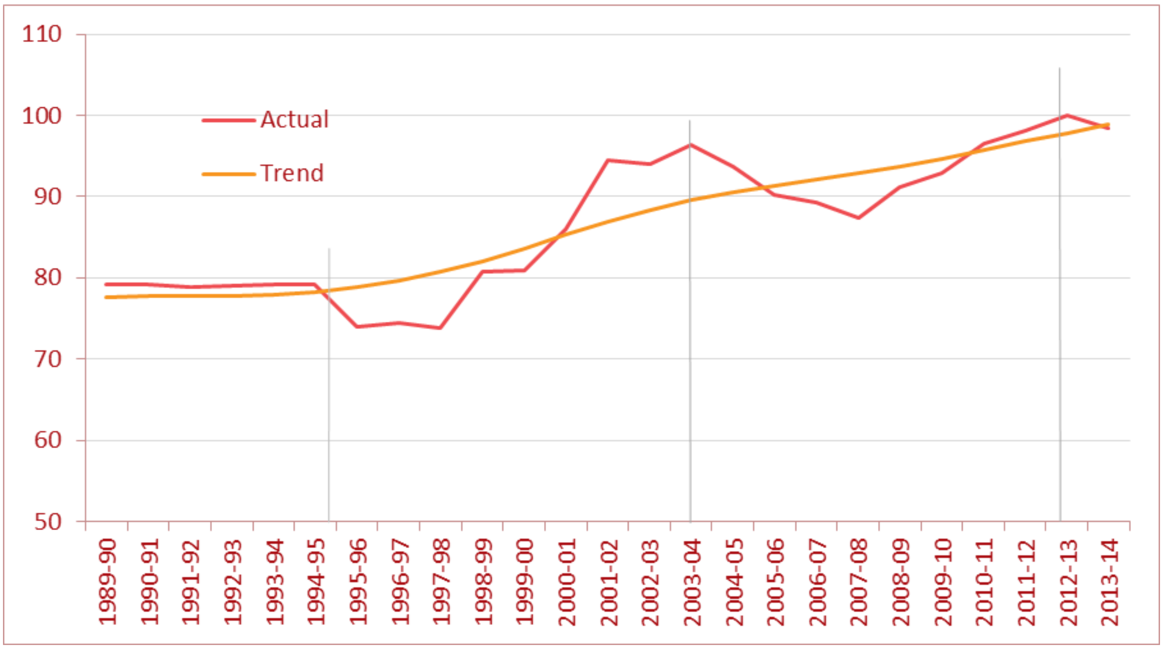
With strong growth in labour, as well as in output, growth in labour productivity (LP) was relatively weak during the period under review. The level of labour productivity increased 24 per cent between 1989–90 and 2013–14, while the average annual rate of growth in trend LP was 1.0 per cent.

Peaks in LP cycles took place in 1989–90, 2001–02 and 2012–13 according to the method set out in section 5.3 (Figure). The Bureau of Communications Research (BCR) overlooked the peak at 1989–90 and made the first peak at 1994–95, as this was where the capital series started. It suppressed the peak at 2001–02 and used 2003–04 instead. This meant the LP growth was closer to trend and therefore more representative.

Average growth rates in actual LP over the cycles were:

- 1994–95 to 2003–04: 2.2 per cent a year, and
- 2003–04 to 2012–13: 0.4 per cent a year. [kk]

Figure I5: Actual and trend labour productivity in PST services[a] (index, actual 2012–13 = 100)



Note: a. Trend series formed with a Hodrick-Prescott filter λ = 100

Source: ABS Cat. No. 5260.0.55.002 and author estimates

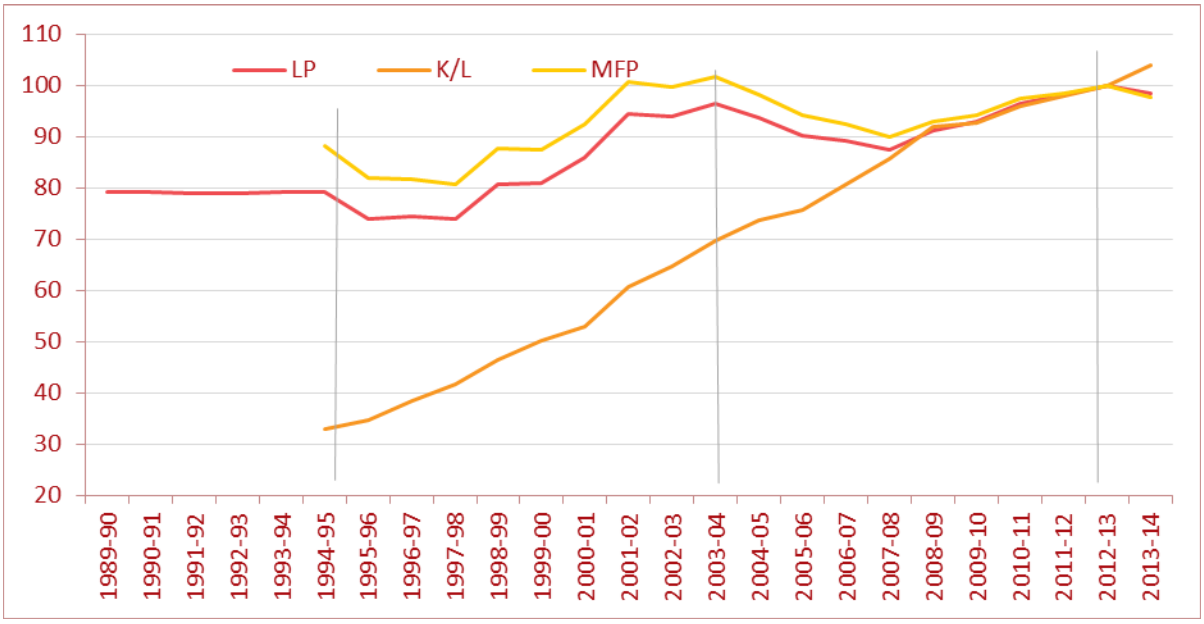
I.2.1 IT capital deepening and LP growth

The growth in labour productivity can be decomposed into contributions from capital deepening and multifactor productivity (MFP) growth (section 4). Capital deepening is growth in the capital-labour ratio, multiplied by the share of total industry income attributed to capital.

The growth in LP, the capital-labour ratio and MFP are illustrated in Figure I6. MFP increased 11 per cent and the capital-labour ratio grew over 200 per cent from 1994–95.[ll]

Note the peaks in LP cycles followed the pattern of peaks in MFP growth.

Figure I6: Labour productivity (LP), the capital-labour ratio (K/L) and multifactor productivity (MFP) in PST services (index, 2012–13 = 100)



Source: ABS Cat. No. 5260.0.55.002

In Table I1 (below), the strong growth in LP in the first period can be attributed to strong MFP growth. In the other periods, MFP growth was negative.

The contribution of capital deepening and the split between IT and non-IT capital deepening were very steady across the three periods. IT capital deepening was relatively small, contributing 0.3 to 0.4 of a percentage point to annual LP growth. Hardware contributed 0.2 to 0.3 of a percentage point of the IT contribution, with software accounting for the other 0.1 of a percentage point.

Table I1: Labour productivity growth accounting in PST services (per cent per annum and percentage points)[a]

	1994–95 to 2003–04	2003–04 to 2012–13
Capital deepening (pp)	0.6 (27)	0.6
IT capital deepening (pp)	0.4 (19)	0.4 (76)
Hardware (pp)	*0.3*	*0.3*
Software (pp)	*0.1*	*0.2*
Non-IT capital deepening (pp)	0.1 (8)	0.2 (65)
MFP growth (pp)	1.6 (73)	-0.2
Labour productivity growth (%pa)	2.2 (100)	0.4 (100)

Note: a. Figures in brackets refer to percentages of labour productivity growth.
Numbers may not add up due to rounding.

Source: Author estimates

I.2.2 IT use and skills

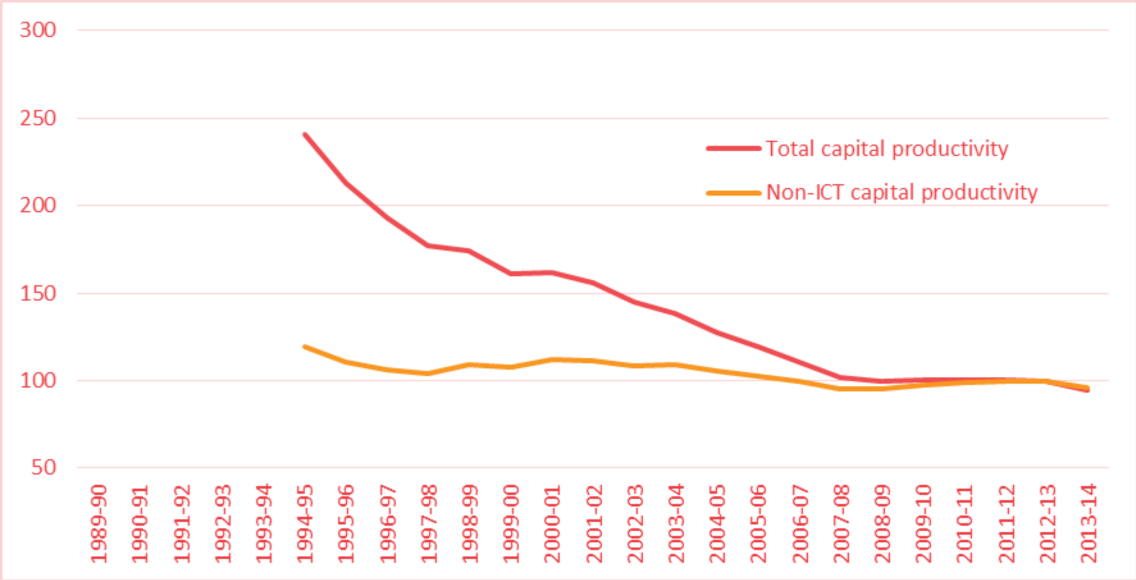
The average skill level in the industry is likely to be high relative to other industries. It increased by 12 per cent over the entire period reviewed. Even though the stock of IT capital increased by much more, there was a high degree of correlation between the two. The correlation coefficient between IT capital and the index of skill composition is 0.98.

I.3 IT, asset use and capital productivity

The productivity of total capital and of non-IT capital during the review period is shown in Figure I7.

There was comparatively little change in non-IT capital productivity, although it did fall by around 20 per cent from 1994–95. Given the strong growth in IT, there was no positive association between IT use and non-IT capital productivity.

Figure I7: Capital productivity of all assets and non-IT assets in PST services (index, 2012–13 = 100)



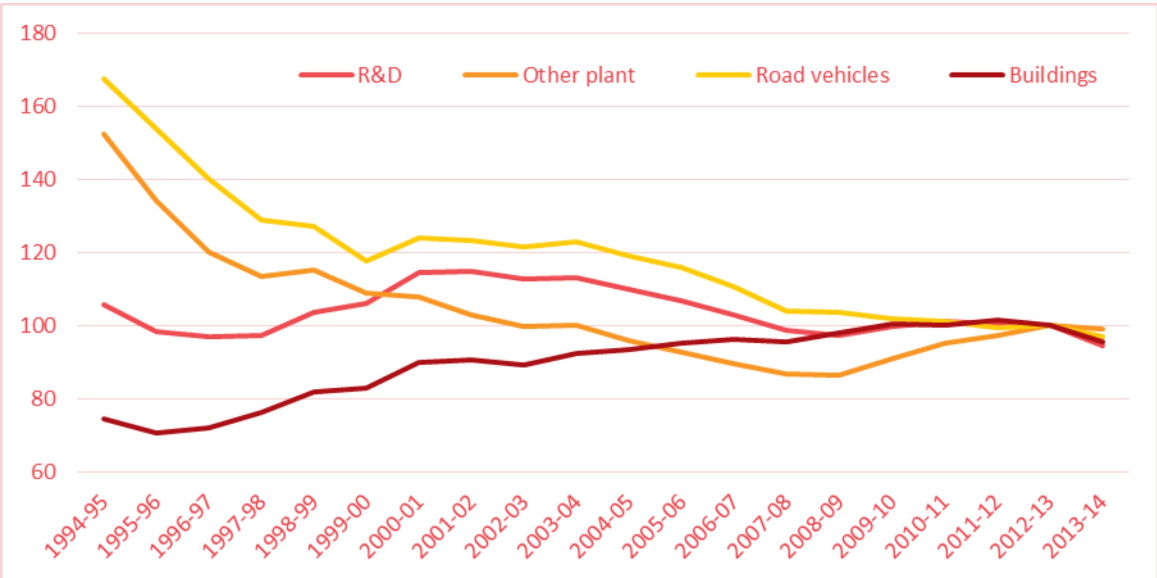
Source: Author estimates

The productivity of individual assets was also investigated. The major non-IT capital inputs in PST services are: research and development (R&D) (23 per cent of capital income)[mm], other plant and equipment (11 per cent), road vehicles (11 per cent) and buildings (11 per cent).

Buildings was the only one of these asset classes to show improvement in productivity over the entire period (Figure I8). The correlation coefficient with IT use is 0.84.

The lack of improvement in R&D productivity over the entire period is surprising. There was, however, some improvement over the second half of the 1990s.

Figure I8: Asset productivity–the ratio of value added to use of selected assets in PST services



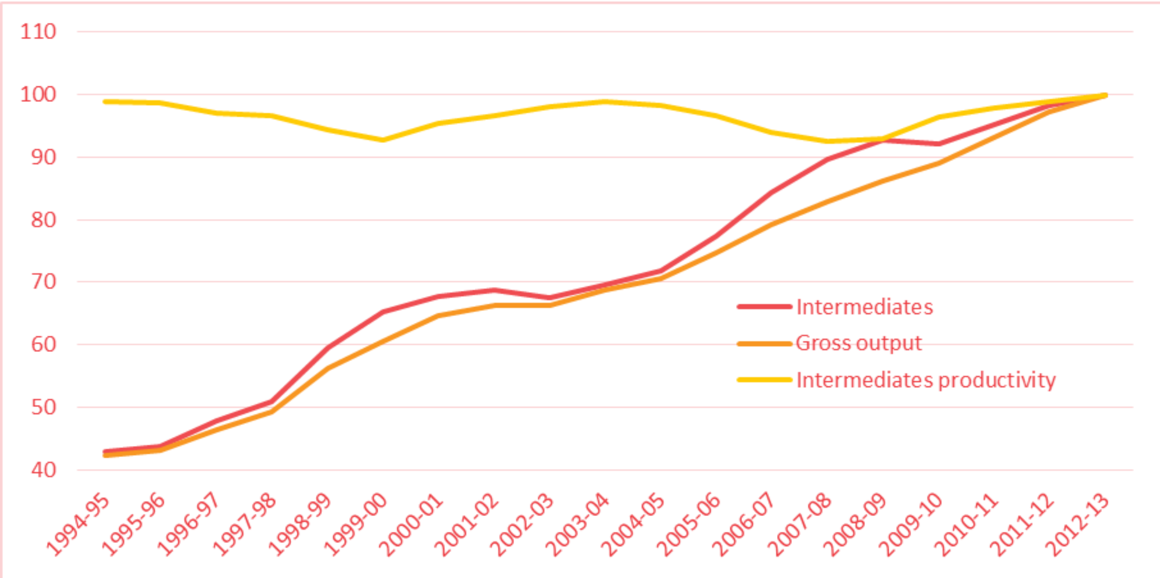
Source: Author estimates

I.4 Use of intermediates

Whether IT could help improve the efficiency with which intermediate inputs (materials, energy and services used in production) are used was another possibility examined for the review period. In the case of intermediate input use, productivity is determined in reference to the gross output rather than the value added, measure of output.

The efficiency of intermediates use did not change much over the entire period (Figure I9).

Figure I9: Gross output, intermediate input use and intermediate input productivity in FIS

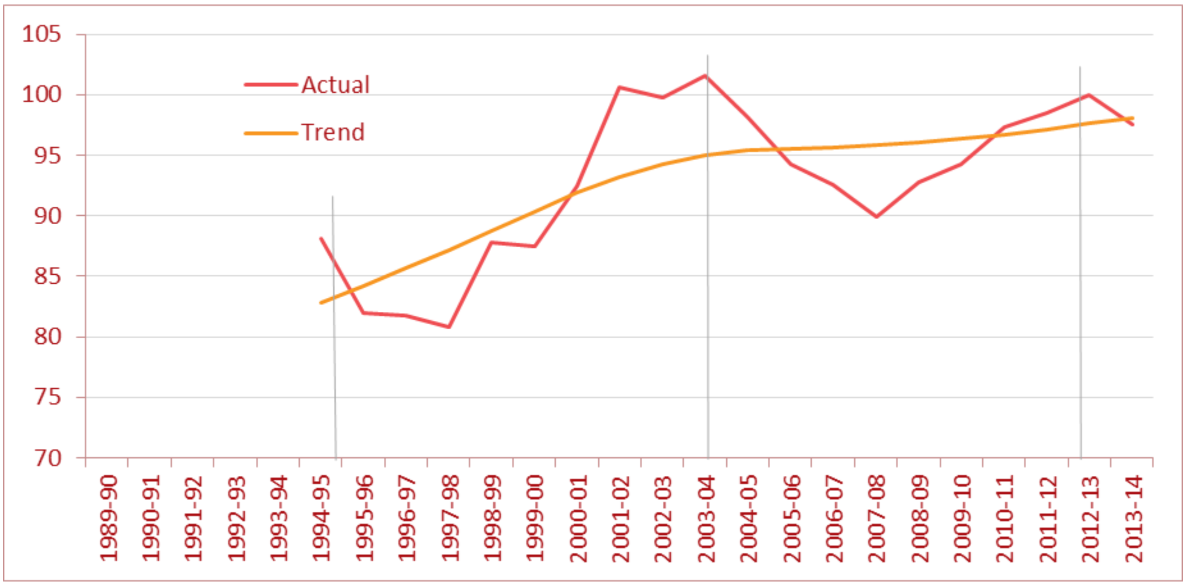


Source: Author estimates

I.5 MFP growth

The association between IT and MFP was examined in the context of MFP cycles (Figure I10). The timing of MFP cycles has been taken to coincide with LP cycles.

Figure I10: Actual and trend MFP in PST services[a] (index, actual 2012–13 = 100)



Note: a. Trend series formed with a Hodrick-Prescott filter λ = 100

Source: ABS Cat. No. 5260.0.55.002 and author estimates

For current purposes, MFP growth was treated as a weighted average of LP growth and capital productivity growth, with the respective income shares as the weights. This allowed the influences of IT growth on MFP to be seen as a combination of substitution effects on labour and on capital.

The MFP growth accounting is presented in Table I2 below. The labour productivity growth contribution plus the capital productivity contribution equals the MFP growth presented in the bottom row of the table.

The IT contribution through IT capital deepening and LP growth was steady at 0.4 of a percentage point, which would indicate IT has not had much influence on non-IT capital productivity.

Table I2: Multifactor productivity growth accounting over MFP cycles in PTS

	1994–95 to 2003–04	2003–04 to 2012–13
LP growth contribution (pp)	2.0	0.3
of which		
> IT capital deepening (pp)	0.4	0.3
KP growth contribution (pp)	-0.4	-0.4
of which		
> IT capital productivity (pp)	-0.34	-0.24
> Non-IT capital productivity (pp)	-0.10	-0.19
MFP growth (% pa)	1.6	-0.2

Source: Author estimates. Numbers may not add up due to rounding.

J. Asides

[a] Because of data constraints, which will be explained below, the PC analysis examined the productivity effects of information technology, rather than ICT. PC 2004.

[b] See, for example, Bresnahan and Trajtenberg (1992) and Jovanovich and Rousseau (2005).

[c] The ABS uses Tornqvist indexes to aggregate the stocks of different assets.

[d] This prospect of capital productivity effects calls for a more sophisticated way of expressing the production relationship, such as capital-augmenting technological change or interaction effects between IT and other assets.

[e] A change in the composition of skills is necessary. If hours worked in each skill category increases proportionately—there is no change in skill composition—the growth in QALI (the weighted average growth in hours worked) will equal the growth in total hours worked.

[f] The ABS does publish ICT data in the form of separate net capital stocks of computers, software and electrical and electronic equipment in the national accounts (Cat. No. 5204.0, Table 70).

[g] There is a possible source of inconsistency between the growth in our aggregation of capital across industries and growth in the aggregate capital stock published by the ABS. This is because the ABS imposes a floor rate of return in its calculation of rental prices for its productive capital stock calculations and these can deviate from the rental prices published in the productivity data cube.

[h] The ABS uses another form of smoothing, the 11-period Henderson moving average.

[i] While it could be argued that setting λ=100 is imprecise, there was not the time to investigate other settings. In any case, as the details provided in the Appendices explain, some judgment was exercised in setting peaks, rather than relying solely on decision rules.

[j] The ABS imputes an intermediate input charge for leased assets to the using industry. This practice reduces value added generated, and decreased capital service flows compared with a situation in which leased assets are attributed to industry of use.

[k] Calculated at basic prices (before net taxes and subsidies) and sourced from ABS Cat No. 5204.0, Table 5.

[l] Calculated as compound annual average rates of growth between cycle peaks.

[m] Averaged over 1989–90 to 2013–14.

[n] The values shown are the contributions of IT capital deepening to labour productivity growth, multiplied by the labour income share.

[o] Calculated at basic prices and sourced from ABS Cat. No. 5204.0, Table 5 (data download).

[p] Calculated as compound annual average rates of growth between cycle peaks.

[q] The growth in the capital-labour ratio needs to be weighted by the capital share of total income, which averaged 0.64, to indicate its contribution to LP growth.

[r] Averaged over 1989–90 to 2013–14.

[s] Calculated as compound annual average rates of growth between cycle peaks.

[t] Correlation coefficients between IT use and the productivities of these other major asset types were negative or weakly positive.

[u] This is the IT capital deepening contribution to labour productivity growth multiplied by the labour income share.

[v] Calculated as compound annual average rates of growth between cycle peaks.

[w] Averaged over 1989–90 to 2013–14.

[x] The values shown are the contributions of IT capital deepening to labour productivity growth, multiplied by the labour income share.

[y] Calculated at basic prices and sourced from ABS Cat. No. 5204.0, Table 5 (data download).

[z] Calculated as compound annual average rates of growth between cycle peaks.

[aa] Averaged over 1989–90 to 2013–14.

[bb] Calculated as compound annual average rates of growth between cycle peaks.

[cc] This needs to be weighted by the capital income share, which averaged around 0.61

[dd] Calculated as compound annual average rates of growth between cycle peaks.

[ee] Averaged over 1989–90 to 2013–14.

[ff] The values shown are the contributions of IT capital deepening to labour productivity growth, multiplied by the labour income share.

[gg] Calculated at basic prices and sourced from ABS Cat. No. 5204.0, Table 5 (data download).

[hh] Calculated as compound annual average rates of growth between cycle peaks.

[ii] Averaged over 1989–90 to 2013–14.

[jj] Calculated at basic prices and sourced from ABS Cat. No. 5204.0, Table 5 (data download).

[kk] Calculated as compound annual average rates of growth between cycle peaks.

[ll] The later needs to be weighted by the capital share of total income, which averaged 0.12, to indicate its contribution

[mm] Averaged over 1989-90 to 2013-14.