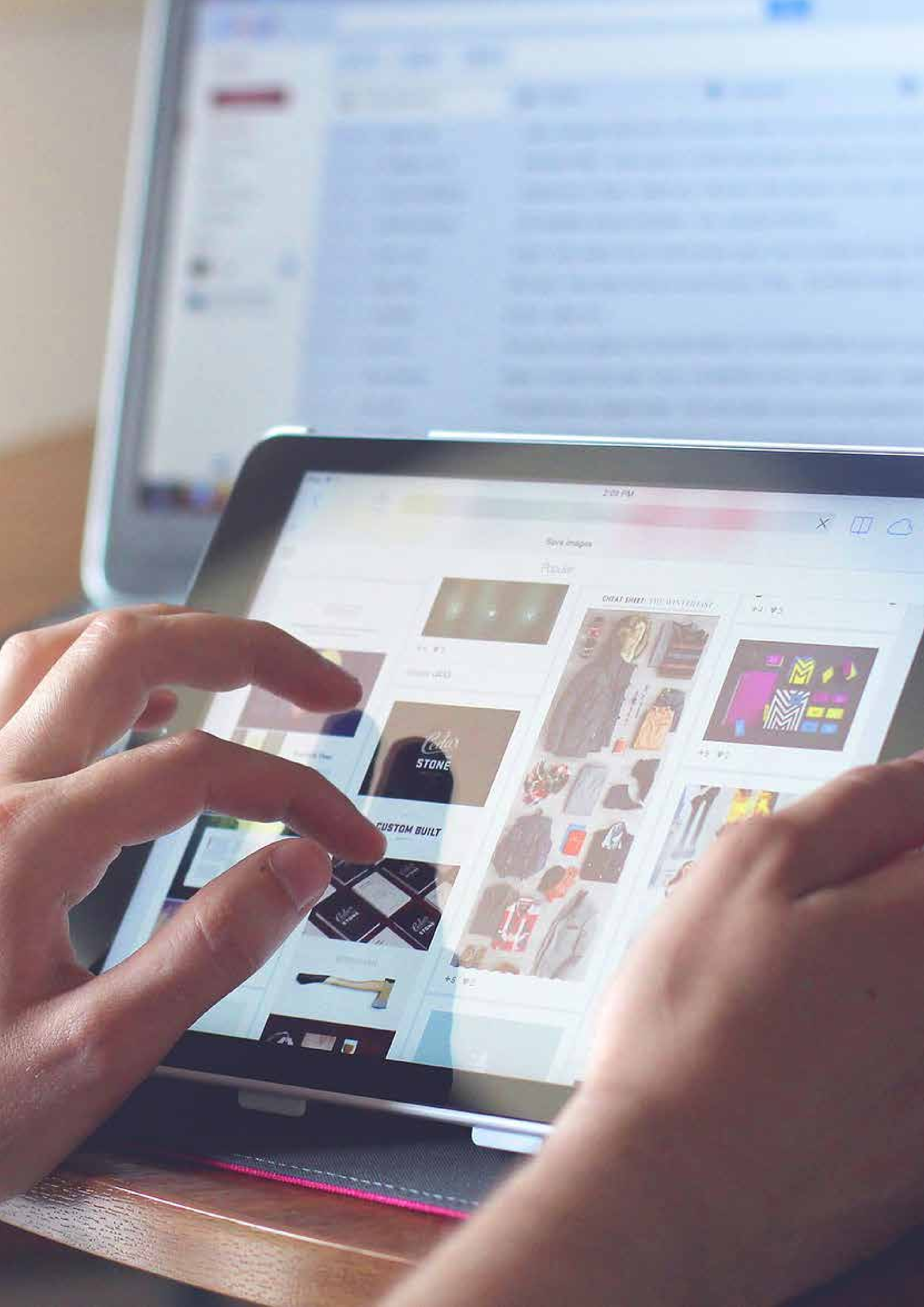
QUT pwc CHAIR IN DIGITAL ECONOMY

Technology investment is not enough:

Growing Australia's Productive Digital Economy

December 2015


STONE
CUSTOM BUILT

Contents

Technology investment is not enough: Growing Australia's Productive Digital Economy

Md Shahiduzzaman, M Kowalkiewicz, R Barret and A Briggs

PwC Chair in Digital Economy based at Queensland University of Technology, Brisbane Australia.

Released 17 December 2015

Keywords: Innovation, Information Technology investment, Gross Domestic Product, Multifactor Productivity, Digital Economy

Executive Summary

Innovation is enabled by information technology (IT). IT investment has the potential to enable new business processes and activities, driving the innovation needed to generate business productivity and national economic performance. The Australian government's National Innovation and Science Agenda released in December 2015 has investment in IT and IT capital deepening at its core – it makes clear the 'ideas boom' will be facilitated by digital technologies being employed in collaborative networks.

In this report we seek to critically examine what, if any, direct relationship exists between IT investment and Australia's economic performance. We analyse empirical data from the 1960s to 2105 to examine this relationship and argue that Australia needs more from business than simply investment in IT to realise productivity improvements. In this report we assert that Australia's strong economic performance in the preceding decades was due, in part, to a period of IT capital deepening, although the Reserve Bank of Australia shows that the mining boom represented one the greatest shocks to Australia's economic performance in recent times. What our analysis shows is that as the Australian economy matures, business investment in IT has slowed, although IT investment intensity remains relatively buoyant. Our interpretation of this is that economic growth creates conditions to improve IT investment growth: we see productivity has slowed down across all economic sectors, despite there being reasonable amounts of IT capital across sectors.

Our analysis leads us to support the general thrust of the government's Innovation Statement – that is, IT investment is not enough to make a positive change to Australia's economic performance. Knowing how to efficiently and effectively use IT capital requires the development of organisational, managerial and individual capabilities. The role of the PwC Chair in Digital Economy at QUT is to enable the development of those capabilities.


5:42
12
5:00–6:00PM
Apple
17°

Chapter 1. Introduction

The Australian economy is being fundamentally reshaped by the development and growth of digital information and communications technologies. The uptake of these new technologies was phenomenal such that Australia was once referred to as a 'miraculous economy' (Krugman, 1998).

The digital economy has been defined as "the global network of economic and social activities that are enabled by platforms such as the internet, mobile and sensor networks, including e-commerce, efforts to achieve efficiency and productivity in production processes, inventory and knowledge management" (ABS, 2015b). Further it has been asserted that the digital economy includes indirect consequences of internet, mobile and sensor network development and implementation and the subsequent new value creation and business models, policy and framework changes and consequential impacts on supply and demand. Although adequately defining the digital economy proves challenging, OECD economies have witnessed a surge of digitally enabled changes in the last decades.

In this report, we make use of aggregate and sectoral data available from the 1960s to 2015, to shed light on the uptake of information and communications technologies in Australia and the impact this has had on the performance of Australia's economy and emergence of the digital economy. By using growth accounting and econometric modelling as well as descriptive statistics we use the data to develop aggregate and sectoral analysis and provide rich insights into the changes in Australia's economy and the challenges for the future.

Definition: Digital Economy

There are various definitions of what constitutes the digital economy. In the PwC Chair of Digital Economy Working Paper 1/2015, Barrett and Bennett (2015) provide a comprehensive overview of the various aspects, phases and components of digital economy. See Picture 1.

The Australian Bureau of Statistics (ABS, 2015c) defines the digital economy as "The global network of economic and social activities that are enabled by platforms such as the internet, mobile and sensor networks, including e-commerce, efforts to achieve efficiency and productivity in production processes, inventory and knowledge management" (definition). This definition is constructed with the purpose of 'sizing' Australia's digital economy, a task we do not wish to attempt.

Description of the Expansion Cycles in the Digital Economy Model

	Cycle 1: Business Economy			Cycle 2: Economy of People	Cycle 3: Economy of Things
	Component 1	Component 2	Component 3	Component 4	Component 5 and beyond
	Digitisation of Information	Digital Marketplace	Digital Innovation and Growth in the Business Economy (Industrial Age business models)	Digital Thinking (Digital disruption by New Firms and Existing Firms)	Economy of Things (i.e. Internet of Things - "things that think")
Description	Delivery of text, images and audio in digital format via internet. This includes the web, social media, VoIP, collection of big data,etc.	Buying and selling goods and services online.	Creating and/or using digital technologies and solutions to improve existing products and services in existing firms and industries (digital enablement).	Re-imaging products and services that disrupt Industrial Age business models and penetrate larger markets. Includes sharing economy and related phenomena.	We move to an economy where things that think are part of our daily lives. Advancement in cloud computing and other new digital technologies and applications will also expand the reach of the digital economy.

Picture 1: Description of the Expansion Cycles in the Digital Economy Model

Background

Productivity improvements facilitated by the development and application of new technologies, underpinned Australia's robust economic performance during the 1990s. Indeed Australia was noted for riding the early (1990s) waves of the information technology (IT) revolution (Parham, Roberts and Sun 2001; Parham 2005a; Banks 2001; Krugman 1998) and cross-country studies identified the strong contribution IT investment had on Australia's economic growth during that period. However the connection between business investment in IT and productivity is unclear at the level of the economy and at the sectoral level.

Australia's real net IT capital stock in all industries grew from A$3 billion in the early 1970s to A$133 billion in 2015. In Figure 1.1 the stock of IT capital as a share of total net capital stock of all industries (excluding dwelling and ownership transfer cost), is presented. As shown in Figure 1.1, the share of IT capital as a share of the total net capital stock increased from less than 0.5% in 1960 to about 4.5% in 2015, reflecting a major transformation in the Australian economy. However, in more recent times, IT capital growth has slowed significantly (evident in the flatter tail at the end of the curve). Possible reasons for this recent softening could include: already high growth in past years; steady declines in computer prices; and the pro-cyclicality of investment with regards to gross domestic product (GDP). These possible reasons are explored in subsequent chapters of this report. However, what is evident in this changing pattern, is increased impetus in the productive use of existing capital stock, both IT and others, to enable growth and productivity.

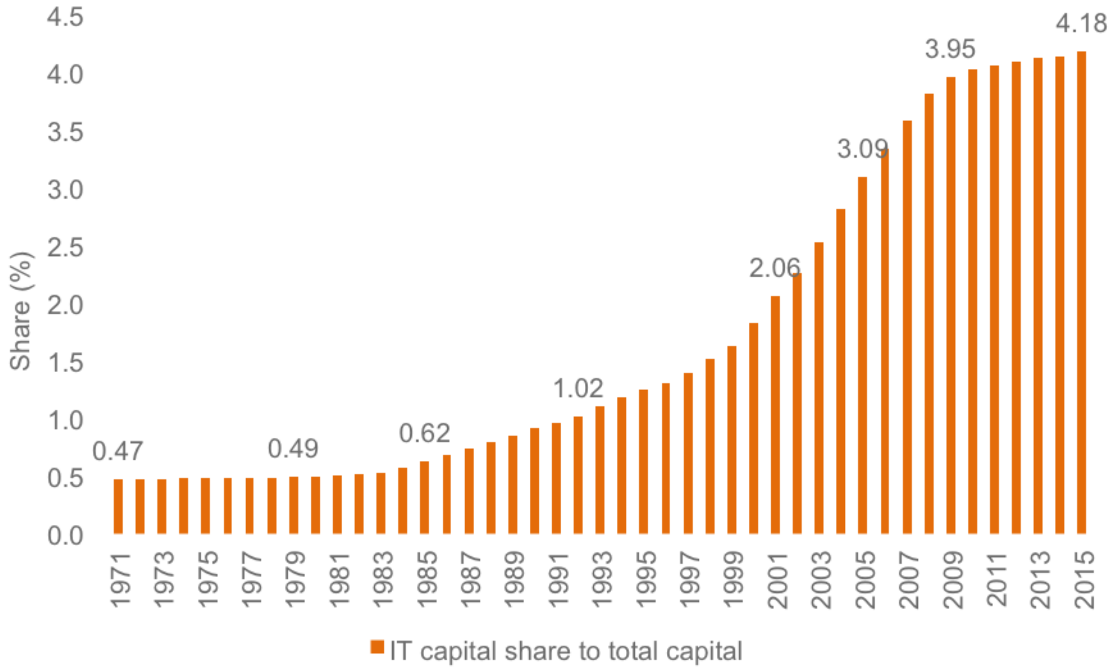


Figure 1.1: Share of IT capital to total net capital (excluding dwelling and ownership transfer cost) in Australia 1971-2015

Source: ABS (2015a)

Notes: Numbers are in 2013-14 chain value measures.

In Chapter 2, recent trends in the growth and productivity of the Australian economy are discussed.

In Chapter 3, historical and recent trends in aggregate IT investment and its components, i.e., computers, hardware and communication technology are overviewed.

In Chapter 4, the contribution of IT investment to economic growth is analysed using aggregate economy-wide data.

In Chapter 5, the uptake and contribution of IT at the sectoral level of the Australian economy is explored.

In Chapter 6, we lay out main findings, conclusions and policy implications.

Definition: Capital stock vs. capital investment

The term 'capital stock' refers to the size or accumulation of capital over time. The term 'capital investment' refers to the investment in, or acquisition of, capital assets (such as IT).

Definition: Information Technology

The ABS does not formally define 'IT capital' but instead reports it in terms of three components:

- **Computers and peripherals**: Computers and peripherals are a subset of machinery and equipment and include computer hardware, such as laptops, tablets, PCs, printers, mainframes and servers.
- **Electrical and electronic equipment**: Consists of a subset of machinery and equipment items, such as modems, phones, switchboards, cable/wire for communication purposes, GPS equipment, television and radio transmitters and radio transceivers. Electrical and electronic equipment is considered as a proxy for communication technology.
- **Computer software**: Computer software is a subset of Intellectual property products. Computer software is defined to include purchased software and software developed in house.

Table 70. Information Technology Gross Fixed Capital Formation, Selected items by Industry from Australian System of National Accounts (ABS cat. no. 5204.0)

Chapter 2. Australia's economic growth and productivity

The Australian economy has grown remarkably over last few decades. Apart from a few short-lived business cycle fluctuations, GDP growth remained buoyant albeit moderating in recent years. Average real GDP growth in the 1960s was 5.3 per cent - the highest decade average in the 20th century – being associated with the post-War boom of the Australian economy. Following the 1970s oil crisis, economic growth settled on a slower path but it recovered significantly in the second halves of the 1980s and the 1990s. Many argue that the 1980s' and 1990s' recovery of economic growth was largely facilitated by business investment in information and communications technologies. Therein the digital economy was born. However in the 2000s, there was a demonstrated softening of economic growth, with no significant sign of improvement (hovering around the downward sloped trend line) in the 2010s (Figure 2.1). The declining economic growth path in recent years has largely been attributed to a decline in multifactor productivity (MFP), which has fallen short of expectations in recent years.

Figure 2.2 shows the trends in industry MFP. Similar to GDP, productivity performance showed a major improvement in the second half of 1990s following the business cycle and a recession earlier in the decade. Overall, productivity grew at a very

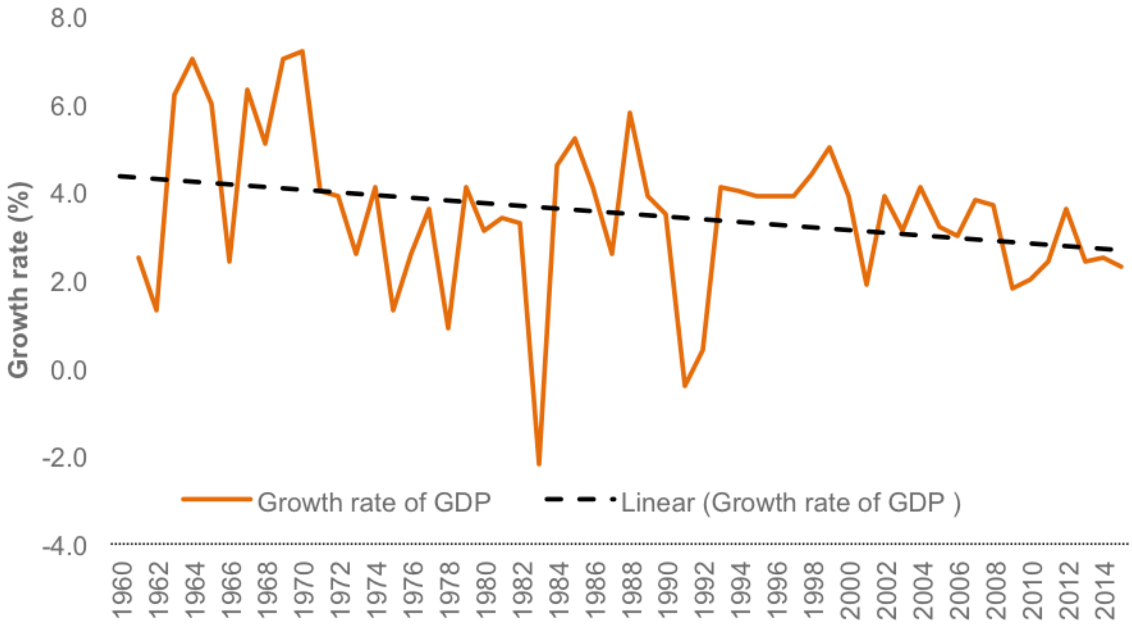


Figure 2.1: Growth rate of GDP

Source: ABS (2015a)

Notes: The dotted line shows the linear trend line.

Definition: Multifactor productivity (MFP):

MFP represents the residual portion of output growth that cannot be explained by increases in inputs, such as labour and capital. According to the ABS (2007) "MFP takes account of several factor inputs at the same time and is largely a measure of the effects of technical progress, improvements in the workforce, improvements in management practices, economies of scale and so on. MFP can also be affected in the short term to medium term by other factors such as weather and by variations in capacity utilisation. Strictly speaking MFP growth occurs when there is an upward shift in the production function" (p. 99).

consistent manner during the period from 1988-2004, no doubt facilitated by significant economic reforms implemented during the 1980s, 1990s and early 2000s (Parham 2004). Rapid increases in business investment in, and adoption of, IT are also said to have contributed to productivity improvement. growth in the 1990s, while, since the mid-2000s, MFP deceleration translated into slower per capita income growth. From a national point of view, the deterioration of MFP performance is a concern for Australia's long-run well-being.

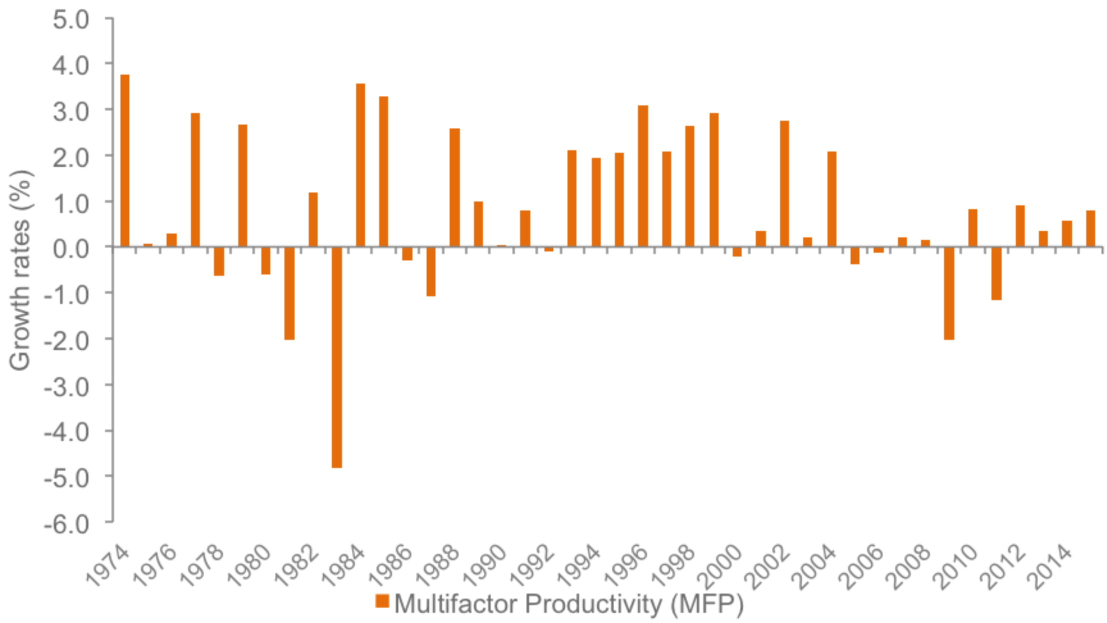


Figure 2.2: Changes in measured MFP of the market sector (12 industries), 1974–2015
Source: ABS (2015b)

However from 2005 onwards, productivity growth has significantly deteriorated with a substantial reduction in its mean (2005-15 average is 0.01%), negating the past influence of IT and policy factors. Real IT investment growth also declined significantly during this period. Output growth, while declining, remained relatively robust during the period as other types of capital deepening were undertaken.

From an international perspective, this disappointing picture of Australia's productivity performance during the 2000s was not shared by other comparable advanced nations. For example, in Box 2.1 we compare the MFP growth rates for Australia, the US and Canada. Whilst Australia shows a relatively better productivity growth than the US and Canada during 1990s, the trend reversed in the 2000s.

In Figure 2.4 the growth rate of Australia's GDP per capita is plotted against the growth rate of MFP from 1970s. A high correlation between per capita GDP growth and MFP growth is evident. MFP acceleration directly lifted the per capita income

IT investment can improve economic growth and productivity through different mechanisms. The neoclassical growth model suggests output is a factor of capital, labour and technology. IT investment, as a capital good, can affect overall capital deepening (i.e., capital per unit of labour) and/or can substitute IT capital with non-IT capital stock. A substitution between factor inputs represents movement along the production function and could raise the output level along a given production possibilities frontier. For example, a well-developed telecommunications infrastructure can decrease the cost of acquiring information and increase efficiency. The importance of information efficiency to investment, and in turn to economic growth, has been widely recognized in the literature (Stiglitz, 2002).

The general purpose technology (GPT) nature of IT capital means that it has the capability to increase efficiency in production and distribution. IT investment can exhibit positive externalities so

Box 2.1: MFP performance for Australia, the US and Canada

Australia's productivity performance has fallen short of expectations since the 2000s. The productivity performance of Australia in recent years is unsatisfying in terms of its own performance in the past and in terms of the performance of other developed countries (Figure 2.3). Although not directly comparable due to differences in economic structure, market size and characteristics, a comparison provides some insight into how Australia has progressed overtime in comparison to peer nations.

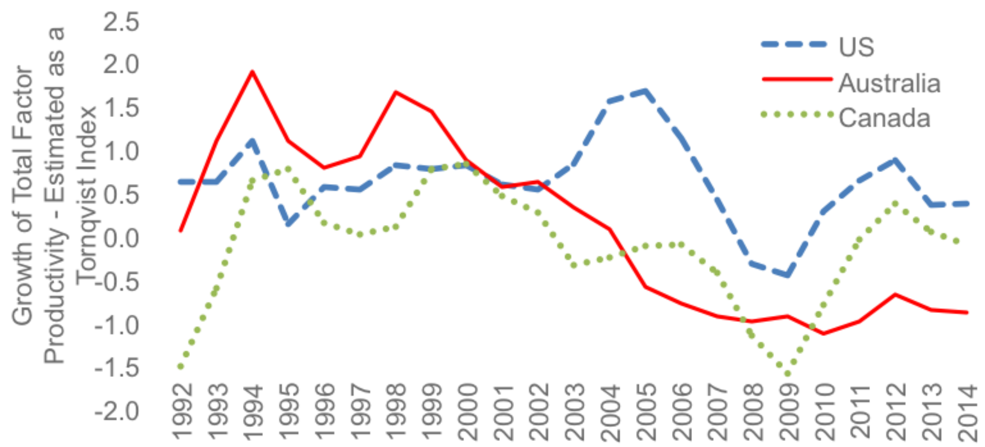


Figure 2.3: Growth of Multifactor Productivity: US, Australia and Canada

Source: Conference Board (2015). Note: Growth of productivity is expressed in 3-year moving average. TFP growth is estimated as a Tornqvist Index.

As shown in Figure 2.3, since the mid-2000s Australia experienced a substantial short-fall in productivity improvement as compared to the US (technology leader) and Canada and this remained unchanged until the post-GFC period. Arguably various factors contribute to Australia's productivity growth slump in recent years including:

A lack of major policy reform. Australia has not been successful to take comprehensive productivity enhancing policy reform since the introduction of GST in 2001 (Garnaut, 2010). From 2003-8 Australia's position slipped against other OECD countries in terms of OECD's integrated product market regulation indicators. However, there has been a demonstrated improvement since 2008 as Australia lowered barriers to trade and investment, reduced import tariffs and simplified screening and approval procedures for foreign direct investment.

During last few decades, profit share to national income has lifted automatically due to gains from terms of trade. Therefore, there has been less pressure to pursue productivity gains (Eslake & Walsh, 2011).

Differences in education and skills might explain some of the productivity gaps. The average year of schooling of Australian workers remained below the US level although this trend is converging gradually (Dolman et al., 2007).

Overall, lifting productivity performance will remain as a key challenge for Australia in the coming years.

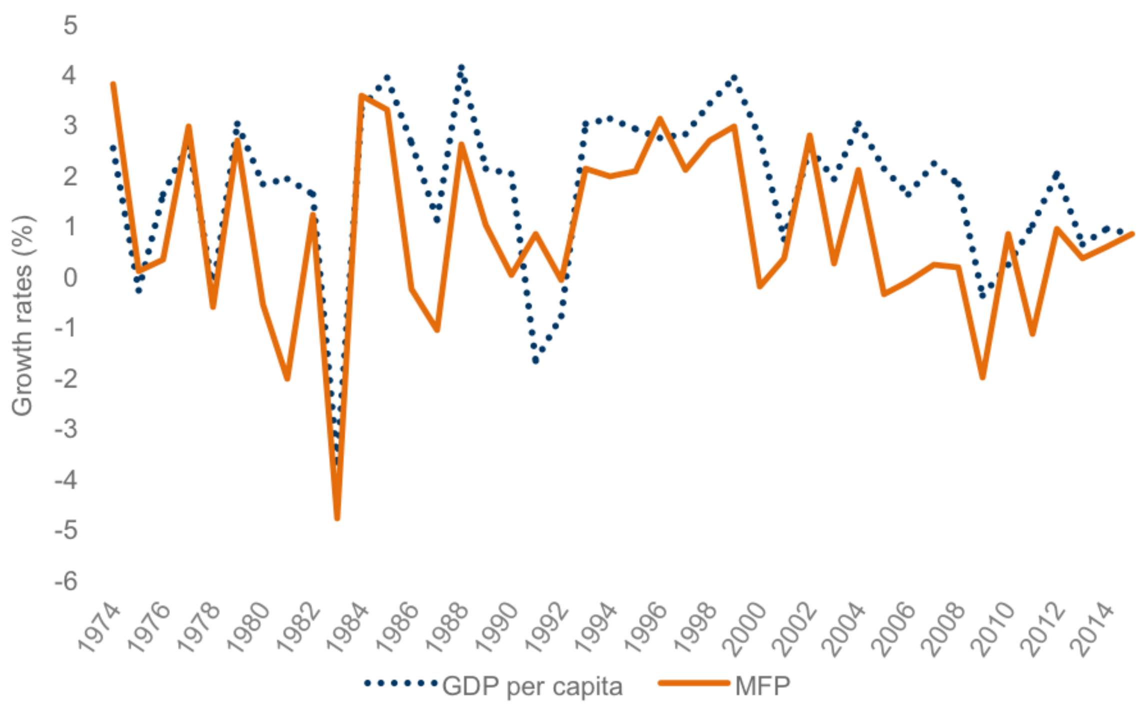


Figure 2.4: Growth rate (annual % change) of MFP vs growth rate of GDP per capita in Australia

Source: Compiled by the authors from ABS (2015a; 2015b).
Note: GDP per capita refers to the GDP per capita in chain volume measures.

that they show increasing marginal products in the aggregate (Lipsey, Carlaw and Bekar 2006). This stimulates increasing social returns, which in turn leads to sustained positive growth rates as envisaged by endogenous growth theory (Romer 1991).

As a GPT, information and communications technology is considered to be an 'enabling' technology. This means its role is more than simple capital deepening. For example, IT contributes not only to reducing searching, storing and sharing costs of information, but also enables more information to be made available, resulting in an efficiency gain in production (Banks, 2001). IT also fuels complementary investment in organisational capital and facilitates new processes, procedures and organisational structures (Brynjolfsson and Hitt, 2000). Together these factors help to leverage growth and productivity. IT as an important driver of economic growth and productivity is now acknowledged in a rich body of literature (Ahmad, Schreyer and Wölfl, 2004; Jorgenson and Stiroh, 2000).

We review the both growth and productivity impacts of IT in Australian in recent years as well as in the historical contexts in the subsequent chapters.

Chapter 3. Australia's IT investment: peaks and troughs

Annual IT gross fixed capital formation (GFCF) (investment, hereafter) for all industries increased from below A$1billion per year in the early 1980s to about A$34 billion per year in 2015. This is more than 14 times higher than the increase in other types of capital investment for all industries. The significant growth in IT capital investment compared to other forms of capital investment, is evidence of Australia's move to a digital economy. Moreover, during this time Australia's real GDP nearly tripled, reflecting a major economic expansion .

Figure 3.1 shows Australia's relative growth in IT investment vis-à-vis an aggregate of other forms of capital investment over more than five decades. Figure shows that IT investment growth has been very substantial as compared to other capital investments in 1980s, 1990s and early 2000s.

But since the mid-2000s, the growth rate of IT investment has slowed significantly.

In Figure 3.2, IT investment growth is plotted against GDP growth. IT investment is seen to be pro-cyclical and volatile. This indicates that IT investment grows strongly during economic booms and declines quickly during economic slowdowns. Business cycle events therefore make a difference to the growth of IT investments. In the post-GFC period, IT investment recovery was slow, although a marginal pick-up has been observed in 2015.

The forms of IT capital that contribute to the increase or decrease in IT investment growth over time is presented in Table 3.1 along with changes and shares of IT, non-IT and R&D investment growth.

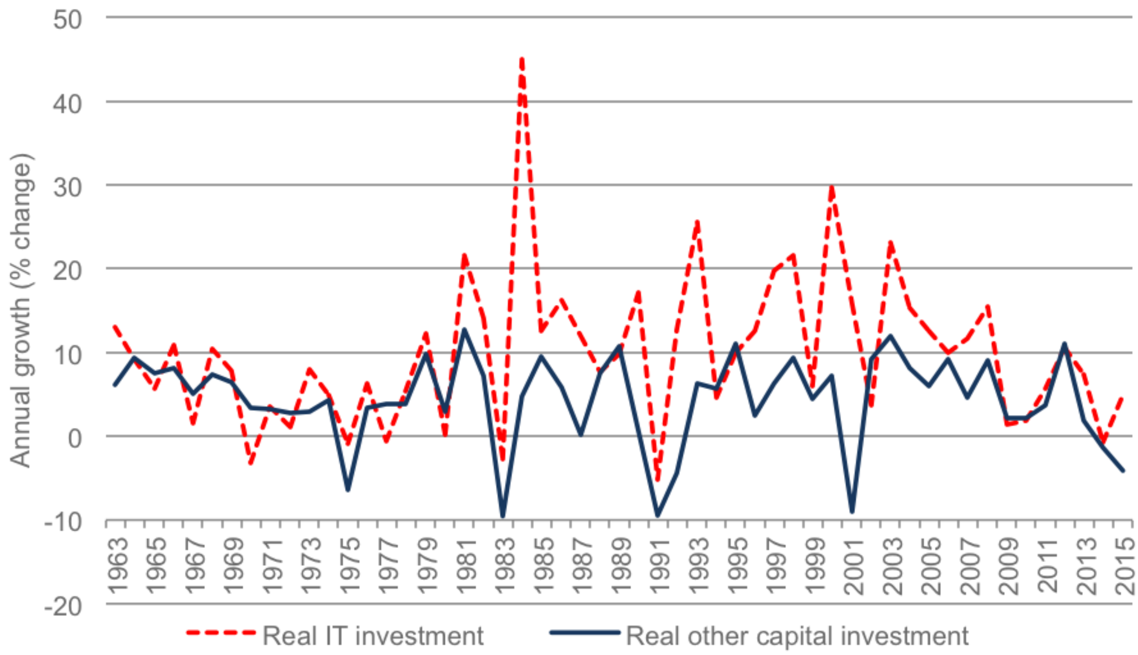


Figure 3.1: Growth of IT and other capital investments

Source: (ABS 2015a)

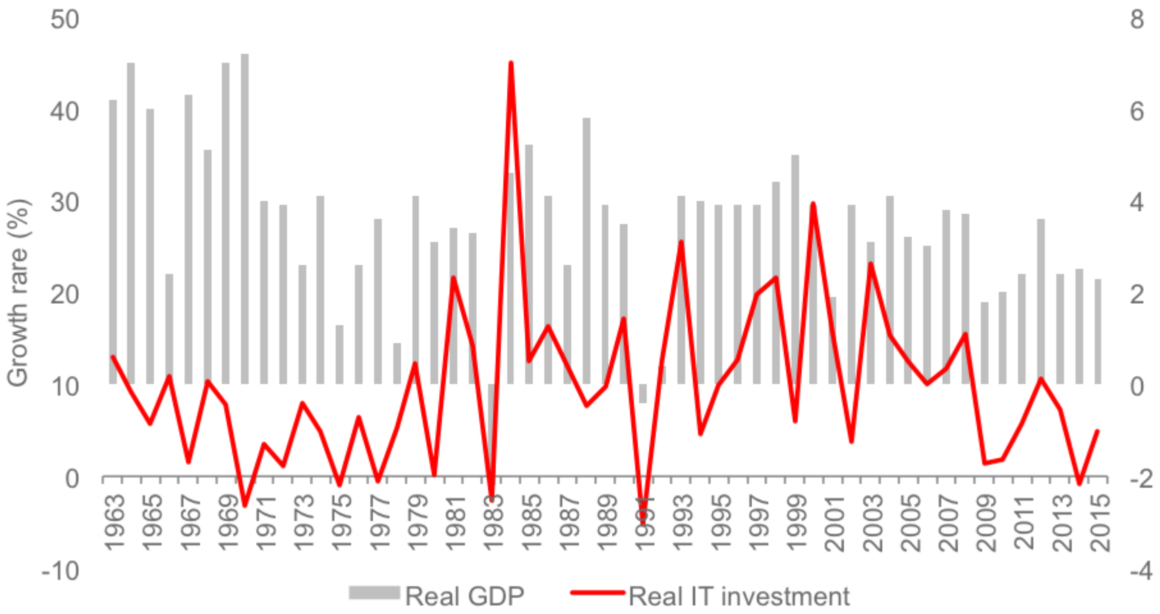


Figure 3.2: Growth of IT investment and GDP

Source: ABS (2015a)

Table 3.1: Growth and share in investment (constant prices) in all industries, 1981-2015

	1981-1985	1986-1990	1991-1995	1996-2000	2001-2005	2006-2010	2011-2015
Growth rate, % per annum							
Total IT	18.1	12.6	9.5	17.9	14.1	8.1	5.5
Computers	30.4	25.9	14.8	36.6	24.6	18.4	2.8
Software	31.2	26.3	15.8	15.9	9.4	7.8	9.3
Electric and electronics	14.9	5.5	2.4	17.5	16.8	1.9	2.2
Other investment	4.9	5.0	1.8	6.0	5.3	5.5	2.3
Total GFCF	5.1	5.1	2.0	6.3	5.7	5.6	2.5
Share to value added (%)							
Total IT	0.2	0.3	0.5	0.7	1.3	1.9	2.2
Computers and software	0.0	0.1	0.3	0.5	0.8	1.2	1.6
Other GFCF	20.0	20.6	18.7	20.6	21.4	25.6	27.1
GDP growth (%)	2.9	4.0	2.4	4.2	3.2	2.9	2.6
GDP per capita, growth rate (%)	1.4	2.4	1.3	3.1	2.0	1.1	1.1
R&D investment share to total	0.6	0.8	1.0	1.1	1.2	1.4	1.5
R&D Growth (%)	6.7	8.6	10.2	0.9	8.6	5.0	3.0

Source: ABS (2015a)

As seen in Table 3.1, IT investment growth is biased by investment growth in computers and software. Investment in computers grew as high as 37% in the latter part of the 1990s. Investment in software grew at a rate of 31% and 26% in the first and second halves of the 1980s. These average growth rates were significantly higher than the growth rates for other forms of capital and R&D investments. Note that the downward trend for IT investment growth is consistent with global patterns – indeed many advanced countries including US experienced such a pattern post-GFC.

The IT investment growth pattern can be explained from three different perspectives: 1) the maturity effect; 2) a cyclical effect, and 3) a relative price effect.

Maturity effect:

The slower growth path of IT investment may reflect a maturity effect. The growth of IT investment was phenomenal in the 30 year period leading up to 2005. This growth indicates an already substantial stock of IT capital (Figure 1.1). Therefore, IT investment growth may have slowed and converged with other forms of capital investment (Figure 3.1).

Cyclical effect:

In Table 3.1, we can see that the share of IT investment as a whole and computers and software in particular to industry value added grew consistently over time with a significant increase in the period from 2011-15. This can suggest that growth in IT investment picks-up as the economy grows. By implication this suggests improving the conditions for economic growth, such as technical progress or MFP, could be an aim of governments. Technical progress can shift the production function, thereby lifting economic growth. We discuss the relationship between IT investment and MFP in further detail in the following chapters.

Price effect:

The price of computers and peripherals is falling while quality is lifting. As 'Moore's Law', suggests, the capacity of integrated circuits has doubled every two years. Fig 3.3 shows the rapid price decline for all three components of IT. This means firms can improve their IT infrastructure without there being any real increase in IT investment.

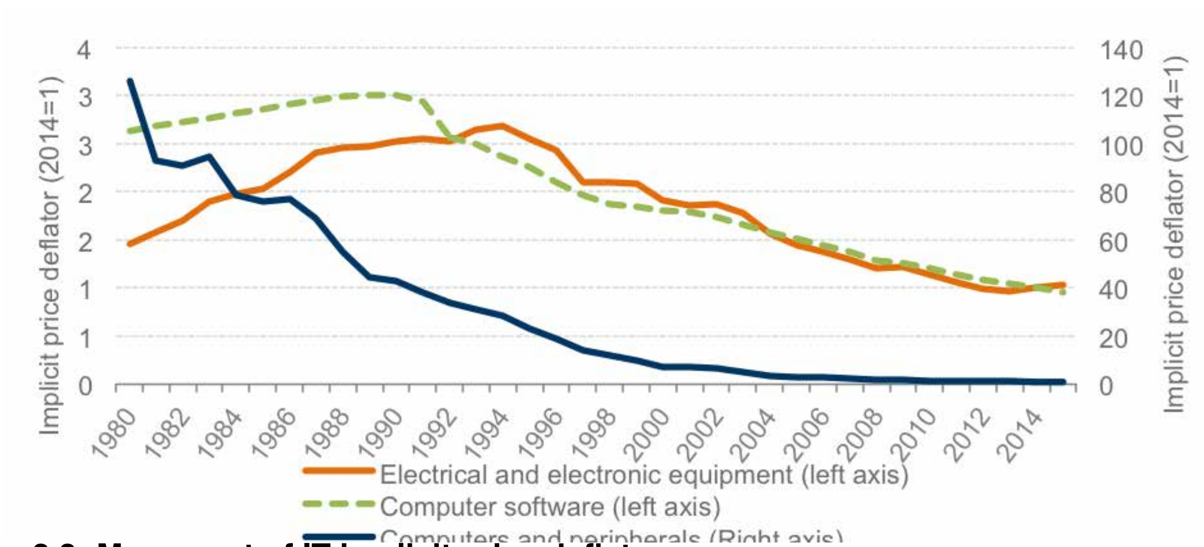


Figure 3.3: Movement of IT implicit price deflators

Source: ABS (2015a)

Note: IT implicit price deflators are computed as a ratio of nominal to real gross fixed capital formation of IT products.

Chapter 4. IT performance: decomposition and elasticity

Applying the standard growth accounting (GA) methodology and econometric modelling enables us to provide insight into how Australia's IT capital investment and performance impacts on MFP and GDP output growth. Specifically, we investigate if a substantiated relationship exists between IT investment and GDP output growth, based on evaluating available historical data. Additionally we explore IT elasticity with a view to understanding what growth levers can be applied to stimulate the Australian economy. Econometric modelling enables an estimation of the impact IT investment has on economic growth and productivity.

Decomposition of economic growth

Standard growth accounting (GA) methodology can be used to evaluate the recent performance of IT capital as it relates to output growth. According to the GA methodology framework, output growth is a product of share-weighted growth of inputs, i.e., capital and labour, where the appropriate share is the proportion of total income payments attributed to the input (Solow, 1957). Furthermore, when these shares of the factors of production are taken as constant, any rise in output is attributed to increase in productivity (i.e. MFP).

Therefore, the GA methodology provides a useful framework to decompose output growth into the contribution from each factor of production separately, as well as MFP. Moreover, the GA methodology allows for multiple factors of production to be taken into account. That is, the contribution from capital can be decomposed further to IT and non-IT capital and further to types of IT capital such as software, hardware and communication technology.

Because the decomposition can be done on a yearly basis, the GA methodology also enables us to observe changes in contribution over time.

Table 4.1: Sources of output growth, yearly changes, period average

	1991-95	1996-00	2000-05	2006-10	2011-14
Output growth (%)	2.7 (100%)	4.0(100%)	3.3 (100%)	2.7 (100%)	2.7 (100%)
Contribution of IT capital	0.5 (19%)	0.8 (20%)	0.9 (27%)	0.8 (30%)	0.7 (26%)
Contribution from non-IT capital	0.4 (15%)	0.9 (23%)	1.2 (37%)	1.8 (67%)	2.0 (74%)
Contribution from labour quantity	0.7 (26%)	0.9 (23%)	0.9 (28%)	0.9 (33%)	0.7 (26%)
Contribution from labour quality	0.2 (7%)	0.3 (8%)	0.3 (10%)	0.2 (7%)	0.2 (7%)
MFP growth	0.9 (33%)	1.1 (28%)	0.0 (0%)	-1.0 (-37%)	-0.9(-33%)

Source: The Conference Board (2015)

Notes: Numbers in brackets represent percentage contribution to output growth.

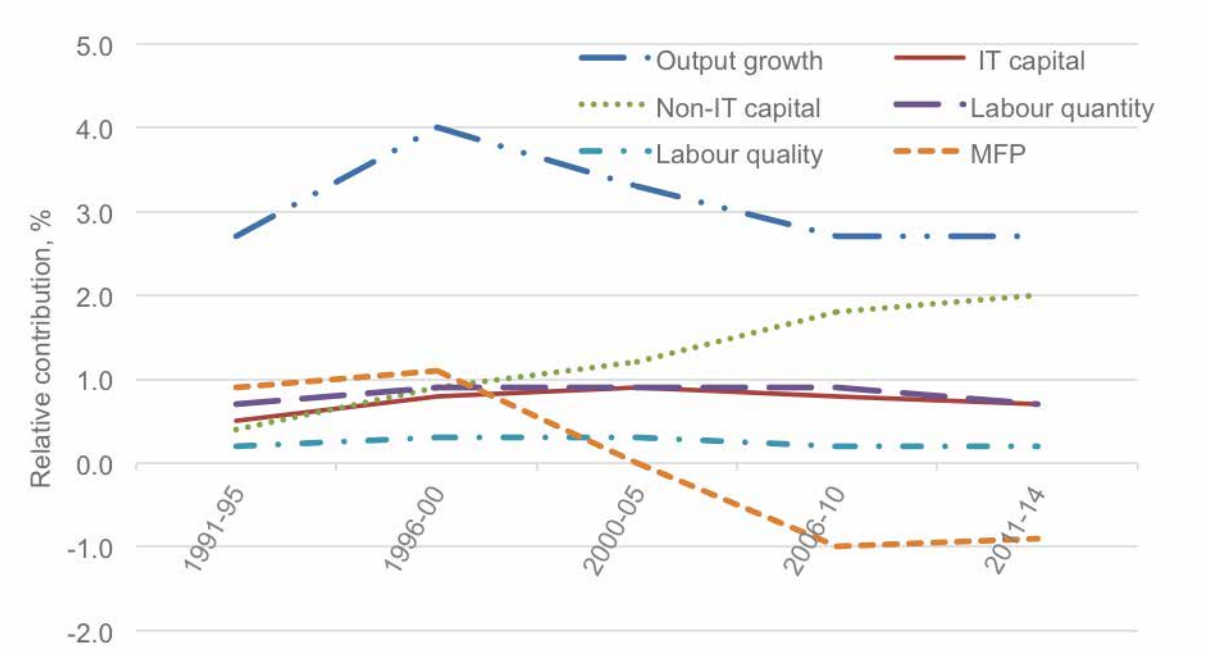


Figure 4.1: Contribution of IT and other inputs to output growth (period average)
Source: Compiled by the authors using data from The Conference Board (2015).

In Table 4.1 the GA methodology shows that the contribution of IT capital input to output growth increased, from a yearly average of 19% in 1991-95 to 30% during 2006-10, but it declined to an annual average of 26% during 2011-14. On the other hand, the contribution of non-IT capital to output growth increased significantly in recent years (74% during 2011-14). The contributions of labour quantity to output growth fell slightly in recent years, while the contribution of labour quality remained relatively unchanged over time.

Output growth slowed post 2005 (an average of 2.7% as opposed to an average of 4% during 1996-2000 and 3.3% during 2000-05), and this is largely attributed to negative MFP. Per capita GDP growth has declined in recent years and economic conditions have not markedly improved much since the Global Financial Crisis (GFC) in 2007/2008.

The data illustrates that the direct contribution of IT was high in the 2000s, however this trend softened in recent years (Figure 4.1). The GA methodology results also indicate that IT capital growth accounts for more than a quarter of GDP growth during 2006-2014, despite a decline in overall IT investment growth.

Estimated IT elasticity

Estimating the impact of IT investment on economic growth and productivity is possible through econometric modelling for a single country and a pool of countries. The advantage of the econometric approach is that it can capture the dynamic nature of relationships that may exist between IT and output. For example, the OECD focuses on the relationship between the emergence of the Internet economy and its impact on economic growth, productivity, consumer surplus and social welfare.

However, there is a challenge in measuring IT due to its 'enabling' nature. As a general-purpose technology the effect of IT on output may be indirect and/or delayed. For example, Citizen A gets information online from a medical practitioner which reduces transaction costs and enables them to avoid a health risk. This interaction and its impact may not show up immediately in the official statistics, but may become partly visible over the long-run. Part of the measurement problem is how the IT operating costs are taken into account. These may be better captured via micro-based firms or consumer measures. Despite this, estimates of the IT elasticity in the overall economy do provide some comparative value as they show changes over time.

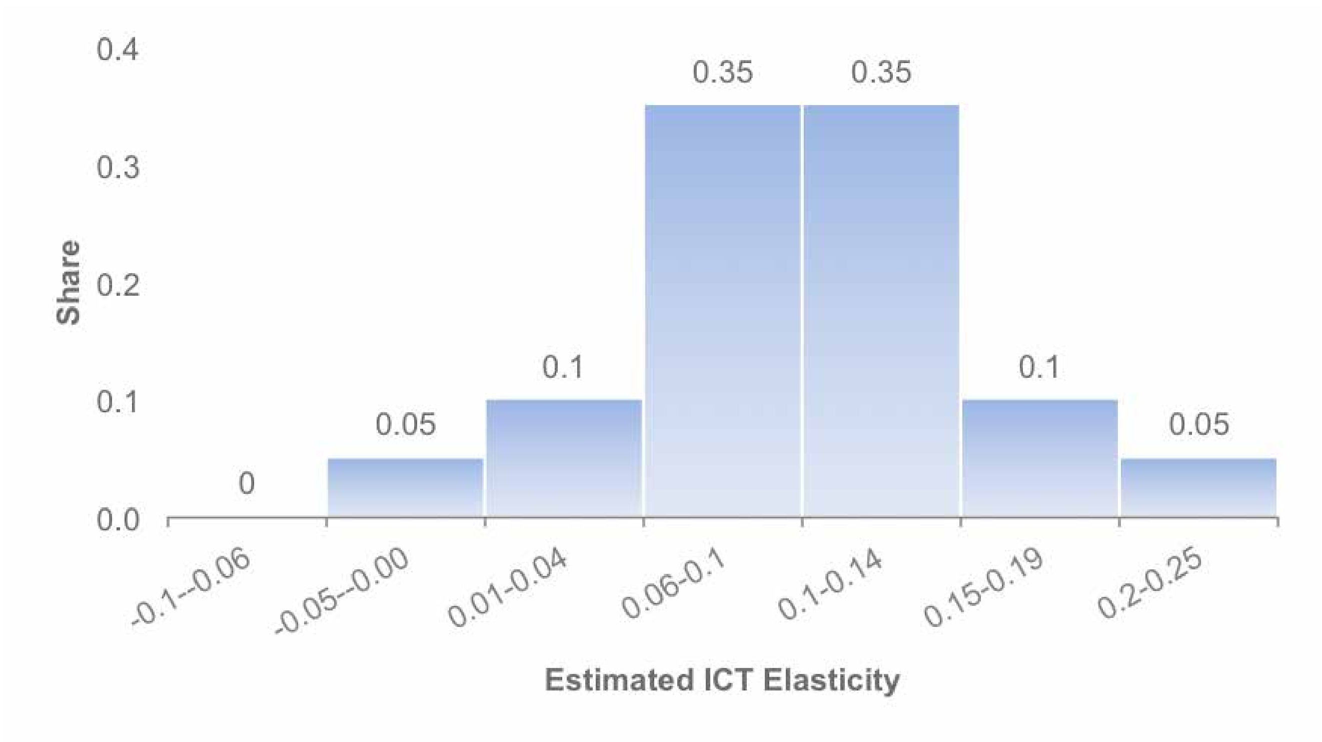


Figure 4.2: Histogram of IT elasticity estimated from 20 studies
Source: Compiled by the authors using data from Stiroh (2002, Table 1)

Stiroh (2002) reports the estimates of IT elasticity from 20 global studies undertaken between 1992-2002. In Figure 4.2 the estimates of IT elasticity over time are reported in the histogram. The mean IT elasticity was found to be 0.05, which can be interpreted as every 20% increase in IT capital increases GDP by 1%.

In a study of the US and EU countries, Venturini (2009) found the estimated IT elasticity of a medium sized country like Australia to be 0.05. Shahiduzzaman and Alam (2014), using data for 1965-2011, found Australia's estimated IT elasticity was 0.04, just below that medium sized country mean.

As output elasticity measures the percentage increase in output associated with the percentage increase of an input, then the contribution of any input to GDP growth can be estimated by multiplying output elasticity by the compound annual growth rate (CAGR).[1] Using this formula, the CAGR for IT capital stock for the time period 1965-2011 is equivalent to 9.24. Accordingly, the per cent GDP growth attributed to IT capital is equal to 9.24 multiplied by 0.04, which equals 0.37 - this roughly accounts for 12% of GDP growth during 1965-2011. This differs somewhat from Parham et al's (2001) estimation of the contribution of IT capital to be 14.7%, which using the CAGR formula would suggest requires an estimated IT elasticity of 0.05 to achieve this contribution.

1 The formula for computing CAGR is

$$CAGR(t_0, t_n) = \left(V(t_n)/V(t_0)\right)^{1/(t_n - t_0)} - 1$$

, where $V(t_0)$=beginning value, $V(t_n)$= ending value, t_n - t_0= number of years.

Table 4.2: Long-run contribution of IT capital to GDP growth, Australia and other countries

	Country	Period	Contribution to GDP growth (%)	
			IT capital	Other capital
Parham et al (2001)	Australia	1965-2000	14.7	38.2
Shahiduzzaman & Alam (2014)	Australia	1965-2011	11.8	46.6
Harchaoui et al (2002)	Canada	1981-1999	17.2	27.6
Jalava & Pohjola (2002)[a]	Finland	1975-1999	13.3	-3.3
Jorgenson & Stiroh (2000)	US	1959-1998	8.95	18.2
Oliner & Sichel (2000)[b]	US	1974-1999	20.3	19.3

[a] Figures refer to simple average of 1975-1990, 1990-1995 and 1995-1999 periods.

[b] Figures refer to simple average of 1974-1990, 1991-1995 and 1996-1999 periods.

Source: Shahiduzzaman and Alam (2014) and authors' computations.

Australia's IT capital contribution has accounted for more than a quarter of GDP growth since 2006 despite an overall decline in IT investment. While the estimates for IT vary depending on whether the GA methodology or econometric modelling is applied, roughly both methods suggest that a 10% increase in IT capital investment results in a 0.5% growth of GDP.

This direct relationship between IT investment and GDP growth indicates that IT investment is an effective lever for stimulating growth in the Australian economy.

Definition: Econometric modelling:

Econometric models are used to measure the statistical relationship between a dependent variable and one or more independent variables. Econometric modeling involves using quantitative data to find meaningful relationships between the variables of interest.

Definition: IT elasticity:

The concept of elasticity is widely used in economics literature (e.g., price elasticity of demand). Elasticity measures the sensitivity of a variable to the change in another variable and computed as ratio of percentage changes. IT elasticity measures the percentage change in output to the percentage change in IT investment, holding constant the contribution of other factor (e.g., non-IT).


T-Mobile.pl
10:43
AAPL 106,82 626,5B
GOOG 501,79 340,4B
FB 74,05 206,4B
DOW J 17 320,71
DAX 9 990,09
79,58 59,55B
92,81 79,96B
1W 1M 3M 6M 1Y 2Y
18 054
13 511
July
2014
July
Market closed
YAHOO!

Chapter 5. IT transformation of economic sectors

IT is reshaping Australia's industries. Although the Mining sector remains key to the prosperity of the Australian economy, sectors such as Information, media and communications, Retail, Health care and social assistance and Finance and insurance services have grown significantly, yielding benefits from IT investment. Other sectors are lagging behind in terms of growth and productivity and we argue that this is a result of the heterogeneous effects of IT investment across different sectors and the (in)efficient use of technology.

In Figure 5.1 the relative performance of different economic sectors in terms of their share to all industry real value added in 2015 over 1990 is presented. As can be seen in the figure, the Information, media and telecommunications[2] sector is at the forefront in terms of changes to sectoral share. The share of this sector to real value added increased from 2.2% in 1990 to 3.5% as of June 2015, reflecting a 62% growth over the period of time. With A$47.5 billion of real value added as of June 2015, the share of the 'Information, media and telecommunications' sector now superseded many other sectors (ABS 2015a).

When Mining is excluded, other sectors that have improved shares from 1990 to 2015 include the Finance and insurance services sector (+45%), the Professional, scientific & technical services sector (+29%), the Health care and social assistance sector (+28%) and the Retail trade sector (+10%). The sectors where the shares of value added have

2 The Information, media and telecommunication sector includes units engaged in (i) creating, enhancing and storing information products in media, (ii) transmitting information products using analogue and digital signals, and (iii) providing transmission services and/or operating the infrastructure to enable the transmission and storage of information and information products.

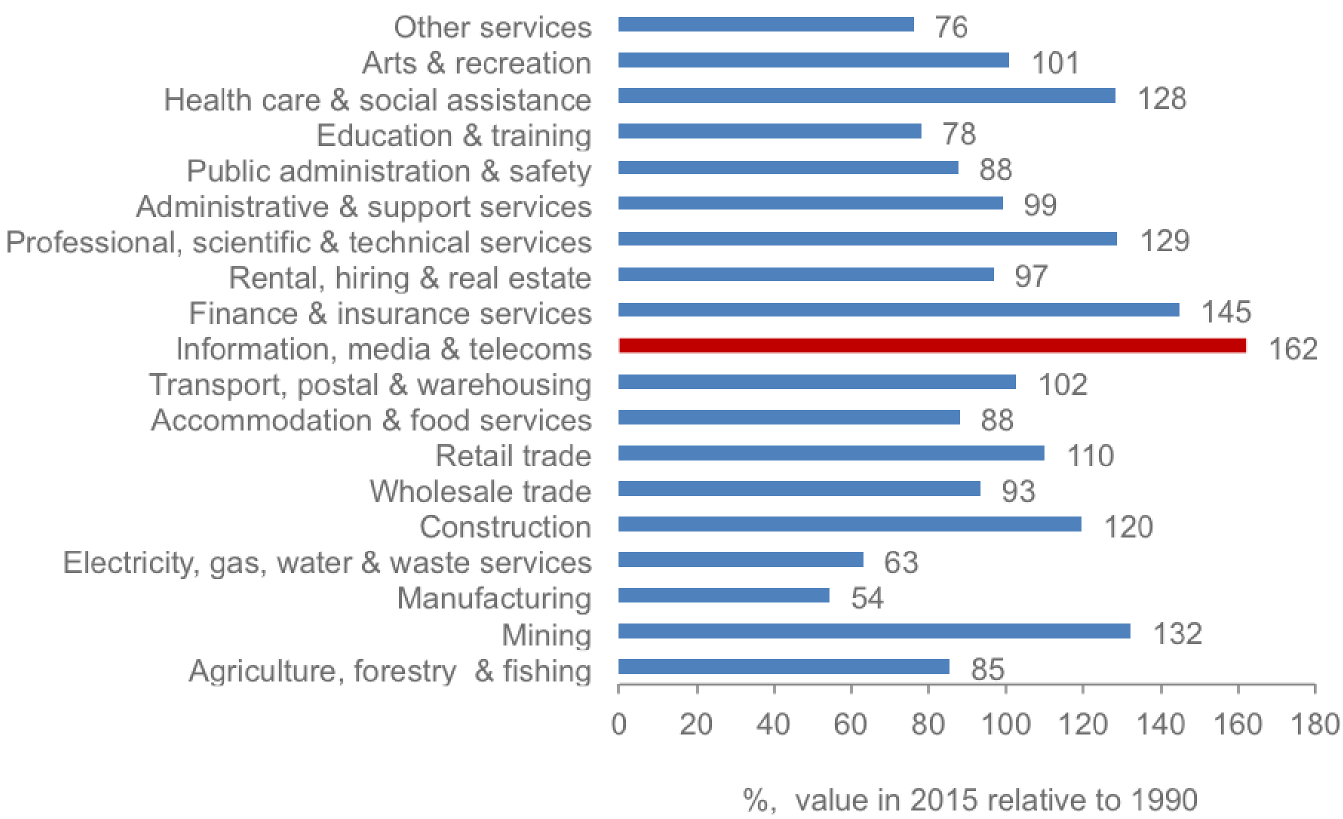


Figure 5.1: Changes in the sectoral share to value added (excluding dwelling) at basic prices, 2015 relative to 1990.

Source: ABS (2015a)

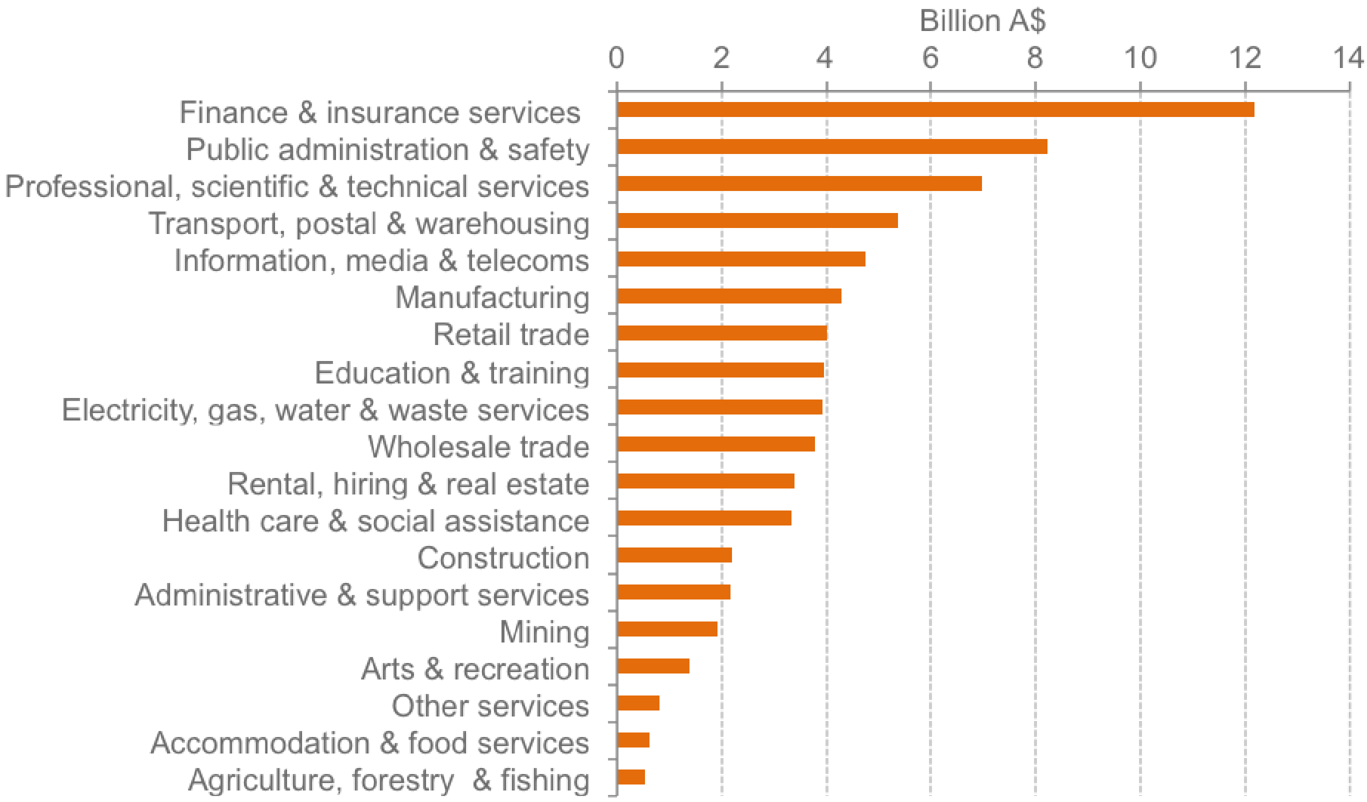


Figure 5.2: Net capital stock - computers, peripherals and software - different industries (as of June 2015)
Source: ABS (2015a).

declined include Manufacturing (-46%), Electricity, gas, water and waste services (-37%) and Agriculture, forestry and fishing (-15%).

In Figure 5.2 the computers and software capital stock in economic sectors as of June 2015 are presented. As can be seen in the figure, the Finance and insurance services sector had the highest level of computers and software capital stock, followed by the Public administration and safety sector, Professional, scientific and technical services sector, Transport, postal and warehousing sector and the Information, media and telecommunication. In Figure 5.1 we can see that, with the exception of Public administration and safety, all these sectors improved their share to value added in 2015 relative to the 1990s. The Retail sector benefited from the uptake of IT capital deepening, however, other sectors, such as Wholesale trade, Manufacturing, and the Utility (electricity, gas, water and waste) services sector lagged.

Productivity change

Australia experienced robust aggregate productivity performance in the 1990s, aided by policy reforms and IT developments. Indeed, productivity performance during the 1990s exceeded that in the preceding three decades by different estimates (Dolman 2009). However, as the 'Internet of Things' evolves the so called 'Productivity Paradox' emerges.[3] According to Australia's National Accounts Estimates, growth of measured MFP in Australia's market sector slipped consistently by -0.79 and -2.09 percentage points during 2001-05 and 2006-2010, respectively, as compared to the average MFP growth during 1996-2000 (ABS 2015b). Although improving slightly in the 2012 and 2013 financial years, the average MFP growth in 2011-14 was about 1.48 percentage points lower that growth in 1996-2000 due to negative growth in 2014.

3 A quarter of a century ago, Economics Nobel laureate Robert Solow quipped in the *New York Times Book Review* (12 July 1987), 'you can see the computer age everywhere but in the productivity statistics'.

While IT can in theory, affect technical change or MFP, measuring its contribution is not straightforward. First, productivity is related to improved efficiency rather than additional capital deepening. Second, there are array of other factors, such as, micro and macro-economic policy reforms, skills, education and innovation which can explain MFP (Parham 2005b, 2004). Not capturing any or some of these factors (due to measurement difficulties) can therefore mean variables are omitted. Consequently, to avoid the problem of spurious estimations, we observe changes in MFP individually across different sectors of the economy and see whether these are IT intensive (production or use) sectors. The findings are discussed below: of productivity in 2005-2014 as compared to 1996-2004.

As shown in Figure 5.3, the Finance and insurance services sector was the only Australian sector which experienced MFP gains in 2005-15 as compared to 1996-2004. The MFP growth in the Information, media and telecommunications sector remained relatively low but consistent over the period of time, growing at an annual average rate of 0.7% during 1996-2004 and at 0.4% during 2005-2014. The major economic sectors of Construction and Manufacturing experienced a decline in productivity growth in 2005-2015 compared to 1996-2004. The analysis suggests that the productivity shortfall from

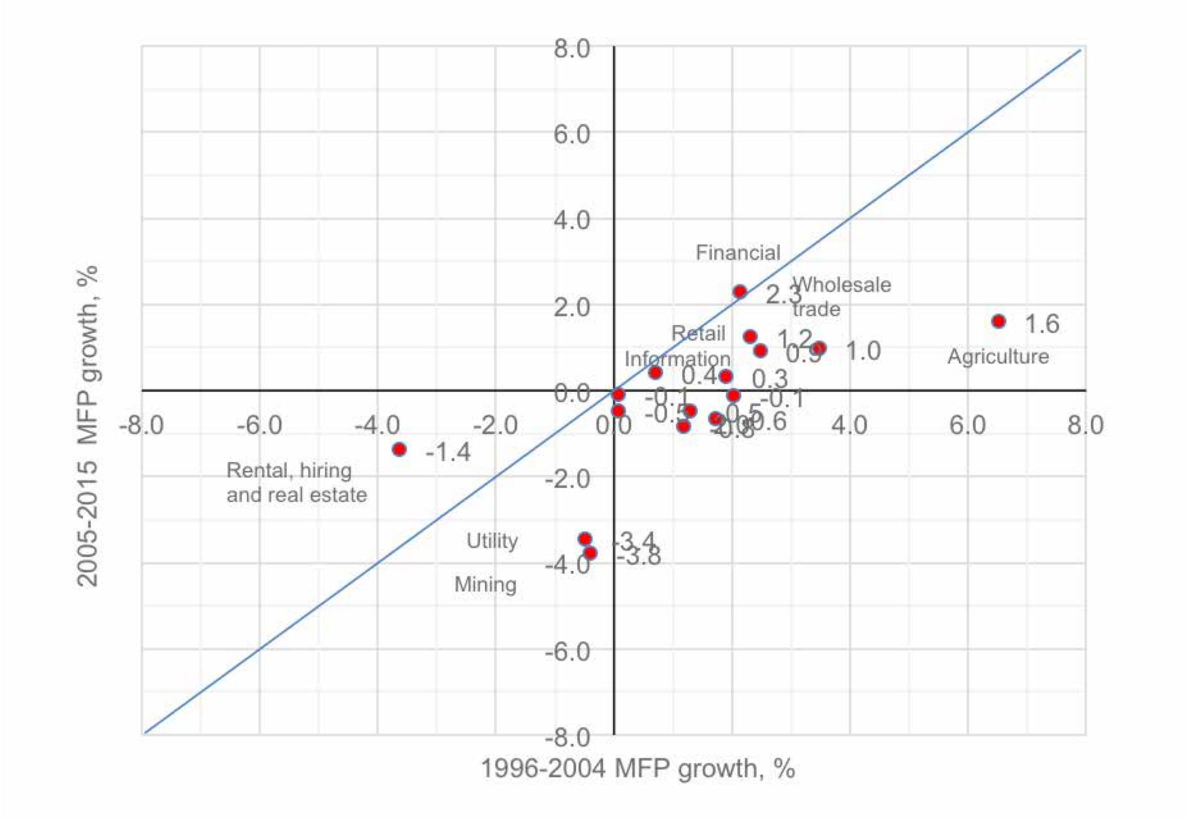


Figure 5.3: Changes in industry MFP1996-2004 vs 2005-2015
Note: MFP is measured on a gross value added and hours worked basis

In Figure 5.3 the percentage changes of industry MFP during 2005-2015 as compared to 1996-2004 for 16 market sector[4] industries in Australia were plotted. Dots above the 45° line show acceleration 2006-2015 was widespread, but the largest declines happened in the Agriculture, forestry and fishing sector, the Mining sector, Utility (electricity, gas, water and waste) services sector and the Wholesale

4 Market sector includes all industries except for Public administration and safety; Education and training; and Health care and social assistance.

trade sector. These four sectors, with more than a quarter of total value added of market sector industries in 2005-2014, experienced large MFP slowdowns during the period.

In the 1996-2004 phases, the largest MFP growth was experienced in the Agriculture, forestry and fishing sector and the Wholesale trade sector. In terms of the weighted (by value added share) contribution, the Wholesale trade made a very strong contribution in the 1996-2004 phases. The extraordinary productivity gain of the Wholesale trade sector in 1996-2004 was caused by a structural transformation of the sector from storage-based to transport-based logistics operations (Johnston et al. 2000; Parham 2005b).

The Mining sector, which represents one-tenth of the share of market sector value added, experienced one of the largest MFP falls, declining at an annual average rate of -3.8% in 2005-15 as compared to -0.4% in 1996-2004. The Electricity, gas, water and waste sector also experienced negative average productivity growth in 2005-15. Both of these sectors showed positive MFP growth performance in the 1990s, but experienced a marked downturn in the 2000s.

Parham (2005b) describes the early falls of MFP in these two sectors as 'transition' arising from the marked input increases, especially labour, in the face of declining output. Following the sharpest fall of MFP in the Mining sector in 2005-06 (-8.2% from the previous year), MFP growth has been consistent negative over 2006-13 – the period in which mineral and energy prices reached record peaks. The bleak MFP performance in the Mining sector in 2000s may indicate the over-investment in capital and labour at a point of time, however, this sector does require large investments to build new capacity

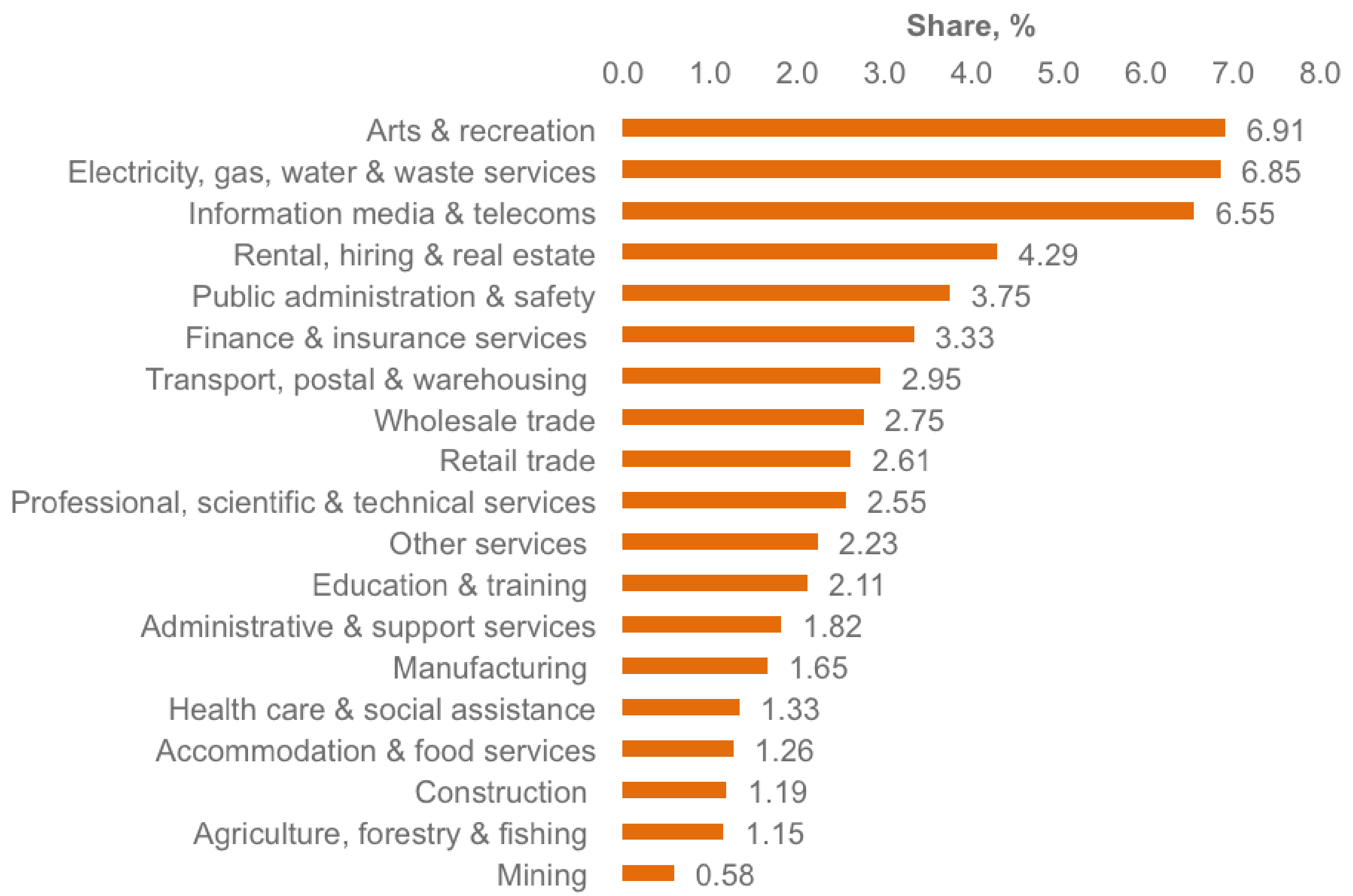


Figure 5.4: IT Investment as a share of sectoral value added in 2013-14

which may explain output effects (Topp et al. 2008). Gruen (2012) however notes that the recent dismal productivity performance picture is not due to massive capital spending by mining companies during that time in response to the huge upswing in Australia’s terms of trade.

Among these three sectors, both the Arts and recreation services sector and Utility services sector experienced negative productivity growth in 2005-2015 (Figure 5.3). MFP in Arts and recreation services sector performed at -4.3% in 2014-15 (ABS, 2015b). MFP growth in the Rental, hiring and real estate services was also negative in recent cycles, but improved by 2.88 basis points in 2005-15 over 1996-2005 (Figure 5.3). Other sectors such as the Finance and insurance services sector and the Retail sector seemed to show a positive correlation between IT investment deepening and MFP growth. Overall, however we did not find any evidence of there being a strong positive correlation between IT investment deepening and MFP growth across all sectors of the economy.

Barker et al (2008) found that the spill over effects of IT investment explained productivity differences more than direct capital deepening. Controlling for wide range factors, such as energy price, terms of trade, weather, openness and business cycle amongst others, Connolly and Fox (2006) found a positive relationship between IT capital and MFP in the Australian economy. What we find is the beneficial effects of IT on MFP in the 1990s in the Wholesale and retail trade sector, the Finance and insurance sector, the Accommodation, cafés and restaurants sector and the Agriculture, forestry and fishing sector.

We also find a lower level of spill over effects in other sectors of the economy, such as the Electricity, gas and water sector. Parham (2002) also found a new set of services sectors had a role in the productivity surge in the 1990s in Australia. Gretton et al (2002), on the other hand, found a relatively weaker association between IT use and productivity growth in the Wholesale trade sector. Essentially there are no simple correlations between MFP growth and IT use across industries in Australia (Gretton et al, 2002).


NOKIA
9:39
3
Phone
People
21
Outlook
Quarterly Budget Review
Briefing Room 1940
Tomorrow 10:30-11:30 AM
Calendar
Mon 02
7
Skype
4
2
LinkedIn
Nokia Drive
myStocks
Me
Updated
Q-2 budget
Excel
CHASE
tripadvisor
Photos
Notes from
meeting
OneNote

Chapter 6. Conclusions

In this paper we examined the uptake and impact of IT investment and capital on the Australian economy. We used aggregate and sectoral data for more than five decades through to 2015 to do this. Our analysis indicates that IT capital deepening has brought significant gains in terms of aggregate value added to the Australian economy. However, the impact of IT has been bleak in terms of its productivity performance, especially in recent years. The main findings of the report are follows:

- Australia has experienced a significant growth in IT capital investment since the early 1980s to the mid-2000s, but its growth rate has declined significantly in recent years. Movements in the business cycle, past growth and the falling prices all play a role in explaining the recent decline in IT investment.
- Despite a decline in growth of IT investment, results from the analysis using GA methodology indicate that IT capital still explains more than a quarter of GDP growth during 2006-14. This contribution is higher than the average contribution of IT investment to GDP in 1990s.
- Econometric evidence indicates that in the long run, a 20% increase in IT investment can increase output measured as GDP by 1%.
- Business investment in IT is found to be pro-cyclical and more volatile than other forms of capital investment. Economic conditions therefore affect the growth patterns of IT investment.
- Over the decade ending 2015, the Australian economy has experienced a major shortfall in MFP. Productivity downturns have been widespread across different sectors of the economy. We find no systematic relationship between IT and MFP growth across industries in Australia.

Looking forward, the main challenge for the Australian economy in the years ahead is to reverse the productivity shortfalls. The periods of high IT capital investment is now gone as the economy has reached to a more mature stage and growth has slowed with little sign of recovery.

The pro-cyclical nature of IT investment growth indicates that growth of IT and other forms of capital investment are highly dependent on business conditions. Clearly IT investment is not enough to stimulate economic growth. More is required and we suggest business improvements utilising IT capital are required to reverse the lacklustre economic performance in recent years.

The poor connection between IT investment and MFP indicates that changes in businesses need to focus increasingly on the effective use of technological opportunities. The enabling characteristics of IT indicate that necessary complementary changes, for example, organisational and managerial changes are required generate benefits from IT.

Glossary

Econometric Modelling

Econometric models are used to measure the statistical relationship between a dependent variable and one or more independent variables. Econometric modeling involves using quantitative data to find meaningful relationships between the variables of interest.

Growth Accounting (GA)

GA is a methodological framework established by Solow (1957) to decompose output growth into the contribution from each factor of production separately, as well as MFP. The methodology provides for a derivation of the MFP measure based on an aggregate production function.

Gross Domestic Product (GDP)

Gross Domestic Product: GDP is the monetary value of all the finished goods and services produced within an economy in a specific of period of time, e.g., a year or quarter.

Global Financial Crisis (GFC)

The Global Financial Crisis (GFC) believed to have begun in July 2007 with the credit crunch in the US financial market. Many economists believe that GFC has been the worst economic recession since the Great Depression of the 1930s.

Gross Fixed Capital Formation (GFCF)

GFCF refers to the "Expenditure on new fixed assets plus net expenditure on second-hand fixed assets, including both additions and or replacements. Expenditure on repair and maintenance of fixed assets is excluded, being chargeable to the production account. Compensation of employees and other costs paid by corporations in connection with own-account capital formation are included" (ABS 2015a, Glossary).

General Purpose Technology (GPT)

"A general purpose technology or GPT is a term coined to describe a new method of producing and inventing that is important enough to have a protracted aggregate impact. Electricity and information technology (IT) probably are the two most important GPTs so far" (Jovanovic and Rousseau 2005, p. 1182).

IT Elasticity

The concept of elasticity is widely used in economics literature (e.g., price elasticity of demand). Elasticity measures the sensitivity of a variable to the change in another variable and computed as ratio of percentage changes. IT elasticity measures the percentage change in output to the percentage change in IT investment, holding constant the contribution of other factor (e.g., non-IT).

Multifactor Productivity (MFP)

MFP represents the residual portion of output growth that cannot be explained by increases in inputs, such as labour and capital. According to the ABS (2007) "MFP takes account of several factor inputs at the same time and is largely a measure of the effects of technical progress, improvements in the workforce, improvements in management practices, economies of scale and so on. MFP can also be affected in the short term to medium term by other factors such as weather and by variations in capacity utilisation. Strictly speaking MFP growth occurs when there is an upward shift in the production function" (p. 99).

References

Australian Bureau of Statistics (ABS). 2007. Information Paper: Experimental *Estimates of Industry Multifactor Productivity*, Cat no. 5260.0.55.001, ABS: Canberra.

Australian Bureau of Statistics (ABS). 2015a. *Australian System of National Accounts*, Cat no. 5204, ABS: Canberra.

Australian Bureau of Statistics (ABS). 2015b. *Estimates of Industry Multifactor Productivity*, Cat no. 5260, ABS: Canberra.

Australian Bureau of Statistics (ABS). 2015c. *Consultation on topics emerging from submissions to the Information and Communication Technology Statistics Review*, Cat no 8179.0.55.002 Retrieved December 10, 2015 from Australian Bureau of Statistics (ABS), Canberra www.abs.gov.au/ausstats/abs@.nsf/mf/8179.0.55.002

Ahmad Nadim, Paul Schreyer and Anita Wölfl. 2004. "ICT investment in OECD countries and its economic impacts", *The Economic Impact of ICT–Measurement, Evidence and Implications,* OECD Publishing, Paris (pp. 61-83).

Banks, Gary. 2001. "The role of ICT in Australia's economic performance", Presentation to the *Commonwealth Research Forum,* Rydges Lakeside, Canberra 26 September 2001 (available at http://www.pc.gov.au/news-media/speeches/cs20010926/cs20010926.pdf). .

Barker, George, Melvyn Fuss and Leonard Waverman. 2008. *The Contribution of ICT to Productivity in Australia*, Working Paper 1, Centre for Law and Economics, Australian National University.

Brynjolfsson, Erik and Lorin M Hitt. 2000. "Beyond computation: Information technology, organizational transformation and business performance", *The Journal of Economic Perspectives*, vol. 14, no. 4, pp. 23-48.

Connolly. Ellis and Kevin J Fox. 2006. "The impact of high-tech capital on productivity: Evidence from Australia", *Economic Inquiry*, vol. 44, no. 1, pp. 50-68.

Dolman, Ben. 2009. "What happened to Australia's productivity surge?" *Australian Economic Review,* vol. 42, no. 3, pp. 243-263.

Dolman, Ben, Dean Parham and Simon Zheng. 2007. "Can Australia match US productivity performance?". Productivity Commission, Canberra (Available at http://www.pc.gov.au/__data/assets/pdf_file/0005/60449/productivityperformance.pdf).

Downes, Peter, Kevin Hanslow and Peter Tulip. 2014. "The effect of the mining boom on the Australian economy", *Reserve Bank of Australia Research Discussion Paper* 8, Reserve Bank of Australia, Sydney (available at http://www.rba.gov.au/publications/rdp/2014/pdf/rdp2014-08.pdf).

Eslake, Saul and Marcus Walsh. 2011. Australia's productivity challenge*", Grattan Institute Report No. 2011-1*, Grattan Institute, Melbourne (Available at http://grattan.edu.au/wp-content/uploads/2014/04/069_productivity_challenge.pdf)

Garnaut, Ross. 2010. *Climate change, China booms and Australia's governance struggle in a changing world,* **2010 Hamer Oration,** University of Melbourne (Available at http://benews.unimelb.edu.au/2010/climate-change-china-booms-and-australias-governance-struggle-in-a-changing-world/).

Gretton, Paul, Jyothi Gali and Dean Parham. 2002. "Uptake and impacts of ICT in the Australian economy: evidence from aggregate, sectoral and firm levels", A Paper prepared for the Workshop on ICT and Business Performance, OECD, Paris (Available at http://www.pc.gov.au/research/supporting/ict-uptake/uiict.pdf)

Gruen, David. 2012. "The Importance of Productivity", Paper presented at the Productivity Perspective Conference: Productivity Commission – Australian Bureau of Statistics, Canberra, 20 November 2012 (Available at http://www.pc.gov.au/research/supporting/productivity-perspectives-2012/01-productivity-perspectives-2012-gruen.pdf)

Harchaoui, Tarek M, Faouzi Tarkhani, Chris Jackson and Phillip Armstrong. 2002. "Information technology and economic growth in Canada and the US." *Monthly Labour Review,* vol. 125, pp. 3-12.

Jalava, Jukka and Matti Pohjola. 2002. "Economic growth in the New Economy: evidence from advanced economies." *Information Economics and Policy,* vol. 14, no. 2, pp. 189-210.

Johnston, Alan, Darrell Porter, Trevor Cobbold and Robert Dolamore. 2000. "Productivity in Australia's wholesale and retail trade", Staff Research Paper, Productivity Commission, Canberra (Available at http://www.pc.gov.au/research/supporting/wholesale-retail/wholesaleretail.pdf).

Jorgenson, Dale W and Kevin J Stiroh. 2000. "Raising the speed limit: U.S. economic growth in the Information Age", *Brookings Papers on Economic Activity* 1, Available at http://www.brookings.edu/~/media/Projects/BPEA/Spring-2000/2000a_bpea_jorgenson.PDF).

Jovanovic, Boyan and Peter L Rousseau. 2005. "General purpose technologies." *Handbook of economic growth* 1: 1181-1224.

Krugman, Paul. 1998. "I know what the Hedges did last summer " *Fortune (December)*.

Lipsey, Richard G, Kenneth I Carlaw and Clifford T Bekar. 2006. *Economic Transformations: General Purpose Technologies and Long -term Economic Growth,* Oxford University Press, USA.

OECD. 2013. *Measuring the Internet Economy,* OECD Publishing, Paris.

Oliner, Stephen D and Daniel E Sichel. 2000. "The resurgence of growth in the late 1990s: is information technology the story?" *The Journal of Economic Perspectives,* vol. 14, no. 4, pp. 3-22.

Parham, Dean. 2004. "Sources of Australia's productivity revival." *Economic Record,* vol. 80, no. 249, pp. 239-257.

Parham, Dean. 2005a. "Australia's 1990s productivity surge: A response to Keith Hancock's challenge", *Australian Bulletin of Labour,* vol. 31, no. 3, pp. 295-303.

Parham, Dean. 2005b. "Is Australia's productivity surge over?" *Agenda,* vol. 12, no. 3, pp. 253-66.

Parham, Dean, Paul Roberts and Haishun Sun. 2001. "Information technology and Australia's productivity surge", Staff Research Paper, Productivity Commission, Canberra (Available at http://www.pc.gov.au/research/supporting/it-surge/itaaps.pdf). .

Parham, Dean. 2002. "Productivity and policy reform in Australia", *International Productivity Monitor* vol. 5, pp. 53-63.

Romer, Paul. 1991. *Endogenous Technological Change,* NBER Working Paper No. 3210, National Bureau of Economic Research (Available at http://www.nber.org/papers/w3210.pdf)

Shahiduzzaman, Md and Khorshed Alam. 2014. "The long-run impact of information and communication technology on economic output: The case of Australia", *Telecommunications Policy,* vol. 38, no. 7, pp. 623-633.

Solow, Robert M. 1957. "Technical change and the aggregate production function", *The Review of Economics and Statistics,* vol. 39, no. 3, pp. 312-320.

Stiglitz, Joseph E. 2002. "Information and the change in the paradigm in Economics", *The American Economic Review,* vol. 92, no. 3, pp. 460-501.

Stiroh, Kevin. 2002. "Reassessing the impact of IT in the production function: a meta-analysis", *Federal Reserve Bank of New York, mimeo*, (Available at http://www.nber.org/criw/papers/stiroh.pdf).

The Conference Board. 2015. "Total Economy Database". http://www.conference-board.org/data/economydatabase/.

Topp, Vernon, Leo Soames, Dean Parham and Harry Bloch. 2008. *"Productivity in the mining industry: Measurement and interpretation"*, Staff Working Paper, Productivity Commission, Canberra (Available at http://www.pc.gov.au/research/supporting/mining-productivity/mining-productivity.pdf).

Venturini, Francesco. 2009. "The long-run impact of ICT." *Empirical Economics,* vol. 37, no. 3, pp. 497-515.

PwC Chair in Digital Economy based at QUT
www.chairdigitaleconomy.com.au

QUT Gardens Point 2 George Street BRISBANE Email: admin@chairdigitaleconomy.com.au
Phone: +61 3138 0474

@chairdigitaleconomy
https://www.facebook.com/chairdigitaleconomy/
https://www.linkedin.com/company/pwc-chair-in-digital-economy
https://soundcloud.com/pwc-chair-digital-economy