The economic effects of broadband: an Australian perspective

RESEARCH STATISTICS AND TECHNOLOGY BRANCH

Department of Communications, Information Technology and the Arts

May 2007

ACKNOWLEDGEMENTS

This paper was prepared for presentation at a joint WPIIS-WPIE Workshop held by the OECD at the DTI Conference Centre, London, United Kingdom, on 22 May 2007. The paper was prepared by:

Peter Collins Manager, Research Research Statistics and Technology Branch	David Day Research officer Research Statistics and Technology Branch	Chris Williams Research officer Research Statistics and Technology Branch

Under the executive direction of Judith Winternitz, General Manager, Research Statistics and Technology Branch, Australian Government Department of Communications Information Technology and the Arts.

For enquiries please contact:

Peter Collins
Manager
Research Statistics and Technology Branch
Department of Communications Information Technology and the Arts
GPO Box 2154
CANBERRA ACT 2601

email: peter.collins@dcita.gov.au
phone: 61 2 6271 1150
fax: 61 2 6271 1144

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LIST OF ABBREVIATIONS

ABS	Australian Bureau of Statistics
ACCC	Australian Competition and Consumer Commission
ADSL	Asymmetric Digital Subscriber Line
ANU	Australian National University
ATAC	Australian Telework Advisory Committee
CIE	Centre for International Economics
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DCITA	Department of Communications, Information Technology and the Arts
DEST	Department of Education, Science and Training
DSL	Digital Subscriber Line
FIBRE	Film Industry Broadband Resources Enterprise
GIS	Geographic Information System
GDP	Gross Domestic Product
GPT	General Purpose Technology
GSP	Gross State Product
ICT	Information, Communication and Technology
IOS	Internet Operating System
IP	Internet Protocol
IS	Information Systems
ISDN	Integrated Services Digital Network
ISP	Internet Service Provider
IT	Information Technology
ITU	International Telecommunications Union
Kbps	Kilo bites per second
Mb	Megabite

Mbps	Mega bites per second
NOIE	National Office of the Information Economy
NPV	Net Present Value
OECD	Organisation for Economic Co-operation and Development
RANZCP	The Royal Australian and New Zealand College of Psychiatrists
RTA	Roads and Traffic Authority
SCM	Supply Chain Management
USA	United States of America
VoIP	Voice over Internet Protocol
WiMax	World interoperability for Microwave access

INTRODUCTION

Broadband is claimed to bring significant economic benefits. In this paper, we assess the available evidence to give an Australian perspective on this issue. In doing so, we report upon the available Australian research into the benefits of broadband and other things with which broadband is associated, such as ICTs, e-commerce, supply chain management and tele-working[1]. Because much of the research investigates things like the economic benefits of things like ICTs, of which broadband is just one component, care needs to be taken when interpreting its results as an indicator of the economic benefits of broadband.

In the second part of the paper, we discuss an approach to estimating the economic benefits of broadband that would rigorously assess the veracity the claims made about the benefits of broadband.

The economic benefits of broadband that we discuss in this paper are those that may have occurred to date. We make no attempt to project what economic benefits broadband may generate in Australia in the future, when second generation broadband[2] is likely to be more widely available and more services are likely to be available to exploit it.

WHAT IS BROADBAND?

Broadband means different things to different people, particularly across international borders. The word 'broadband' means broad bandwidth, but by itself, this is not very helpful and there is no definitive definition of what 'broadband' actually is. This is partly because Internet speeds are constantly increasing and as a consequence, the meaning of broadband is regarded as a 'moving target' (ITU, 2003).

Reflecting the problem of definitively defining broadband, some broad definitions have emerged that are relative in nature. The ITU (2003 p.6), for example, refers to broadband as being *'Internet connections that are significantly faster than today's dial-up technologies, but [it is] not a specific speed or service'*. DCITA (2006a p.10) provide a similar definition, referring to broadband as allowing users *'fast, 'always on' online access to digital content, applications and a range of services, some or all of which can occur simultaneously'*.

What these relative definitions reflect is that broadband is simply faster data speeds over the Internet, with the added convenience of an always on connection, rather than being something radically new. The arrival of the Internet itself was the profound

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1 It is necessary to go beyond research that investigates the benefits of broadband directly because this research is not common in Australia. In the Unites States, this also appears to be the case, Lehr *et. al.* (2006) state most previous research has concentrated on the benefits of particular broadband projects. Their own research, is by their own admission, a very preliminary investigation that needs the weight of further evidence to support its conclusions before strong inferences may drawn from it, particularly with regard to its estimates.

2 Second generation broadband is regarded as being connections that run at between 2 and 10 Mbps. The concepts of first and second generation are explored more fully in the next section of this paper.

change. Some argue that the Internet is a General Purpose Technology (GPT), or a technology that is pervasive with the potential to radically change the way we do things, including through inspiring the development of complimentary technologies that further increase its power.[3] In this vein, technologies, like ADSL, that make wide scale access to faster data speeds over the Internet possible, could be thought of as complimentary technologies to the GPT.

Another thing that the relative definitions allude to is that the Internet could potentially operate anywhere along a continuum of data speeds. What we call broadband simply reflects the next part of the continuum to which we are about to migrate, or have already migrated, to have access to faster data speeds over the Internet than we have had previously. Broadband could thus be thought of as a somewhat arbitrary differentiation between the relatively fast Internet speeds of today and the slower Internet speeds of yesterday, which we now call narrowband. Moreover, the data speeds at which the point of differentiation occurs is likely to change over time. This is consistent with the ITU's (2003) notion that broadband is a 'moving target'. The OECD (2002) has also noted that '*broadband today may be considered narrowband in a couple of years*'.

Definitions of broadband have nevertheless emerged that specify a minimum downlink speed for a connection to be considered broadband, as we know it today. The ABS (2006) considers it as being *'an 'always on' Internet connection with an access speed equal to or greater than 256 Kilobits per second (Kbps)'*. The OECD (2002) provides a similar definition; that broadband is transmission capacity that provides '*downstream access of 256 Kbps'*.

Reflecting the somewhat arbitrary classification of broadband, some consider 'true' broadband to be at least 2-10 Mbps. This type of connection is also referred to as 'next generation' broadband. The lower broadband speeds, such as 256 Kbps, are referred to as 'first generation' or 'early' broadband.

For this paper we have adopted the ABS definition of broadband, which is stated above. Even though this may well be considered the narrowband of tomorrow, it has, to date at least, been consistent with the dominant entry level broadband package available in Australia, which has a 256 Kbps downlink and a 64 Kbps uplink. By adopting this definition we avoid the risk of excluding benefits that have been experienced by a large number of Australians to date and we also capture those that have accrued through 'next generation' broadband services.

BROADBAND IN AUSTRALIA

The use of broadband is growing in Australia and recently the ABS (2006a) reported that just over half of all Internet connections were broadband. As at September 2006, there were around 6.7 million active Internet subscribers in Australia, of which

[3] See, for example, Harris (1998). Others like Lipsey *et.al.* (1998) argue that the Internet is part of a wider family of technologies known as Information and Communication Technologies (ICTs) that are collectively a GPT.

88 per cent were households and 12 per cent were business and government. Of these, around 3.9 million[4], or around 59 per cent were broadband subscribers.

Broadband users in Australia are connected to the Internet by a wide range of technologies. The most commonly utilised are:

- *Digital subscriber lines* (DSL): available via normal copper wire connections. An asymmetric digital subscriber line (ADSL) is a type of DSL.
- *HFC (Hybrid Fibre Coax)*: data is sent over a network comprised of optical fibre and co-axial television cable.
- *Wireless*: includes a range of technologies that utilises various bands of radiofrequency spectrum.
- *Satellite*: a satellite is used in conjunction with a radio link and a satellite dish to supply broadband. This service is commonly used by those in regional and rural areas who are out of reach of other alternative broadband infrastructure.
- *Fibre*: high capacity fibre optics, which split out single fibres to the end-user.

ADSL is the technology that is used to provide the vast majority broadband connections in Australia, providing around 76 per cent of these (Table 1). The next biggest is cable at around 17 per cent. The other category, which includes fibre and wireless connections, has been growing rapidly, although it still represents a relatively low percentage of total connections (ACCC, 2006)[5]. The proportion of these connections is, however, expected to grow in light of the roll out by Telstra of its Next G network *"which is slated for 98 per cent of the population, promises speeds of up to 14.4 Mbps by 2007"* (DCITA, 2006, p.30).

TABLE 1: AUSTRALIAN BROADBAND SUBSCRIBERS BY DELIVERY MEDIUM, 2006

Broadband medium	Percentage of subscribers
Cable	17
ADSL	76
Satellite	1
Other DSL	2
Other	4

Source: ACCC, 2006

The vast majority of Australian broadband users are using what was referred to earlier as first generation broadband. Around 83 per cent have been estimated to be using connections with downlink speeds of less than 1.5 Mbps (Table 2), which would imply that around 17 per cent, or less, of broadband users would be using Internet connections that are second generation broadband. The number might be less than 17 per cent because second generation broadband was referred to as a connection with a

4 This estimate includes those people with an ISDN connection, who are outside of the definition of broadband being used in this paper.

5 The ACCC data is collected from a limited number of major ISPs and does not cover the whole industry, which means its estimates of subscriber numbers may be inaccurate. Despite this, the estimates of the share of subscribers using each technology should be reasonable.

downlink of between 2 and 10 Mbps, whereas the 17 per cent is based on an estimate of users with a connection that is at least 1.5 Mbps.

TABLE 2: SUBSCRIBERS BY DOWNLOAD SPEED

Download speed	Business subscribers (%)	Household subscribers (%)	Total subscribers (%)
Less than 256 kbps	34	42	41
Broadband			
256 kbps to less than 512 kbps	21	20	20
512 kbps to less than 1.5 Mbps	26	21	22
1.5 Mbps or greater	19	17	17
Total broadband	*66*	*57*	*59*

Note: Connections of 256kbps and over are defined as being broadband.

Source: ABS (2006a)

International comparison

Australia has a lower penetration rate for broadband compared to some other countries but it had been growing quickly in recent years, which suggests Australia is an earlier adoption phase to many other OECD members. As at December 2006, Australia had 19.2 subscribers per 100 inhabitants, which ranked Australia ranked 16th out of the 30 countries surveyed (Table 3).

TABLE 3: OECD BROADBAND SUBSCRIBERS PER 100 INHABITANTS

Country	Rank	Subscribers
Denmark	1	31.9
Netherlands	2	31.8
Iceland	3	29.7
Korea	4	29.1
Switzerland	5	28.5
Canada	9	23.8
United Kingdom	11	21.6
Australia	*16*	*19.2*
New Zealand	21	14.0
Ireland	23	12.5
Greece	28	4.6

Source: OECD, 2006a

Between 2004 and December 2006, penetration more than doubled in Australia from 7.7 to 19.2 subscribers per 100 inhabitants. This growth has seen the Australian penetration rate grow from well below the OECD average to well above it.

INDICATORS OF ECONOMIC BENEFITS

The big picture

Contribution of ICTs to productivity growth

The effective utilisation of broadband is often touted as having a positive effect on productivity growth. Productivity is a measure of how effective firms are at converting inputs into products and services and growth in productivity is a key driver of economic growth. A pragmatic view of measuring productivity growth, used by Diewert and Lawrence in DCITA (2005a p.58), is that:

> *…productivity growth [is] an index of output growth divided by an index on input growth….*

There have not been any studies undertaken in Australia that seek to estimate the contribution of broadband to productivity across the economy. There have, however, been studies focused on the effect of ICTs, of which broadband is one component, on productivity growth.

Data inadequacies for productivity estimates

The contribution that ICTs have made to productivity growth has been somewhat of a conundrum for researchers over recent years. Many have thought that the contribution of ICTs has appeared lower than expected, especially given the widespread use of ICTs. Recent research by internationally renowned experts in productivity measurement has suggested that a major cause of the conundrum is the inadequacy of sector data to support this type of measurement for ICTs. DCITA (2005a) draws in part upon commissioned research by Diewert and Lawrence into the contribution of ICTs to productivity growth to address this issue.

The ABS uses the growth accounting method to estimate multifactor productivity growth in Australia. The growth accounting method estimates multifactor productivity as an increase in aggregate output that is not explained by an increase in aggregate inputs. Growth accounting assumes constant returns to scale and perfectly competitive markets.

Diewert and Lawrence contend that these assumptions, and hence the growth accounting framework, are not ideally suited to measure the contribution to productivity growth that is made by ICTs. They use an econometric approach which they argue better separates out the effects of increasing returns to scale, which is a movement along the production function, and technical progress, which is a shift in the production function.

The approach taken by Diewert and Lawrence made use of the same data that the ABS uses to estimate multifactor productivity. These data provide a measure of all the productive inputs and outputs by industry sector. The input data are comprised of capital and labour. The capital input is an index of capital services, which is constructed by adding together varying constant price productive capital stocks estimates using rental prices as weights. This index is then added to an index of labour hours to form an overall index of inputs. The output measure is taken to be an index of gross value added.

In constructing the data for their analysis, Diewert and Lawrence noticed that there are problems with the ABS data that leads to problematic estimates of the rental price and rate of return for capital. The first issue is that it is very difficult to measure and value capital inputs with any confidence. The difficulties arise because of the limited age, use and efficiency information which is needed to estimate the capital stock. The second issue is that the rate of return needed to balance the value of outputs with the value of inputs differs considerably and implausibly between sectors. To over come this, rental prices were calculated by assuming that a producer would expect to earn a 4 per cent real rate of return, which is an average said to be consistent with a number of other national and international studies. Using this rate of return, however, did not result in each sector balancing the capital and labour inputs with outputs unless the rental rate for capital was implausibly low and in some instances, negative. The magnitude of this problem depended on the capital intensity of each sector.

The problems with estimating a rental and rate of return for capital meant that Diewert and Lawrence could apply their method of analysis to only four of the twelve industry sectors.

Another data issue to which Diewert and Lawrence drew attention is the issue of quality improvements. These are prevalent in ICTs but never fully captured in price indices, which ultimately skews the productivity estimates.

The work of Diewert and Lawrence indicates that productivity benefits derived from the use of ICTs in Australia, of which broadband is just one component, may be understated using traditional methods and existing ABS data.

Estimates of the contribution to productivity growth by ICTs

Despite the measurement issues discussed immediately above, it is still useful to review the findings of these studies to gain an insight into the effect ICTs may have had on productivity growth.

The Productivity Commission (2004) analysed the firm level effects of using ICTs and suggested its productivity effects accounted for a relatively small amount of the estimated total productivity gains. They found that the rise in ICT adoption during the 1990s raised the rate of growth in Australia's labour productivity and multifactor productivity. Increased use of ICTs added around 2-3 tenths of a percentage point to the acceleration of annual growth in output and capital deepening over the latter part of the 1990s. The Commission also found that increased use of ICTs contributed an estimated 1-2 percentage points to Australia's annual multifactor productivity growth. NOIE (2003), however, undertook a series of firm level case studies and found that ICTs contributed up to 1.26 per cent growth in labour productivity.

ICT has differing impacts on productivity across industry sectors. NOIE (2004a) explored the impact ICT use had on the level of productivity in Australia's manufacturing sector. They found that an increase in the capital deepening accounted for around 20 per cent of the growth in labour productivity. They also estimate that between 65 and 85 per cent of multifactor productivity growth in manufacturing during the 1984-85 to 2000-01 periods was due to technological factors. A study undertaken by DCITA (2005b) of the service industry found that 59 to 78 per cent of productivity growth can be attributed to technological factors over the same period. It found that the average annual labour productivity growth rate for industries that used ICT intensively (heavy users being determined by ICT investment relative to each working hour) was six times greater than the productivity levels achieved by light users of ICT, strongly associating the intensity of ICT use with productivity growth.

DCITA (2005a) reported on Australian studies at the aggregate level that examined the contribution of ICT to productivity growth, using a growth accounting approach. Keeping in mind that this particular method has been shown to face data-collection challenges, it was found that ICT capital accounted for more than a quarter of output growth and over a third of labour productivity growth. Over 40 per cent of labour productivity growth remained unexplained, which may or may not be represented by further contributions of ICT not picked up in capital deepening. These findings were preliminary, however, and Diewert and Lawrence in a follow up study for DCITA (2005d) conducted an analysis based on a more robust data set they constructed in association with the ABS. In the follow up study they found that:

- Australia's productivity performance over the previous 40 years had previously been underestimated significantly;
- ICT inputs are worth around 40 per cent more to producers than what they pay for them; and
- Around 85 to 90 per cent of Australia's MFP growth is accounted for by technical progress rather than increasing returns to scale in production.

While the studies discussed immediately above provide evidence that ICTs have contributed significantly to productivity growth, none address the issue of the contribution of broadband directly. None provide any evidence of the quantum of the contribution that broadband has made to the contribution that ICTs have made to productivity growth.

There is some evidence available in the form of survey data that sheds some light on the contribution of broadband to productivity. The Allens Consulting Group (2003) using data gained from a survey of businesses on the costs savings derived from using broadband Internet estimated that on average, the cost savings would result in a productivity gain of around 0.32 per cent for business. The survey results also indicated that businesses experienced savings in costs of around 6.3 per cent from broadband Internet compared to 1.5 per cent for dial up.

In another survey conducted by the Australian Industry Group (2003), 73 per cent of firms indicated that connection to broadband technologies had a positive impact on their productivity and efficiency. Eleven per cent believed, at that stage, that it was too early to make a judgement.

While the survey data is further evidence of broadband having a positive effect on productivity, it is not necessarily a good guide to the quantum of that effect. It is almost certain that the business respondents would have nominated cost savings of going from narrowband to broadband in a world where the Internet and associated services have developed to take advantage of the bandwidth made available by broadband. It is likely, however, that services which cut costs and enhance productivity could have developed in a world with narrowband that, while not as developed graphically as those around today, may have been almost as functional. It is the difference between the levels of costs and productivity that may have been achieved in a world without broadband and those being achieved today with broadband that are the real benefits of broadband, rather than those nominated by the business respondents in the survey. Those responses could, however, be interpreted as an upper limit estimate of the benefits of broadband to their businesses.

Output employment and wages growth

Productivity growth is a critical driver of output growth, which in turn helps drive growth in employment and real wages. Unfortunately, there have not been any backward looking analyses of the effects that the productivity gains discussed above may have had on output, employment and wages. There have, however, been forward looking studies, which are much more problematic because both the base case and the counterfactual scenarios are projections or analytical creations. In a backward looking analysis, only the counterfactual scenario is an analytical creation while the base case is what actually occurred. It is also the case that the estimates should be treated as upper bound because the productivity shocks put into the models have been constructed without reference to how productivity might have improved in a world without broadband, in the same way businesses have estimated the cost savings that are discussed immediately above.

The Allen Consulting Group[6] et al (2002a), in a forward looking study, examined what the economy might look like if greater involvement in the information economy gave rise to efficiency gains being forecast by businesses. In a second part of the study, Allens investigated how different the projected future might be if the cost to businesses of broadband access was 25 per cent higher than in the base case with perfectly competitive prices. The projected effect of high priced broadband was that GDP might be around one third lower in 2004-05 than with perfectly competitive prices. The high price broadband was also projected to generate around 73 000 less jobs in 2004-05 and cost around $10 280 per employee in foregone real wages over 10 years.

Projecting future events is an imprecise art and the veracity of the projections Allens made in 2002 may only be verified, or otherwise, if a backwards looking study was now completed using the same counterfactual scenario but using actual efficiency gains in the base case.

Allens (2003) also analysed the effects constructing a next generation broadband network in the major urban area of Queensland. Two scenarios were compared to the base case, in which the network was not built. In one scenario, broadband infrastructure was operated by a single vertically integrated owner and retail service provider. In the second scenario, open access to the network was given to numerous retail service providers.

In the case of a the next generation broadband network being operated by a vertically integrated firm, GSP and consumption for Queensland was projected to be around $854 million and around $500 million higher in 2018-19 than in the base case, in which the network was not built. Additionally, around 2 172 additional jobs were

[6] In some places in the rest of this paper we refer to ‘The Allen Consulting Group’ as Allens for ease of expression.

projected to be created in Queensland in 2018-19 and real wages were projected to be around 0.038 per cent higher than in the base case.

In the case of an open retail access to the next generation broadband network, GSP and consumption for Queensland was projected to be around $840 million and around $492 million higher in 2018-19 than in the base case, in which the network was not built. Additionally, around 1 650 additional jobs were projected to be created in Queensland in 2018-19 and real wages were projected to be around 0.037 per cent higher than in the base case.

Microeconomic benefits

At a microeconomic level, studies of the benefits of broadband are rare. As with the big picture studies, the micro level studies tend to be more about the benefits of ICTs and the Internet more generally, which still has a significant number of narrowband users, even amongst small business. The studies tend to focus on the changed ways in which businesses have operated since advances in ICTs have facilitated new and more efficient ways of transacting business and communicating with stakeholders. These changes have ultimately given rise to the changes to the big picture indicators discussed in the previous section. In the first instance, we discuss one industry in which broadband appears to be important to its recent development: the production and distribution of digital content. We then summarise the microeconomic benefits at a firm level before discussing three business and commerce processes that help generate these benefits, supply chain management, e-commerce and tele-working.

Production and distribution of digital content

The production and distribution of digital content occurs in many industries, some of which have been around for a long time. Others have emerged in the age of digitisation. The Australian Interactive Media Industry Association (AIMIA 2005, p. 3) has identified:

> *… visual effects and animation (including virtual reality and 3D products), interactive multimedia (e.g. websites, CD-ROM's) and software development, computer and online games, educational multimedia (e-learning) and digital film and TV production and film and TV post-production…*

as key areas in which digital content is produced.

The production and distribution of digital content is a significant and growing economic activity. A report prepared for DCITA (2005), by the Centre for International Economics (CIE), estimated that the production and distribution of digital content for 2002-03 to be worth around 3.3 per cent of GDP, or around $18 billion. CIE further estimated that around 289 000 people were employed in the production and distribution of digital content in the same year, this having grown by an average of around 2.7 per cent per year during the previous 6 years.

The OECD (2006b) alluded to the importance of the development of, and innovation in, broadband content in order for digital content industries to remain economically viable. In doing so, it noted facets of its production and delivery that rely on broadband technologies. The Film Industry Broadband Resources Enterprise (FIBRE, 2003), in its submission to the *House of Representatives Inquiry into 'the* *future opportunities for Australia's film, animation, special effects and electronic games industries*, also noted some of the collaborative activities and functions that require the use of a broadband network, including:

- sending digital files or scanned film images from laboratory to effects house;
- sending CGI elements of commercials to overseas agency clients for approval;
- recording 'ADR' sessions while the actor is in a remote location;
- linking music recording studio with sound editing facility;
- linking interstate branches of post production facilities for any of the above; and
- high quality video-conferencing sessions during production meetings, previews of work.

Perhaps one of the most important contributions broadband makes to the production of digital content in Australia, particularly given our location and the international nature of the content aggregation business, is making possible cost-effective collaboration with customers and clients who are overseas. The high speeds of broadband are essential for the movement of large files of graphics, video and audio.

The production and distribution of digital content appears to have the potential to grow. CIE (2005), in its study for DCITA, projected the worth of this activity might possibly be worth up to $38 billion by 2015 under favourable conditions, particularly with regard to access to skilled labour and finance, both of which have been major issues of concern for firms operating in this area.

An important point the CIE study did make is that while broadband is, and would continue to be, important to the production and distribution of digital content, by itself, it was not enough to bring success. In the words of the authors:

> *Having widespread access to true broadband services is necessary but far from sufficient to support change. It is the way that these facilities are used and factored into everyday life that matter.* (p. 36)

What this means for a rigorous assessment of the benefits of broadband is that the analysis would have to control for the influence of changes to these other critical factors that may change simultaneously with the advent of broadband but not be caused by it. This is necessary because if access to other critical factors like venture capital and sufficient skilled labour had been insufficient, the advent of broadband may not have been enough by itself to facilitate the production and distribution of digital content to its present levels. Furthermore, if all critical factors are present in a broadband world, but not a narrowband world, we could not attribute to broadband all the success of the production and distribution of digital content.

Firm level benefits

There have been some common themes that have run through qualitative studies into the benefits businesses may gain from the changes to their operations that are driven by advances in ICTs and a wider use of these.

The Productivity Commission (2004) investigated the more significant impacts of ICTs on firm performance and found these to include:

- reductions in staff levels in some cases and the enhancement of human capital;

- the reduction of some facilities and the outsourcing of particular functions;
- more timely management information;
- increased centralisation of decision making in relation to management practice;
- improved relationships with customers and clients through enabling improved responsiveness to customer needs; and
- improved and more frequent communication with customers and suppliers.

Business expectations and perceptions about what the Internet could bring appear to accord with the Commissions findings. In a survey of 634 Australian businesses, Allens (2002) found that the majority of respondents believed that the Internet would be beneficial across several important areas of running a business (Table 5).

TABLE 5: BUSINESS PERCEPTIONS OF INTERNET BENEFITS

Business perception	Per cent with Broadband	Per cent with Dial-up
Increased knowledge of market	67	61
Customers increasingly aware of channels to do business	63	55
Increased sales, customers or business revenue	49	40
Provides access to new markets or customers	60	56
Provides value-added applications	63	50
Increased efficiencies in sales and distribution	57	46

Source: The Business Database; Allen Consulting Group

In all instances, a significantly higher proportion of broadband than dial up users had positive expectations of what the Internet could achieve for their business. Clearly though, significant proportions of dial up users had positive expectations about what the Internet could do for their businesses.

The ANU and Central Queensland University (2004) reported that information and research, online banking and business communication are the three most common uses of the Internet by business. This report also found that the transmission of large files was one of the less important uses of the Internet by businesses and online sales were listed as the least important.

Supply chain management

One of the key contributors to improved business processes is the potential for substantial improvements to supply chain management (SCM). DCITA (2004, p. 1) has defined a supply chain as encompassing:

> *…all activities and information flows necessary for the transformation of goods from the origin of the raw material to when the product is finally consumed or discarded. This typically involves distribution of product from the supplier to the manufacturer to the wholesaler to the retailer and to the final consumer, otherwise known as nodes in the supply-chain. The transformation of product from node to node includes activities such as production planning, purchasing, materials management, distribution, customer service and forecasting.*

Effective SCM is reliant on collaboration between all elements or nodes within a supply chain. It is also reliant on the Internet for the electronic transfer of data and information, and to optimise the efficiency of collaboration. Examples of supply chain enhancements enabled by the Internet include:

- cost savings from the removal of paper transactions such as invoices;
- reducing transcription errors by lessening the need to re-key information from paper documents as the information is passed along the supply chain;
- increases in customer satisfaction; and
- integration of dispatch and distribution data with product development data all the way along the supply chain.

And for a globally trading enterprise, Gunasekaran et al (2004, p. 270) considered ICTs mandatory to an effective supply chain:

> *Since suppliers are located all over the world, it is essential to integrate the activities both inside and outside of an organisation. This requires an integrated information system (IS) for sharing information on various value-adding activities along the supply chain. IT is like a nerve system for SCM.*

The Australian Telecommunications Users Group (2007) presented a number of examples of the effective integration of broadband into SCM practices and processes. These examples offer solid illustrations of how ICTs may enhance productivity through more efficient functioning of various elements in the supply chain.

In one example, a company in the sugar industry that integrated remote sensing satellite technology, a GIS mapping system and a web interface to co-ordinate harvesting and transportation arrangements. The system slashed the manpower required, achieving a 50 per cent reduction in field officers, and inefficient communication and data flows. The 80 per cent of growers and harvesters using the portal regularly were better able to make timely and informed decisions and farmers could be presented quickly with the most up-to-date information. This example would require a broadband connection in order to sustain the GPS tracking and interactive web interface.

In a second example, a car dealership, freed up $200 000 through the use of a broadband connection to view and assess car parts, and order these for next-day delivery. This negated the need to keep $200 000 worth of parts in stock at any one time. Although broadband was used in this example, there is no explicit evidence that that it was essential. It is highly likely that, unless the parts were viewed in high quality video clips, which seems unlikely, the whole process could be supported by a narrowband connection.

NOIE (2004b) presented the case of the Bojangles hotel/restaurant business in Alice Springs. Bojangles invested $15 065 in an online supply chain and e-commerce strategy, which included time taken to research the requirements, payment to an external web developer, and software costs. Benefits flowing from the online supply chain of the business included a substantial reduction in the amount of paperwork, increased employee efficiency and improved customer satisfaction. There were also savings on administrative costs and in total, the savings amounted to $57 236. The online sales component of the strategy generated $1 200 of additional revenue. A narrowband Internet connection was used to support this initiative but there were problems logging online from time to time, which occasionally disrupted business processes.

E-commerce

E-commerce is similar to broadband itself in that the term means different things to different people. The OECD (1999, p. 16), for example, defined e-commerce more broadly as:

> *…a business model built around the application of information and communication technologies to any aspect of the value chain for products and services*

The ABS (2002a), on the other hand, defined e-commerce more narrowly as:

> *…purchasing or selling via the Internet, or more precisely placing or receiving orders for goods and services via the Internet, with or without on-line payment.*

While the ABS definition would most closely estimate the benefits of broadband when used for e-commerce, analyses of e-commerce in Australia have taken a broader view of e-commerce more in line with the OECD definition above. NOIE (1999, p. 2), for example, defined e-commerce as:[7]

> *…any type of business transaction or interaction in which the participants operate or transact business or conduct their trade electronically.*

While most e-commerce is Internet based, the definition is much broader than that and would also take in commercial transactions completed over the phone or facsimile.

In the early days of e-commerce in Australia, NOIE (1999, p. 3) observed that:

> *...e-commerce has significant implications for the whole of business process. Adoption of e-commerce has led many organisations, for example, to reengineer the way that they do business. Others are transforming their approach to business, or their business model, entirely.*

There seems little doubt that the proliferation of ICTs has changed business structures and processes and as a result, increased efficiency, productivity and output. The revenues earned from online sales, however, may not always be a large net benefit to the Australian economy, even though these may increase the revenue of an individual business. This may be the case where sales have simply been diverted from another part of the economy. Nevertheless, the growing and innovative use of e-commerce seems to have brought significant economic benefits through lower costs and efficiency gains.

The value of e-commerce activities in Australia grew from $9.4 billion in 2000-01 to $33.3 billion in 2003-04 and $39.6 billion in 2004-05 (ABS, 2005b). In 2002, more than half of Australian businesses earned some revenue online and on average, 6.4 per cent of total revenue was earned online (Allen Consulting Group et al, 2002b).

NOIE (2001) reported on 34 case studies of SMEs that analysed the rate and effectiveness of business adoption of e-commerce. The aggregate results indicated that improved efficiency in business operations was the primary opportunity afforded by e-commerce for 62 per cent of respondents and for the other 38 per cent, it was the opportunity to increase sales to new and existing markets. Consistent with this, 55 per cent of the gross benefits reported came from efficiency savings, which were generally in the form of utilising more efficient communication means, online transactions, and the deployment of a website for marketing purposes. The remaining 45 per cent came from additional revenue, which was generated primarily by the acquisition of new customers who had discovered the businesses through their websites.

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7 This reference follows that used by DCITA (1999).

In another study, DCITA (2006a, p. 53) reported that:

> *Many businesses are using broadband to reduce costs, increase productivity and expand their markets. A niche business in the Gold Coast Hinterland, Huppy's Chalk Art, creates custom designed, smudge-proof chalk boards for local and international markets. To serve an international clientele in Japan, the USA and Canada, the owner makes initial contact through a website. To clarify requirements he uses a VoIP facility which enables him to have a 10 minute conversation for about 30 cents. He is also using a VoIP gateway to allow potential clients to ring him for the cost a local call.*

In this example, broadband is utilised to provide cost effective and prompt communication with international clients. Although VOIP is able to operate on a narrowband connection running at 128/64 Kbps, it does so at a much reduced quality, which would not be attractive to a business attempting to woo international customers. Aside from the use of VoIP, however, it is likely that the business could have achieved a similar international presence with a narrowband Internet connection.

DCITA (2006c) reported on three more examples where broadband facilitated e-commerce applications where there is a need to transfer large amounts of data electronically. The first is a marketing consulting business run from home on the Gold Coast that regularly sends and receives large files containing graphics. The second is a wedding garden business that regularly has to transfer large files of 10 Mb. The third is an IT business in Barrington that in part develops web pages. The operators found that narrowband, operating over a dial-up connection, could not cope satisfactorily with the large files associated with the web page development part of the business.

Tele-working

Teleworking, also known as telecommuting, has been defined by ATAC (2006, p. 6)as:

> *…work undertaken, either on a full-time, part-time or occasional basis, by an employee or self-employed person, which is performed away from the traditional office environment, including from home, and which is enabled by ICT, such as mobile telephony or the Internet.*

There are economic and social benefits that may flow from tele-work, which depending on the circumstances, may include:

- giving employees an improved quality of life at work and more flexibility, leading to improved employee morale, reduced stress and a better work/ personal life balance (Bauer et al, 2002);
- allowing mature age workers seeking lifestyle changes to move away from cities and keep working;[8]
- creating more employment opportunities for people who live in regional and rural communities;
- giving people with disabilities the flexibility to work from home, which would be especially beneficial where home-based care might be required; and
- environmental and cost benefits from reduced travel.

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[8] This and the next two listed dot points were sourced from http://www.workplace.gov.au/workplace/Pages/ContentPage.aspx?NRMODE=Published&NRORIGINALURL=/workplace/Category/SchemesInitiatives/WorkFamily/TeleworkingorHomeBasedWork.htm&NRNODEGUID=%7b895AAEEF-8F02-49CF-B9B3-D9E67709902B%7d&NRCACHEHINT=Guest#benefits

While there is no doubt that broadband contributes to the achievement of these sorts of benefits, it is far from clear that broadband is critical to generating them. That is, it is far from clear that many of these benefits could not have been generated in a world that had only narrowband access to the Internet. Sensis (2005), for example, defined tele-working as:

> *working away from your usual workplace during normal business hours aided by some form of technology,*

and surveyed individuals and businesses about several aspects of tele-working. Sensis found that:

- While 30 per cent of individuals did tele-work, it is very much a part time activity. Five hours was the most common number of hours a person tele-worked in a week and 80 per cent indicated they spent 25 per cent or less of their working week tele-working.
- The three most frequent tasks performed by tele-workers were reported as servicing customers, communications tasks, and e-mailing and completing administration tasks, at 24, 23 and 19 per cent.
- Perhaps the most telling statistics indicating that broadband is useful but not critical is the benefits generated by tele-working is that the most common item of technology used to tele-work was the mobile phone, at over 53 per cent of individuals. A notebook computer was next, at 42 per cent, closely followed by desktop computers at 37 per cent. Broadband internet was some way behind the leading group at 25 per cent, along e-mail and telephone land-lines at 21 per and dial-up internet at 20 per cent.
  - Access would not seem to be an impediment to broadband internet being higher up the list of the most common technology used to tele-work. Of the individuals that did tele-work, 51 per cent indicated they had broadband internet.
- Individuals not tele-working did not identify lack of access to broadband as a major impediment to them tele-working. Only 9 per cent indicated that lack of access to suitable equipment/technology of any type as the reason they did not tele-work. The major reason given, by 25 per cent of individuals who, for example, worked in the hospitality industry, was that their work did not suit tele-working.

Before broadband became widey available, the Road and Traffic Authority (1994) conducted a pilot project to assess the value and implications of tele-work and found that it generated significant benefits. They found that the test group: experienced a 79 per cent reduction in their average total daily travel distances and when they completed work items of similar scope to others outside the group: 30 per cent did so at a lower cost; 35 per cent did so to a higher quality; and 69 per cent took less time to complete the work.

Broadband will most likely be more critical to tele-working in the future, where the Internet is required. As Bauer et al (2002) has noted for the USA, narrowband services are becoming increasingly inadequate for use in telecommuting for those who use the Internet intensively, frequently transfer large files or need to keep in constant contact with clients via the Internet.

Health Education and Government Services

The delivery and use of health education and government services are often cited as areas where broadband has the potential to deliver significant benefits. Many of the benefits relate to the ‘social well-being’ of users but there are also direct and indirect economic benefits potentially available for providers and users that may be attributed to the use of broadband to deliver these services.

Health

NOIE (2003a) estimated the impacts of accelerating the rollout of broadband infrastructure to hospitals in Australia using a cost benefit analysis. The report estimated that in 2003:

> *the net economic benefit accruing to Australia from the deployment of broadband to major Australian hospitals currently without broadband at $190 million over 10 years. A delay in the rollout of broadband would reduce the net present value of this benefit in the order of $58 million to $87 million.*

Many of the savings contributing toward these benefits stem from the delivery of health services using telecommunications technology. This is referred to as ‘telehealth,’ or e-health. E-health services often require a lot of complementary resources and equipment to be delivered adequately, which means that broadband is just one of many technologies that should be credited with giving rise to e-health benefits.

E-health services are generally categorised as either synchronous or asynchronous. Synchronous services are those that require a real-time examination of a patient and generally require powerful networks and stable communication channels to transmit high-quality images so that accurate diagnoses may be made (Bauer et al, 2002). The low delay times of broadband are crucial to the successful delivery of these services to regional and remote communities without either them or the service provider having to travel considerable distances and often at significant cost. Broadband-enabled applications that are commonly delivered in Australia presently include e-psychiatry, e-ultrasound and e-radiology (NOIE, 2003a).

A hospital at Inglewood, regional Victoria, for example, makes use of a 10 Mbps Internet connection to perform a range of tasks that require a large amount of bandwidth because of the large amount of information transferred. The more bandwidth hungry uses include: VoIP telephony; transferring of digital X-ray images to experts outside the region; and case conferencing by video (DCITA, 2006c).

Although e-psychiatry is often delivered over broadband, RANZCP (2002) has noted that most e-psychiatry services in Australia are presently delivered satisfactorily using narrowband connections with data speeds of 128 kbps. The number of services utilising higher bandwidths is increasing, however, due to the increases availability of broadband, the clearer picture, smoother motion and better synchronicity of sound provided by broadband.

Asynchronous services permit greater flexibility because these are not time critical and the ‘always on’ feature of broadband may not always be required. These services may thus be provided satisfactorily using narrowband. These include emailing medical data and diagnosis or consultation via the telephone or fax.

Broadband may also assist in meeting the increasing demand for aged care in Australia by increasing the capacity for elderly people to remain at home and have quick access to assistance when it is required. Video-based broadband connections allow people to stay at home to access medical staff and certain diagnostic tools, such as checking the heart rate, blood pressure and urine samples.

The CSIRO Hospital Without Walls project is a prime example of using broadband technology to assist the elderly and chronically ill to remain at home while being continuously monitored. A small wireless device worn by the patient monitors their vital signs and movements and the relevant information is recorded by a local computer. It is sent to the appropriate clinicians, nurses or caregivers and reduces the need for hospital stays and improves the quality of the person's life. With a broadband connection, more information can be sent in real time, thus increasing the scope and number of patients to whom this option is available (NOIE, 2002a).

Education

Good education outcomes have long been linked to more productive labour, which benefits the individuals themselves, the firms who employ them and the economy more generally. E-learning has emerged as an important educational aid as the technology has emerged to facilitate it.

E-learning is any kind of learning that utilises electronic communications technologies and may simply be a computer based training course stored on a CD. But there are many applications of e-learning that involve the transmission of data and or images across the Internet or other network. These types of applications have the potential to give people access to educational resources at any time and at a lower cost, irrespective of their location.

Perhaps the best example of e-learning that utilises the bandwidth capacity of broadband is the interactive distance e-learning initiative operated by the School of the Air[9], which uses satellite broadband to bring a virtual classroom to students in remote areas. Students use laptops to interact with each other and work collaboratively on projects through features such a virtual whiteboard. This provides students with a quality of service not previously possible using two-way radio and allows teachers to engage the students as a group (NOIE, 2002b).

In higher education, many e-learning tools available to students are not able to operate through dial up services. NOIE, (2002b) has suggested that schools require connections of at least 2 Mbps to be to take advantage of the e-learning tools now available. It is likely, however, that in a world without broadband, e-learning tools of some form would have emerged to take advantage of the bandwidth available. Just how functional these might have been compared to the tools that have actually emerged is a matter of conjecture, but it would be wrong to attribute to broadband all the benefits of e-learning aids.

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9 Australia is a huge continent and is home to some of the most geographically isolated and remote communities in the world. Many children living in these communities are educated through the

Government

Government services are commonly delivered over the Internet now and this is referred to as e-government. AGIMO (2006) reported that nearly five out of ten Australian adults surveyed in 2006 had contacted an Australian Government via the internet during the previous 12 months. Forty on per cent of broadband users reported contact with government compared with twenty three per cent of dial-up users. That said, however, NOIE (2003c) indicated that most e-government services available in Australia may be accessed using a narrowband Internet connection. There has, however, been some move towards the more complex forms of e-government service delivery, which would increasingly require broadband to be fully utilised.

RIGOROUSLY ESTIMATING THE BENEFITS OF BROADBAND

Broadband is often touted as having significant economic value. While there is no doubt that broadband is associated with many things that generate significant economic benefits, it is not clear from the research conducted thus far how large a contribution broadband has made to those benefits. If, however, we regard the Internet or ICTs as a GPT and first generation broadband as a manifestation of complimentary technologies that provides an incremental improvement to the evolving GPT, GPT theory predicts a small incremental contribution to economic growth by first generation broadband.

Until the research is done to clarify the contribution of broadband to the economic benefits discussed in this paper, caution should be exercised in speculating on the size of the economic effects of broadband to date; otherwise dogmas may emerge that while fashionable, are unsubstantiated. By way of example, economic historians almost universally and uncritically accepted for many years the notion that the railways were critical to the development of the United States in the nineteenth century. People observed that the railways had expanded simultaneously with rapid development and the correlation was interpreted as a critical causal link. While there was little doubt of a causal link, it was not until Robert Fogel (1964) had conducted a ground breaking piece of research that the notion of it being critical during this period was challenged and revised.

A counterfactual approach

Fogel (1964), for the first time, used quantitative methods to model the development of the United States in the nineteenth century, as it happened, and compared this to a counterfactual scenario in which it was assumed the railways had not been invented during that time. In doing so, Fogel assumed much greater use would have been made of the canals, rivers and horse drawn drays, and that combustion engine vehicles would have developed sooner.

Fogel's results were initially controversial because they challenged a popular dogma by concluding, amongst other things, that if railways had never been invented, the level of per capita income achieved by January 1, 1890 would have been delayed by only a few months. In time, however, his methods of analysis and results became widely accepted.

Just as with assessing the role of the railways in the economic development of the United States in the nineteenth century, we may assess the true contribution that broadband has made to the Australian economy to date with a rigorous counterfactual analysis. Until that analysis is done, the principles of a counter factual analysis should guide what we take from other analyses to tell us something about the contribution to date of broadband to the Australian economy.

The analyses we have reported upon in this paper are useful for gaining an insight into the economic benefits that broadband may generate but fall short of a rigorous counterfactual analysis in three important areas. The first is that we have to be mindful that most of the analyses on which we call to gain an indication of the economic contribution that broadband makes, evaluate much more than the effects of broadband. Furthermore, people sometimes discuss broadband and its benefits as if it is a technology that, by itself, is a driver of economic growth and development. Such judgements, however, are rarely correct about any technology. The Royal Swedish Academy of Sciences (1993) noted in its press release when announcing it had jointly awarded Robert Fogel the 1993 Nobel Prize in Economics, in part for his work on the contribution of the railways to American economic growth in the nineteenth century, that:

> *Joseph Schumpeter and Walt W. Rostow had earlier, with general agreement, asserted that modern economic growth was due to certain important discoveries having played a vital role in development. Fogel tested this hypothesis with extraordinary exactitude, and rejected it. The sum of many specific technical changes, rather than a few great innovations, determined the economic development.*

The notion expressed in the Academy's announcement almost certainly also applies to broadband in the twenty first century, which presents a significant measurement and attribution issue for evaluating the economic benefits of broadband. Because broadband is a facilitator, and just one component of a wider group of complementary technologies known as ICTs, it is difficult to disentangle the benefits provided by broadband and other things that contribute to its creative use. Broadband, for example, is used with innovative software and hardware to provide many services.

Attributing benefits separately to broadband and other ICTs in the provision of these services would be exceedingly difficult, but necessary, if the benefits of broadband were to be evaluated rigorously.

The second area in which the analyses reported upon in this paper fall short of a rigorous counterfactual analysis is that none make reference to how narrrowband Internet may have developed in the absence of broadband. The comparison made in the analyses reported upon in this paper is between broadband and the narrowband alternatives as these are today. This is misleading because development of the alternatives slowed dramatically, or stopped altogether, when broadband technologies came along. Furthermore, complimentary technologies became optimised for broadband, making them work less than optimally with the alternatives. These considerations would be at the forefront of our minds when designing a plausible counterfactual scenario for a counterfactual analysis. We are not going to attempt that formally for this paper but when considering other analyses for insights into the economic benefits of broadband, there are six things we should be mindful of that would form an integral part of a counterfactual scenario. These are:

- Dial up connections give Internet subscribers a theoretical maximum data speed of 56 Kbps but real life speeds are somewhat less than this and there is little prospect of this being improved;
- Before broadband connections running at a minimum of 256/64 Kbps became widely available, and affordable, there were narrowband connections available that could bring the Internet to most users at speeds of 128 Kbps on the down channel and 64 Kbps on the up channel;
- The delivery platform that was carrying narrowband Internet at speeds of 128/64 Kbps was being further researched and faster narrowband speeds seemed possible;
- Narrowband services running at 128/64 Kbps were, and still are, expensive, but it is reasonable to assume that these may have become considerably cheaper due to competitive pressures had widely available and affordable broadband not come along, just as the price of broadband has indeed declined;
- There are many web pages and Internet services that could be made much less demanding of bandwidth without a significant loss of functionality if the 'glitzy' graphical overheads were removed, which is most likely how these would have developed without the invention and wide adoption of broadband technologies; and
- In a counterfactual world without broadband, all countries would not have broadband.

Another thing that could be added to such an analysis is that when people discuss the benefits of broadband, they seem to be discussing the benefits of the 'democratisation' of broadband. That is, the benefits of small businesses and households being able to access fast Internet at an affordable price through technologies such as ADSL. Large corporate and government organisations could gain, and afford, access to higher bandwidth services through delivery technologies like leased lines and ATM for a long time before the broader proliferation of broadband. For these sectors, the 'democratisation' of broadband has made broadband cheaper but not opened up access for the first time, as it has with the wider community.

The third thing we would need to consider carefully in a rigorous counterfactual analysis is just how much bandwidth is needed for activities conducted on the Internet and consequently, how much broadband, as defined for this paper, really adds to the narrowband that existed prior to it. Even with the current development of the Internet, many online activities, such as Internet banking, the majority of e-commerce and email with small to moderate sized attachments, for example, do not need a lot of bandwidth and operate quite well on a narrowband Internet connection (Table 4). Broadband offers lower download times for all applications, bringing with it a time saving, but is not a prerequisite for these sorts of Internet activities and the benefits these generate. For other Internet activities, however, a broadband connection is essential.

TABLE 4: APPROXIMATE MINIMUM SPEEDS FOR INTERNET ACTIVITES

Application	Bandwidth requirements (Mbps)
Email	0.028 – 0.056
IP telephony	0.028 – 0.128
Basic internet surfing	0.056 – 0.256
Online games	0.056 – 1
Teleconferencing	0.064 – 0.528
Video conferencing	0.128 – 1.128
Video on demand	1.128 – 7
Multi channel television	3 – 20
Download a 3 Mb CD in 5 seconds	5 – 20
HDTV (Mpeg 2)	25 – 34

Source: Various sources, including KPMG (2003); Geiselhart and Huta (2003)

The ideal bandwidth, however, is higher than the minimum and for bandwidth hungry activities, the difference lowers the quality of the user's experience. As Bauer et al (2002) notes, narrowband is enough for downloading or transferring a several hundred kilobyte document but a 10 Megabyte file requires broadband because the time requirement at narrowband speeds would be prohibitive. Furthermore, video conferencing and video on demand, for example, require a minimum bandwidth of 0.128 Mbps and 1.128 Mbps and an ideal bandwidth of 0.650 Mbps and 7 Mbps respectively (Geiselhart and Huta, 2003).

The use businesses and households make of the Internet is also critical in determining the benefits of broadband. Ericsson (2004) found that the top five reasons for use being connected to the Internet were to: send and receive emails; do banking; search for information about products and services; general browsing; and searching for specific information. Many of these applications work quite well on a narrowband connection, although, as noted previously, the extra speed of broadband adds to the experience of users.

With the above considerations in mind, services which broadband are used to access may be put into three broad classes. These are:

- Services for which broadband provides marginal benefits over narrowband. These services may be accessed and used effectively over narrowband, although broadband would provide a speed and time advantage over narrowband. These services include, for example, online payments, Internet banking, and email with small attachments.
- Services for which broadband provides significant benefits, although these may still be accessed over narrowband at a much reduced quality. These services include, for example, email with moderately large attachments and transmitting video, such as web cam images.
- Services for which broadband is essential. Narrowband simply does not have the capacity to carry these services at an acceptable quality. These services include, for example, email with very large attachments and transmitting high quality video, such as high quality videoconferencing and video on demand.

Other issues

In an analysis in which we are interested in determining how changes to broadband over time affect the changes to the benefits it brings, another measurement issue would be the ‘network effect’. This effect is that higher benefits are available to broadband users as the number of broadband users and services increase. A business providing a movie download service, for example, has a higher number of potential customers as the number of broadband users increases. In this exercise, however, we are only interested in the magnitude of the economic benefits that broadband has provided and are not concerned with determining if these are due to changes to broadband itself or the network effect.

CONCLUSION

Broadband means different things to different people but in Australia the most common entry level package is a 256/64 Kbps connection, most often delivered using ADSL. For this reason we have defined broadband for this paper as:

> *an 'always on' Internet connection with an access speed equal to or greater than 256 Kilobits per second (Kbps)(ABS, 2006)*

While there is no doubt that broadband has a positive economic value, it is not clear how large that value has been to date. The quantitative research has not been completed in Australia to answer this question.

Until the research is done, caution should be exercised in speculating on the size of the economic effects of broadband; otherwise dogmas may emerge that while fashionable, are unsubstantiated. By way of example, we discussed how economic historians almost universally and uncritically accepted for many years the notion that the railways were critical to the development of the United States in the nineteenth century. This remained the case until rigorous counterfactual research demonstrated otherwise.

Just as with assessing the role of the railways in the economic development of the United States in the nineteenth century, we may assess the true contribution that broadband has made to the Australian economy to date with a rigorous counterfactual analysis. Until that analysis is done, the principles of a counter factual analysis should guide what we take from other analyses, on which we rely for the moment, to tell us something about the contribution of broadband makes to the Australian economy. We also have to be mindful that most of the analyses on which we call to gain an indication of the economic contribution that broadband makes, evaluate much more than the effects of broadband.

Conducting a counterfactual analysis is always difficult and in the case of estimating the economic effects of broadband particular difficulties loom large. Productivity is one are we would expect the benefits of broadband to show up but at a sector level, the work of Diewert and Lawrence indicates that productivity benefits derived from the use of ICTs in Australia, of which broadband is just one component, may be understated using traditional methods and existing ABS data. Another difficulty is that because broadband is a facilitator, and just one component of a wider group of complementary technologies known as ICTs, it is difficult to disentangle the benefits provided by broadband and other things that contribute to its creative use. Broadband, for example, is used with innovative software and hardware to provide many services. Attributing benefits separately to broadband and other ICTs in the provision of these services would be exceedingly difficult, but necessary, if the benefits of broadband were to be evaluated rigorously.

We have reported the results of several studies that provide strong evidence that ICTs, of which broadband is a component, have made a significant contribution to productivity growth in Australia. None of these studies, however, address the issue of the contribution of broadband directly. None estimate the contribution that ICTs may have made to productivity growth in a counterfactual world without broadband. Without doing this, how much broadband has contributed to productivity growth must remain a matter of speculation.

We have also reported the results of modelling that indicate broadband has a positive effect on output, employment and real wages. These estimates should be treated as upper bound because the productivity shocks that have been put into the models have been constructed without reference to how productivity might have improved in a counterfactual world without broadband. The shocks, therefore, most likely overstate the productivity benefits of broadband over a counterfactual world in which there is only narrowband, along with broadband being delivered on platforms like ATM and leased lines for those who could afford it.

Lastly we have reported on a large body of research that principally investigates the effect that ICTs have had in some important areas in the economy. The areas on which we have focussed are:

- the production and distribution of digital content;
- supply chain management;
- e-commerce;
- tele-working; and
- health, education and government services.

There is no doubt of the importance of broadband to the benefits generated by ICTs in areas where bandwidth hungry activities are significant. This is partularly evident in the production and distribution of digital content, where large amounts of data have to be moved regularly, often internationally. In these areas, care needs to be taken, however, not attribute to broadband benefits that should in part be attributed to other critical factors. In the case of the production and distribution of digital content, for example, access to venture capital and skilled labour are also critical to the success of that activity. What this means for an assessment of the benefits of broadband is that a counterfactual analysis would have to control for the influence of changes to these other critical factors that may change simultaneously with the advent of broadband but not be caused by it. In some areas of e-health, such as case conferencing and the transfer of digital images, for example, the evidence also indicates that broadband has helped to generate economic benefits. Again, however, broadband has not been not alone in generating these benefits.

In other less bandwidth hungry areas, it is far from clear from any of the studies reviewed that broadband has been a critical ingredient to date to the benefits that ICTs have generated or that many of the claimed benefits of broadband to date could not have been obtained to a significant extent in a counter factual world without broadband.

To those familiar with the GPT literature, the apparent patchy performance to date of broadband in generating economic benefits in Australia would not come as a great surprise or be seen as a reason not to invest further in broadband. If, as has been postulated, the Internet or ICTs are a GPT, and the various generations of broadband are manifestations of complementary technologies that help make the GPT more useful in an incremental and evolutionary process, GPT theory predicts each incremental development will bring about small changes. The change from narrowband to first generation broadband, as has been experienced by many Internet users in Australia, could be viewed as one such small incremental development. Over a long period, however, GPT theory predicts the aggregate effect of the incremental developments will be significant. Evidence of this playing out in Australia may be found in how much further from a narrowband world second generation broadband has taken some Internet services compared to other services developed for first generation broadband.

As we move into the future, broadband is likely to generate higher economic benefits than it has to date, whatever that quantum may be. Second generation broadband is likely to be more widely available and more services are likely to be available to exploit it, taking us further into activities and services that may generate benefits a world without broadband would most likely find difficult to emulate.

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