Deloitte Access Economics

Mobile Nation: Driving workforce participation and productivity

Australian Mobile Telecommunications Association, 2016

Deloitte.

Contents

Glossary

1G	First Generation
2G	Second Generation
3G	Third Generation
4G	Fourth Generation
4G-LTE	Fourth Generation Long Term Evolution
5G	Fifth Generation
ABS	Australian Bureau of Statistics
ACMA	Australian Communications and Media Authority
AMTA	Australian Mobile Telecommunications Association
Apps	Mobile applications
CGE	Computable General Equilibrium
DAE-RGEM	Deloitte Access Economics' Regional General Equilibrium Model
EFTPOS	Electronic Funds Transfer at Point of Sale
IOT	Internet of Things
IP	Internet Protocol
LTE-A	Long Term Evolution Advanced
GDP	Gross Domestic Product
GPS	Global Positioning System
HR	Human Resources
M2M	Machine to Machine
MHZ	Megahertz
MM-WAVE	Millimetre Wave
MIMO	Multiple Input, Multiple Output
MR	Multiple Response
NFC	Near Field Communication
OECD	Organisation for Economic Co-operation and Development
SMS	Short Message Service
WAP	Wireless Application Protocol
WI-FI	Wireless Fidelity

Executive summary

Over the past three decades, the capabilities and adoption of mobile technologies have grown substantively. They have gone from being a novelty to become ubiquitous; an essential tool for modern life.

As the features of mobile technology have evolved, adoption has also significantly increased. While the ability to communicate on the go was at the forefront of the mobile revolution, the evolution of SMS continued to drive mobile adoption. 3G and data introduced a new world of possibilities, as it became possible to access the internet and email independent of location. From the late 2000s, smartphones with apps dramatically increased the functionality of mobile technologies.

Today, faster connections and ubiquity mean that mobile devices are used for everything – from commerce and research to location-based services and games. The mobile revolution has spread beyond smartphones to a range of devices, including tablets, laptops and dongles.

Mobile Nation (2013) reported that the mobile telecommunications sector contributed $14.1 billion in value added to the Australian economy in 2011-12. This included a direct economic contribution of $7.6 billion and indirect economic activity across the economy stimulated by mobile of $6.5 billion, and supported 56,972 full-time equivalent jobs. It focused on the business, social and productivity impacts of mobile, with a focus on data.

The next wave of the mobile revolution is now emerging. More businesses and individuals are adapting the way they behave and respond to mobile technology. Improvements in speed and latency will enable a range of new disruptive services, including the Internet of Things (IoT), autonomous driving, mobile wallets and drone technologies.

For this report, the Australian Mobile Telecommunications Association (AMTA) has asked Deloitte Access Economics to report on the updated impact of mobile on productivity in the Australian economy. Deloitte Access Economics was also asked to assess the importance of mobile technologies in enabling workforce participation in the economy, conducting this research for the first time.

Economic benefits of mobile technology

The Commonwealth Treasury regularly refers to the 'three Ps' of growth – productivity, participation and population (Intergenerational Report, 2007). Australia is currently facing an economic challenge to maintain national income and living standards over the coming decades. As commodity prices fall and the returns from the decade-long mining boom recede, Australia will need to find other sources of economic growth.

As technology has evolved, so has its impact on society and the economy. Mobile has had a positive impact on productivity and labour force participation – two of the 'three Ps' of economic growth.

This report seeks to quantify these impacts, using econometric analysis drawing off an extensive survey and computable general equilibrium modelling to estimate productivity and model participation impacts.

Improving labour productivity

Improving productivity is a key priority for businesses and policy makers. In the period 2001-2013, labour productivity contributed approximately 1.5% to growth, less than the 2.2% contribution over the period 1991-2000. To maintain growth in national income over the next decade at the level experienced from 2001-2013, labour productivity will need to increase significantly.

Mobile technology has played a key role in stimulating labour productivity growth since its introduction, by allowing employees to make more productive use of time, and work more efficiently with productivity-enhancing tools such as mobile apps. This report uses econometrics to model the annual productivity impacts of mobile on the Australian economy, controlling for other factors that may impact on productivity.
It estimates the economy is around **2.0% or $34 billion** larger in 2015 than it would otherwise be because of the long-term productivity benefits of mobile technologies. This compares to the productivity impact of the internet and digital technology to the economy – an estimated $45 billion in 2013, and the annual economic boost, which was forecast to arise from the National Competition Policy, estimated to be $40 billion in 2015.

Contributing to participation

Mobile technology's contribution to the economy is not limited to improving productivity. It also allows more people to work, or facilitates working more hours, thereby improving participation in the workforce. This will be important for future economic growth, with the Intergenerational Report (2015) projecting that, by 2054-55, the participation rate for Australians over 15 years old will fall to 62.4%, compared to 64.6% today.

Although these issues have been considered in the context of broadband, this important, but often overlooked impact of mobile, has not previously been analysed in detail in Australia.

This report is a fresh contribution to our understanding of the impact of mobile technologies on workforce participation in Australia. The main way in which mobile technologies' impact on work hours has previously been discussed, is how it may contribute to work intensification, with employees feeling a responsibility to respond to calls and emails outside traditional working hours. This is an important consideration for individuals and businesses about how work is done and time is recorded.

However, mobile technologies also allow more people to work. The analysis in the report is based on a survey of over 1,000 individuals – including part-time workers, parents, carers, people with a disability, young people, prospective retirees and people living in rural/regional areas – to determine whether mobile facilitated their willingness to work, or enabled them to work more hours.

Reducing barriers to employment can open up a new set of opportunities for individuals in these groups. For those who want to work but have not previously been able to, it can create social connectedness and improve financial independence.

For these groups, the flexibility facilitated by mobile is very important to labour force participation. Of those who are currently employed, nearly 15% would work fewer hours if they could not work remotely using mobile technologies, and 11% would work fewer hours if they could not meet personal commitments while at work. In total, it is estimated that those surveyed would work on average **0.6 hours less per week** if they did not have access to mobile devices. This means that the economy is **$8.9 billion** larger in 2015 than it would otherwise be as a result of mobile-enabled labour force participation. This additional GDP supported approximately **65,000** full-time equivalent jobs – about 1% of total employment.

Cumulative impact

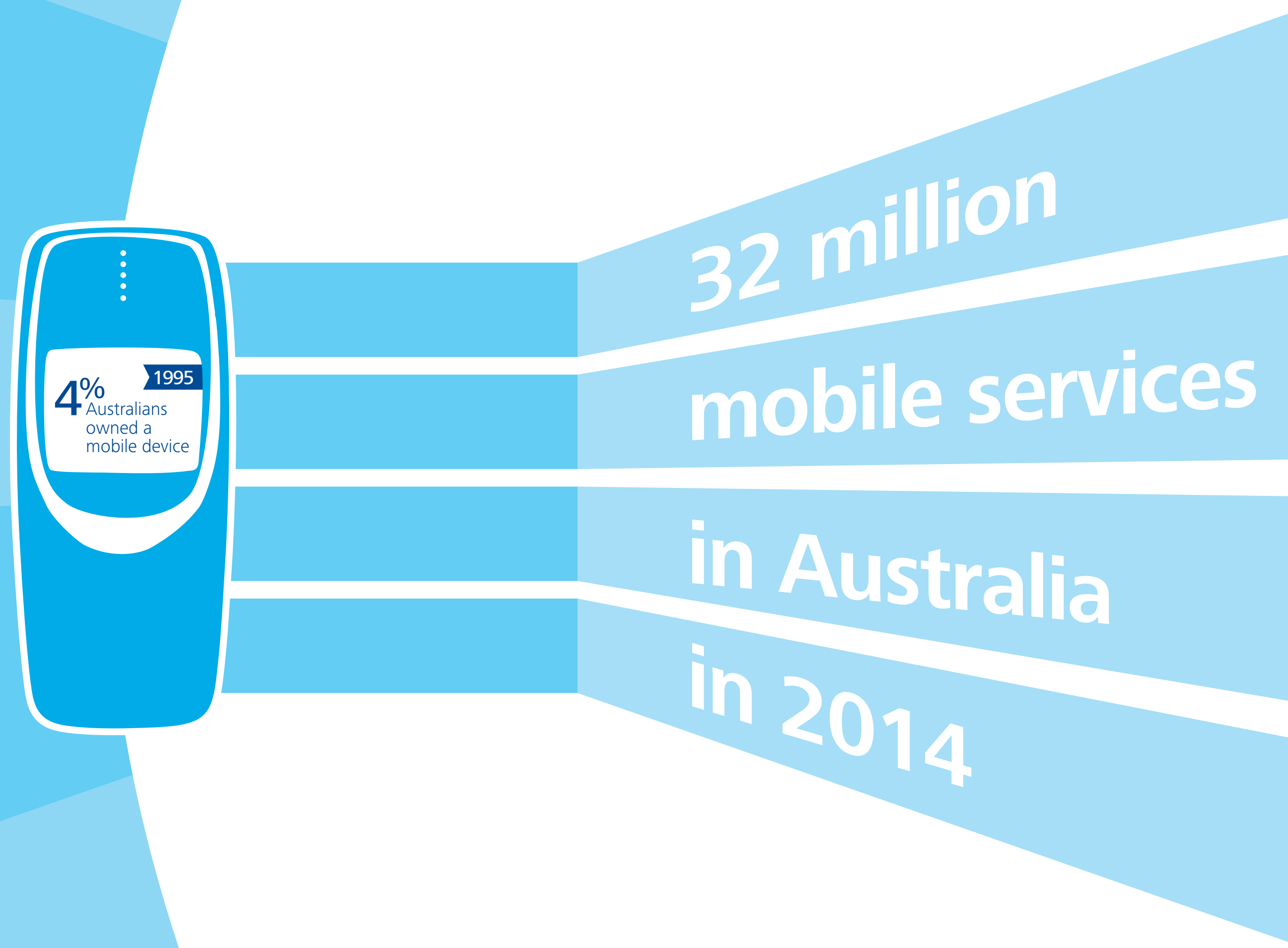
Cumulatively, this report estimates that the economy is $42.9 billion larger in 2015 than it would otherwise be, because of the productivity and participation benefits arising from mobile. This represents 2.6% of GDP.

Conclusion

With the next wave of new technology emerging – drones, the IoT, mobile wallets and autonomous cars – mobile will continue to grow in coming years. The impact of these technologies on society and the economy is yet to be seen. However, it is clear that mobile will continue shaping the way Australians communicate, work and interact. Harnessing the potential of new and existing technologies will be important for securing economic growth and living standards in to the future.

Deloitte Access Economics

1 Introduction



2015

52%

of Australian smartphone owners check their phones within 15 minutes of waking up

28%

check their phones within five minutes of going to sleep every night

Mobile technologies have improved the lives of Australians by making work and staying in touch easier. Smartphones, tablets, dongles and laptops provide an effortless way for people to keep in touch with family, friends and colleagues. Capabilities introduced by data – including the ability to access email, data and information anywhere or anyplace – allows people to stay engaged and connected. New industries and jobs have emerged to support this demand, including the application economy and the portable gaming industry.

There are still many areas of future growth. New mobile-enabled technologies – such as autonomous driving – will have a disruptive impact on the economy and society in coming years.

Few technologies in history have diffused as rapidly as mobile. Just two decades ago only 4% of Australians owned a mobile device – now, their presence and usage is ubiquitous (AMTA, 2008). According to the ACMA, at June 2014, there were 31.77 million mobile services in operation in Australia (ACMA, 2015). This is happening all over the world – for example, 52% of Australian smartphone owners check their phones within 15 minutes of waking up, and 28% check their phones within five minutes of going to sleep every night (Deloitte, 2015). Continual developments in mobile technology to improve their convenience, functionality, portability and simplicity have also allowed them to become the preferred channel to access the internet for most people in Australia and internationally (Search Engine Land, 2015).

There is a rich body of work that discusses the impact of mobile technologies on society, business and the economy. Previously in the *Mobile Nation* series (2013), Deloitte Access Economics found that the total value added of the mobile telecommunications sector in 2011-12 was $14.1 billion. This included a direct economic contribution of $7.6 billion and indirect economic activity across the economy stimulated by mobile of $6.5 billion, supporting 56,972 full-time equivalent jobs. The importance of the mobile sector was echoed by a recent report from Boston Consulting Group (2015), which found that the mobile value chain plays an important role in fuelling economic growth, generating almost $3.3 trillion in revenue globally in 2014 and directly responsible for 11 million jobs.

This edition in the *Mobile Nation* series takes a deeper look into some of the labour market impacts of mobile technologies, including improved productivity and increased labour force participation. This research makes a first attempt to quantify the value of these changes to the Australia economy, in particular, those attributable to the development and adoption of mobile technologies.

New research into the impact of mobile on workforce participation

The impact of broadband technology on workforce participation has previously been discussed. Reports such as Deloitte Access Economics' 2012 *Creating Jobs through NBN-enabled telework* discuss how the ability to work remotely could encourage more individuals to join the labour force.

However, the existing literature focuses on the role of the internet more broadly in facilitating participation. The role of mobile technology, specifically, in supporting workforce participation has not previously been quantified.

In this report, we conduct analysis based on an **extensive survey** and use **computable general equilibrium modelling** to determine the **role of mobile technology in increasing the level of workforce participation in the economy.** These details are discussed in more detail in section 4.4 of this report.

1.1 What is mobile?

Defining what constitutes 'mobile' is increasingly difficult. As the scope of mobile has expanded in recent decades, it has become harder to divorce devices from the telecommunications infrastructure that facilitates their use. This distinction is likely to become more complex in the near future, as the next wave of mobile technology emerges.

Broadly speaking, when asked to consider 'mobiles', many people think about a device – such as a smartphone or tablet. However, many of the features of these devices (such as making phone calls and using the internet) would not function without a mobile subscription.

Modern devices offer many means of connection – including mobile subscriptions, Wi-Fi (leveraging a fixed line network) or Bluetooth. These tend to be seamlessly integrated in most modern devices. This has allowed people to enjoy the benefits of mobile technology without actively managing – or even considering – their connection type.

People connect different devices to the internet in varying ways. A survey conducted for this report found that most people use a variety of methods to connect one device to the internet.

Modes of accessing the internet on various devices

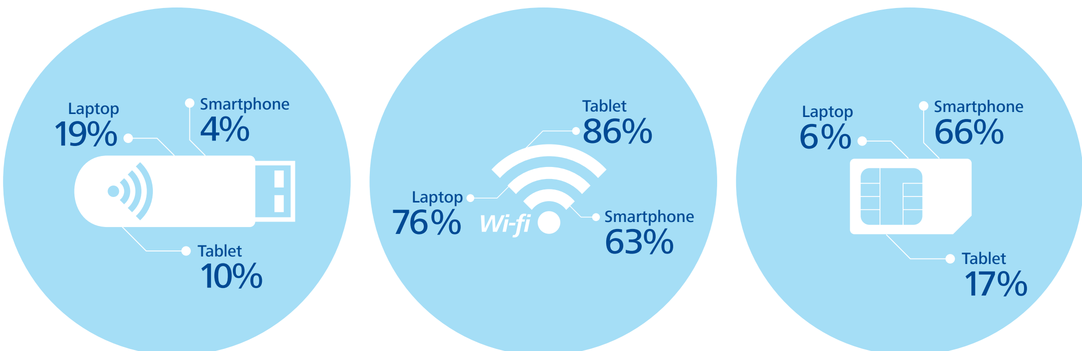
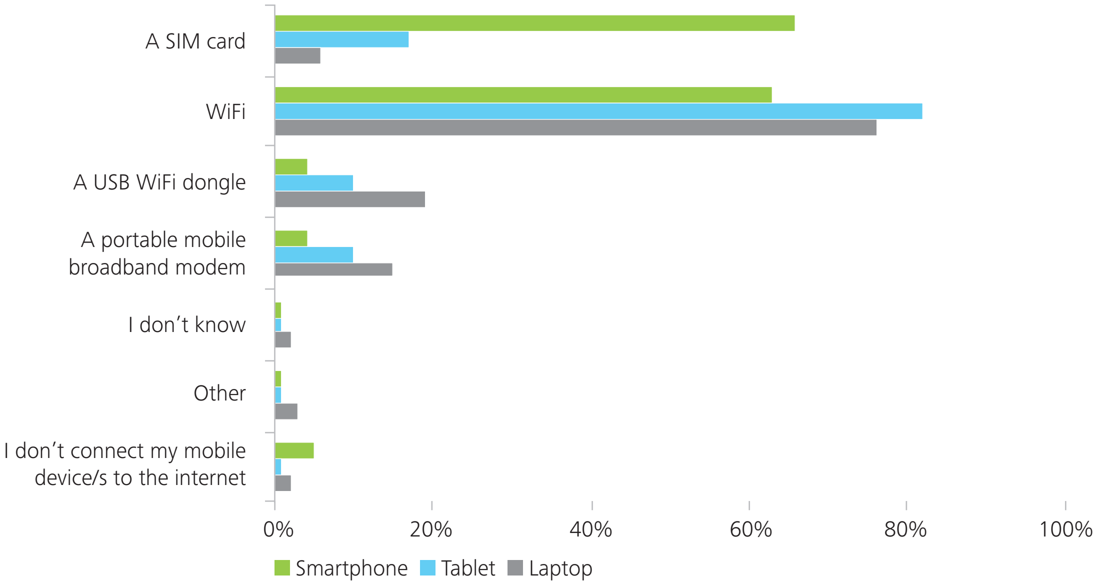


Chart 1.1: How do you use your mobile device to connect to the internet?



Source: Deloitte Access Economics, 2015

Chart 1.1 shows that methods of connecting to the internet vary between types of devices. For example, smartphone users are more likely to access the internet through a SIM card relative to other devices. This may be because they are more likely to be used while on the go.

It is clear that networks and devices are interdependent. As such, the research in this report considers the integrated impact of mobile devices (e.g. smartphones, tablets and dongles) and mobile telecommunications, which include the subscription services provided for mobile devices (including voice calls, mobile data and apps).

1.2 Our approach

Mobile technology has wide-ranging impacts on the economy, including through productivity and participation impacts. Qualifying and quantifying these impacts requires a diverse and robust research methodology, which is specifically catered for the task.

This report employed a number of different approaches, including:

- **primary research** to investigate the impact of mobile on labour force participation through their ability to complete personal commitments and work at home, conducted through a survey of more than 1,000 Australians from varying cohorts, including:
  - part time workers (i.e. those who work on average less than 35 hours per week);
  - carers of someone who is long-term ill or has a disability;
  - parents of children under five
  - people with a disability;
  - individuals who are considering retirement;
  - young people (aged 16-24); and
  - individuals living in rural/remote areas;
- an **econometric analysis** to model the relationship between mobile technology take-up (measured by mobile phone penetration rates) and productivity across 27 OECD countries;
- **dynamic computable general equilibrium modelling** to quantify the economy-wide impacts of increased participation in the workforce as a result of mobile; and
- **real world insights** obtained through stakeholder consultations with:
  - Able Australia;
  - Per Capita Longevity Forum;
  - Workible; and
  - Jigsaw.

Mobile technologies also have wide ranging implications for society. These include connectivity, the need to be 'always on', privacy concerns and real-time news. These are significant issues, which require detailed exploration. This report however focuses only on the economic impacts of mobile technologies.

1.3 Report structure

This report is the seventh in a series of economic reports on the mobile telecommunications industry and its broader impact undertaken by Deloitte Access Economics and its predecessor, Access Economics. Each report has brought new insight, as the industry continues to evolve with new technical capabilities, increasing adoption and economic significance.

The Australian Mobile Telecommunications Association (AMTA) has asked Deloitte Access Economics to report on the economic contribution of the mobile telecommunications industry as well as assess the importance of mobile technologies in enabling workforce participation and productivity in the economy.

The remainder of the report is structured as follows.

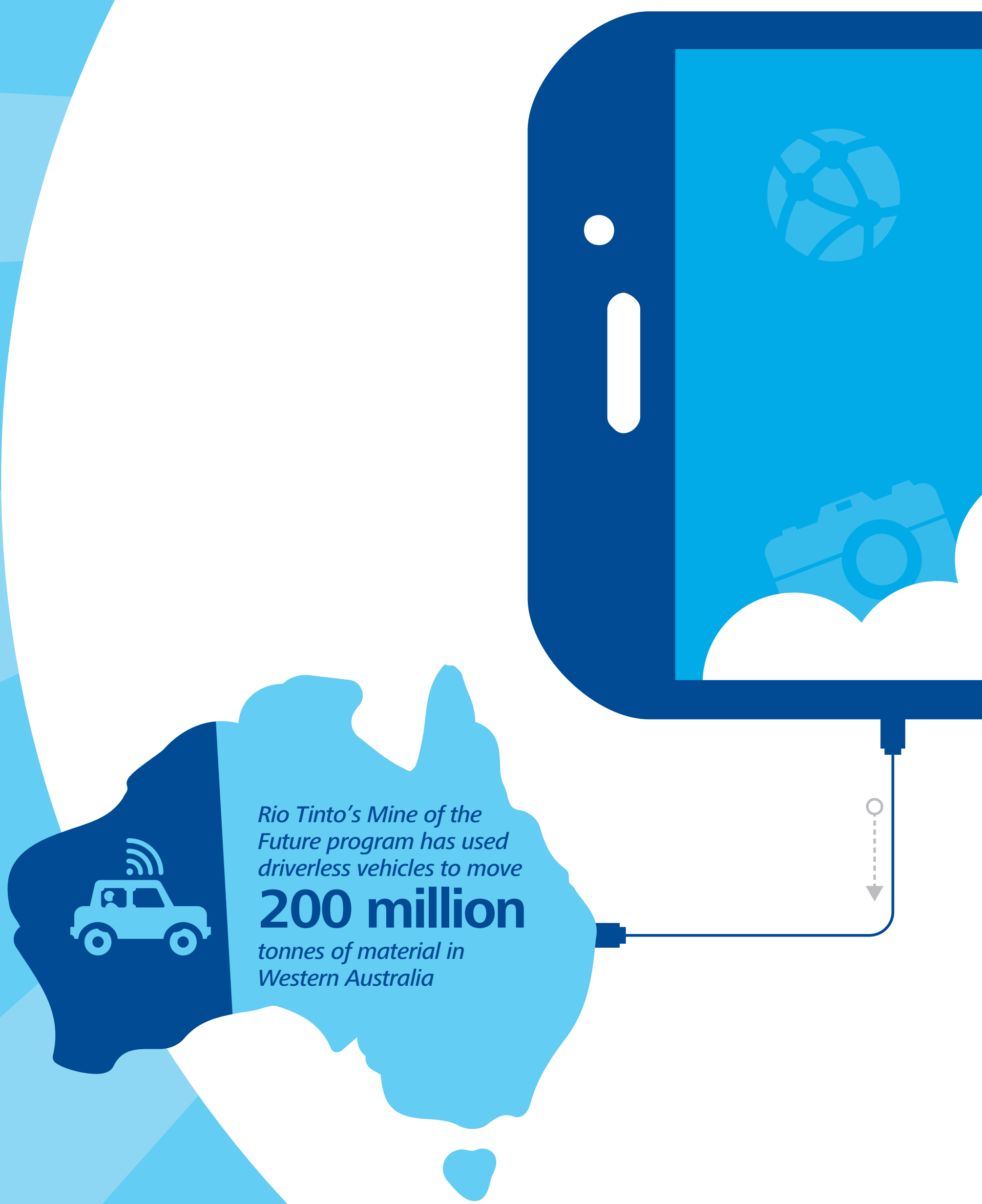
Chapter 2 discusses the evolution of mobile technology in recent history, and canvasses the potential benefits of new mobile technologies in the near future.

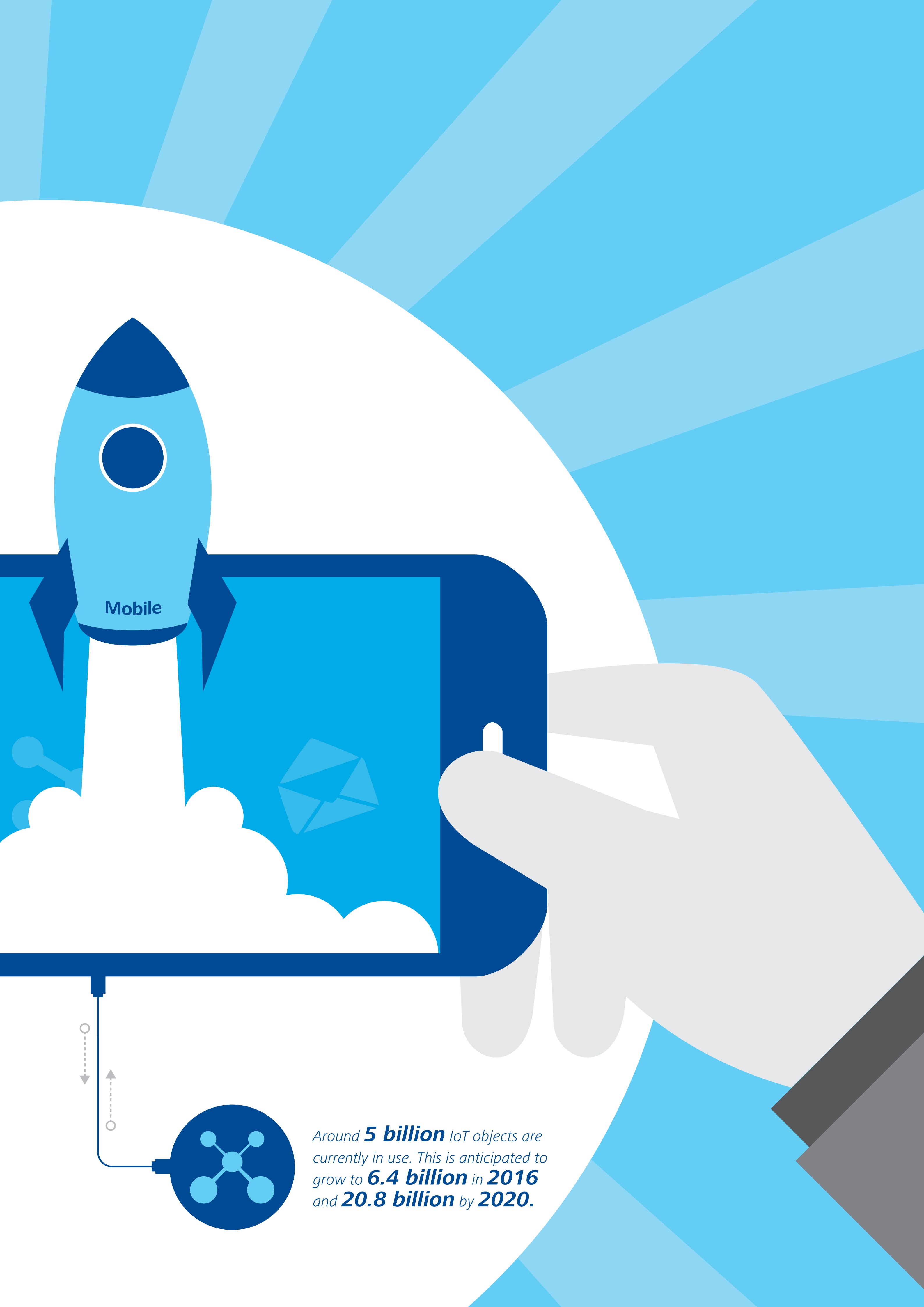
Chapter 3 quantifies the productivity impacts of the mobile telecommunications industry in Australia using econometric analysis.

Chapter 4 discusses how mobile technologies can improve participation in the labour market by facilitating remote work arrangements and allowing individuals to complete personal commitments while at work. It also quantifies the impact of this additional participation on GDP and employment.

Finally, the Conclusions summarise the key findings of our research.

2 The mobile revolution





*Around **5 billion** IoT objects are currently in use. This is anticipated to grow to **6.4 billion** in **2016** and **20.8 billion** by **2020.***

The continuing evolution of mobile technologies has delivered significant economic benefits to businesses and broader society. It has improved convenience, with always-available productivity-enhancing tools. It offers more efficient ways to manage, monitor and complete a variety of tasks. Mobile has also created new ways of engaging with customers and marketing products, as well as introducing a new platform for sales and opportunities for new products and services.

This chapter begins by briefly discussing the impact of mobile technology including the key milestones during the past 30 years. It goes on to explore some of the mobile-enabled technologies that are set to emerge in the near future – such as autonomous driving, the IoT and drone technology – and discusses the benefits these technologies could confer on individuals and society.

2.1 The impact of mobile

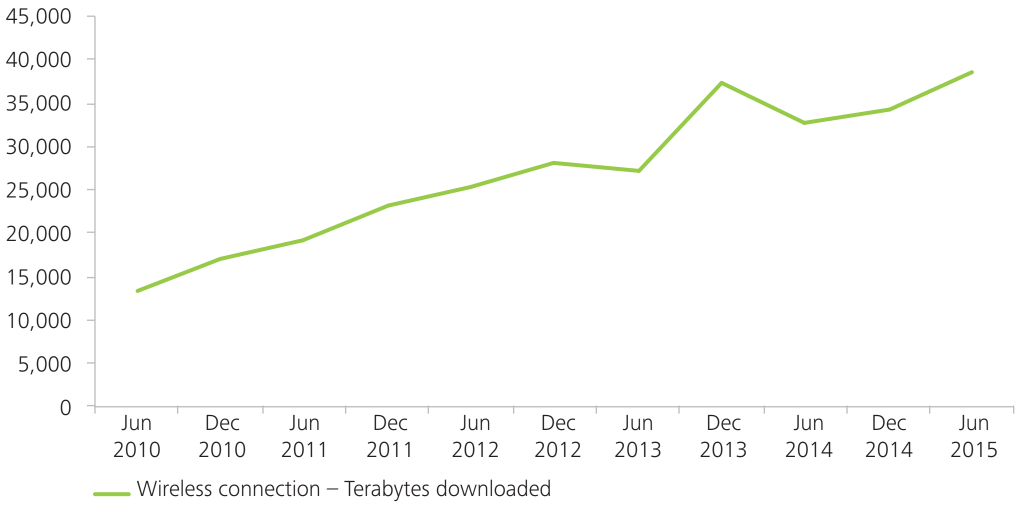
When commercial mobile phones first became available to Australians in the late 1980s, few would've imagined the features, possibilities and adoption of mobile technology to emerge in the forthcoming decades.

The popularity of mobile devices typically increases significantly with the introduction of major improvements in technologies and functionality. In the past 30 years we have seen:

- the development of **Short Message Service (SMS)** technology, enabling Australians to communicate efficiently using short messages, improving convenience;
- new functionalities available in mobile devices such as **high quality cameras** which have disrupted traditional products such as digital cameras;
- the rapid **growth of the internet and the availability of data** on mobile phones – to view information, video and multimedia; and
- the capability to **personalise and add functions** to mobile devices through mobile applications.

These capabilities have added to the appetite for data by mobile device users. Activities that could traditionally only be done on desktops because of limitations to speed and technology – such as downloading information and viewing multimedia and video – are now often done on mobile devices instead.

Chart 2.1: Volume of data downloaded by access connection, Australia, 2010-2015



Source: ABS (2015), Catalogue 8153: Internet Activity

The innovation and exponential growth predicted in Moore's Law have been particularly evident in mobile technologies. The past decade has seen mobile data become faster, cheaper and more accessible, with the average mobile subscriber cost per megabyte decreasing by 99% between 2005 and 2013 (Boston Consulting Group, 2015) and fourth generation networks offering data transmission speeds more than 12,000 times faster than second generation networks.

The last three years however have been the most remarkable, with smartphones being the fastest spreading technology (Extreme Tech, 2012) and 4G becoming the fastest adopted mobile technology in human history (CCS Insight, 2014).

Current 4G and 4G LTE mobile technologies have the ability to conduct video conferencing, view high definition multimedia, broadcast TV (IP TV), ultra-broadband internet access with data transfer rates of 20-100Mbps, IP telephony and cloud computing.

However, with the current growth in mobile demand, researchers are required to constantly address capacity issues and find more innovative solutions to meet wireless data demand in a spectrum-limited world. Major providers have been upgrading and rolling out new networks for 4G LTE and LTE-A, and are adopting new incoming technologies that improve efficiency such as multiple input, multiple output (MIMO) antennae and carrier aggregation.

Generation	Primary services	Key differentiator	Weaknesses
1G	Analogue phone calls	Mobility	Poor spectral efficiency and security issues
2G	Digital phone calls and messaging	Secure mass adoption	Limited data rates – difficult to support the demand for internet and email
3G	Phone calls, messaging and data	Better internet experience	Failure of Wireless Application Protocol (WAP) for internet access
3.5G	Phone calls, messaging and broadband data	Broadband internet and applications	Mobile specific architecture and protocols
4G	All-IP services (including voice and messaging)	Faster broadband internet and lower latency	

Source: GSMA Intelligence (2014)

Mobile-first jobs – expanding new job markets and services

Mobile technologies have made a significant impact to the global economy, expanding the job market by more than 11 million jobs and contributing to $3.3 trillion in revenues in 2014 according to Boston Consulting Group (2014).

In recent years, mobile technology has generated new markets and industries such as the application economy – with 8.9 million or 68% of Australians downloading a mobile application in the six months to May 2013 (ACMA, 2013). Mobile applications have improved our everyday lives and created innovative solutions to geo-location based problems. Growth in the application economy has also increased demand for a whole host of technical ICT occupations and opportunities for software and web developers, mobile user experience and interface designers, applications engineers and mobile application testers.

Finally, with the growing presence and preference of mobile-based services and technologies among customers, businesses (particularly in banking) have responded by transforming their business models to accommodate customers by becoming more smartphone-centric. For example in 2015 Citigroup launched a new business division called Citi FinTech, which focuses on providing and improving its mobile banking services across a range of client services (American Banker, 2015).

Figure 2.1: Super disruptors of the digital era

Digital era – Super disruptors

- Mobile
- Analytics
- Could
- Social
- Web
- Content

Exponential era coming...

- Artificial intelligence
- Genomics
- Connected home
- Internet of things
- 3D printing
- Robotics
- Crypto-currencies
- Drones
- Mobile payments
- Electric and connected cards
- Wearables
- Oculus rift

Source: Deloitte Digital (2015)

2.2 The next wave of mobile technology

Mobile technologies have progressed significantly since their introduction and are anticipated to play a substantial role in the future technologies of the exponential era – through areas of growth including the IoT, wearables, instant mobile payments, robotics, and drone technologies.

Mobile technologies already allow users with smartphones to screen their health anywhere and anytime, superimpose digital information to the real world through augmented reality, and transfer or pay money instantly through tap-and-go. Although these developments have improved and assisted our lives, the next major phase of mobile developments is anticipated to launch the capabilities of our mobile devices to significantly greater and previously unimagined heights.

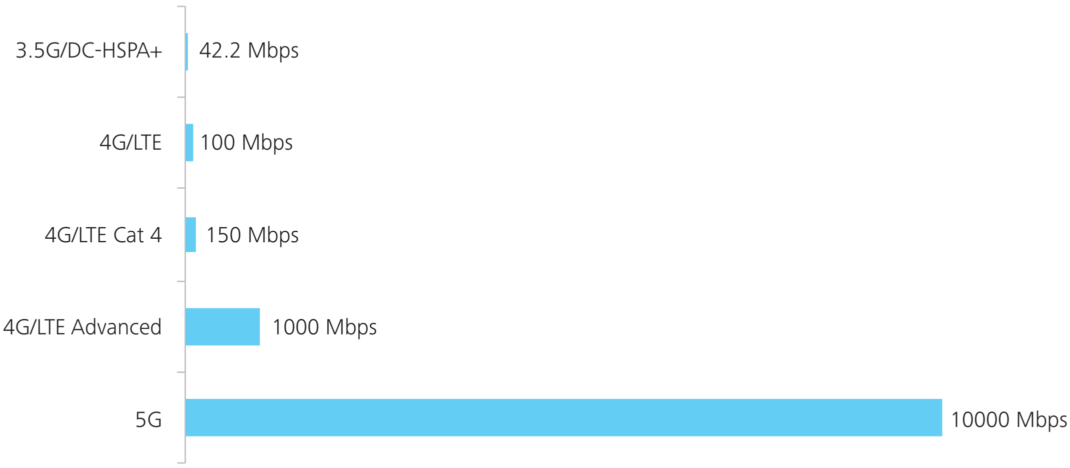
The next wave of mobile developments in **fifth generation mobile networks (5G)** is positioned to address the evolving demands and business contexts of 2020 and beyond. It will allow a fully mobile and connected society where new possibilities such as autonomous driving and harnessing the full potential of connectivity through the IoT will be made a reality.

5G will also bring significant benefits in speed, reliability and lower latency compared to previous generations of mobile technologies. These new 5G mobile technologies are anticipated to deliver **significant economic benefits** by lifting the level of productivity in the economy compared to previous mobile phone generations. Also, opportunities originating from the growth and creation of innovative industries and job markets will contribute to and support future growth.

The following sections briefly discuss some of the major developments and applications of mobile technologies in the near future, which include:

- autonomous driving;
- improvements in speed, latency and reliability;
- the Internet of Things and drone technologies;
- m-payments, mobile wallets and near field communication; and
- spectrum allocation and future possibilities.

Figure 2.2: Maximum theoretical downlink speed by technology generation, Mbps



Source: GSMA Intelligence (2014)

2.2.1 Autonomous driving

Enabling vehicles to communicate with each other and the outside world could result in considerably more efficient[1] and safer use of existing road infrastructure. If vehicles were connected to a network incorporating a traffic management system, they could potentially travel at much higher speeds and within closer proximity of each other without risk of accident or potential for human error. Also, autonomous vehicles can also free up time for individuals to engage in other activities (such as work or leisure) during commuting.

To make autonomous driving viable, it is essential to have ultra-reliable networks and low latency regardless of location and geography. Currently, network-related errors and limitations in latency are constraining the applicability of driverless cars. This is because if a vehicle is being operated via a cloud-based autonomous driving system, a sudden loss in connection signal could lead to devastating consequences.

Developments in 5G technologies could potentially remove many of these limitations. Currently, fourth generation (4G) networks have latencies around 40-80 milliseconds however 5G technology is anticipated to potentially reduce latency to as low as one millisecond for use cases that are sensitive to delay.[2]

Additionally, 5G technologies will enable data-intensive vehicle applications including machine learning, sensor fusion and highly accurate GPS. Other safety-related improvements enabled by 5G technology include augmented reality dashboards. These display overlay information on top of what a driver is seeing through the front window, identifying objects in the dark and providing information about the proximity and movement of the objects, which could reduce road accidents.

Autonomous driving also has applications in a commercial context. For example, Rio Tinto's Mine of the Future program has moved 200 million tonnes of material in Western Australia through its fleet of autonomous haul trucks based on a 4G LTE network which has delivered significant productivity benefits and savings in maintenance, tyre life and fuel consumption (Alcatel-Lucent (now Nokia) and Rio Tinto, 2014).

Figure 2.3: Driverless car model

Source: Google (2014)

[1]By reducing the effective drag coefficient on 'following' vehicles it could significantly reduce highway fuel use.
[2]According to the requirements defined in 3GPP TR 22.891.

2.2.2 Improvements in speed, latency and reliability

5G technology is anticipated to deliver substantial improvements in the speed, latency and reliability of mobile networks. This will enhance customer experiences by allowing near instant responses, opening up possibilities such as autonomous driving (as previously discussed) and multi-person videoconferencing. Also, 5G technology has the potential to make the wireless cloud office concept a reality, with vast amounts of data storage capacity sufficient to make such systems ubiquitous.

There will also be growing demand for mobile service reliability in moving vehicles such as trains and aircraft in the future. Currently, radio planning determines hot spot areas for optimisation by assuming stationary hot spots. However, spatial relocation can generate capacity variation depending on times and locations of the day.

5G technologies will also complement the stationary mode of planning capacity by incorporating dynamic hotspots and provide reliable capacity in cities in real time. This will help improve the consistency of internet services as well as optimise data usage and address demand issues.

2.2.3 Internet of Things (IoT) and drone technologies

The development of 5G will be important for the future growth of new technologies such as the Internet of Things (IoT) and drone technologies.

IoT combines and integrates the physical world with computer-based systems such as electronics, software, sensors and networks. This enables these systems to collect and exchange data and interact intelligently with their surroundings. Examples of their application include smart fire safety alarm systems that send messages to the local fire brigade if no motion is detected after a smoke alarm has gone off, and the Edge Building in Amsterdam, which is fitted with more than 28,000 sensors that carry and process data to optimise energy consumption, improve office space utilisation (through hot-desking) and personalise user experiences in the building through mobile applications.

Around 5 billion IoT objects are currently in use according to Gartner (2015). This is anticipated to grow to 6.4 billion in 2016 and 20.8 billion by 2020. Future growth in IoT will be dependent on the ability to leverage vast amounts of data with high levels of reliability and low latency.

Through use of higher frequencies and bandwidths, 5G could also assist with the viability of more experimental uses of mobile technology such as unmanned aerial vehicles and drones. Drone technologies have shown significant potential in delivering economic benefits for industries and scenarios including:

- the logistics industry, by reducing the cost and improving the operational efficiency of the delivery and transportation of parcels;
- damage surveillance and the assessment of ongoing threats, and for locating stranded and injured victims during natural and manmade disasters;
- tactical surveillance and investigations in law enforcement – reducing the need for the physical presence of law enforcement personnel and improving safety; and
- improving the monitoring of vast or hard to reach places such as agricultural land management and infrastructure maintenance for skyscrapers.

2.2.4 M-payments, mobile wallets and near field communication

Advancements in mobile technology have simplified and improved the convenience of everyday tasks such as banking and payments.

New generations of mobile devices have included near field communication (NFC) technology. NFC allows short-range wireless connectivity between devices, providing the ability to ‘tap’ to connect.

One of the uses of NFC technology through mobile devices has been in payments. It has facilitated the development of ‘mobile wallets’, which store an individual’s payment details and then initiate a transaction when ‘tapped’ to a merchant NFC-enabled device.

This technology is creating more competition in the payments industry. Traditionally, the industry has been dominated by large financial services providers and payment platforms. However, mobile wallets have allowed more businesses to get involved, including innovative providers such as Square, as well as new offerings from device providers, such as Apple Pay.

Australian retail banks have recently introduced capabilities and mobile applications that allow for contactless payments using NFC. This has led to substantial operational efficiency and convenience benefits for both consumers and retailers by reducing the time required to complete and confirm payment, as well as created greater security and features (such as payment history, virtual card provisioning and user-configured PIN-protection) over traditional mag-stripe card payment methods.

The Commonwealth Bank of Australia introduced *Albert* in 2015. *Albert* allows small businesses (such as retail stores, restaurants and cafes) to obtain an affordable point-of-sale device that facilitates contactless and instant payments. Transactions through this platform can be recorded to provide richer data on consumer spending patterns, which can be used to inform business strategy.

2.2.5 Spectrum allocation and future possibilities

One of the biggest constraints on increasing mobile data usage is the availability, allocation and use of spectrum. The ACMA is continually exploring opportunities to increase the utility of spectrum including the potential to re-assign or re-allocate spectrum to assist it in moving to its highest value use. Reforms to the *Radiocommunications Act 1992* are pending under the Spectrum Review process. These reforms are anticipated to be fundamental to the spectrum licensing framework over coming years.

Since 2009, the Australian Communications and Media Authority (ACMA) has delivered a number of important outcomes, including the reallocation of the digital dividend (700 MHz), the associated completion of the digital television switchover and the progressive harmonisation of government spectrum use in the 400 MHz band.

The 2015-19 ACMA five-year spectrum outlook focuses primarily on near to medium-term issues and include regional and remote band planning and allocation in the 1800 MHz frequency as well as a review of the 800 and 900 MHz bands, 3.5 GHz and most recently the 27 GHz band. Also, the spectrum review provides an opportunity to investigate and explore options to reform the regulatory toolkit to meet challenges in these areas.

While spectrum has become scarce at microwave frequencies, there is currently very little use of millimetre wave (mm-Wave) or extremely high frequencies from 30 to 300 GHz. One of the more promising avenues of consideration for 5G technologies is the use and application to high frequency signals in the mm-wave range. This could lead to increases in allocation of bandwidth, which could deliver faster, higher quality video and multimedia content to users.

ACMA is expected to release its updated strategy for mobile broadband in *Beyond 2020* during March 2016. This will inform future developments in spectrum allocation.[3]

[3]Beyond 2020: A Spectrum Management Strategy to Address the Growth in Mobile Broadband Capacity

3 Mobile enabled productivity growth

The Australian economy was around

$34 billion

larger in 2015 than it would otherwise have been as a result of long-term productivity benefits generated by mobile technology take-up.

Australia faces many challenges to maintaining living standards over coming years. The 2015 *Intergenerational Report* highlighted three factors that will be crucial to Australia's long-term economic growth:

- increasing the level of labour force participation;
- addressing the ageing population; and
- improving productivity.

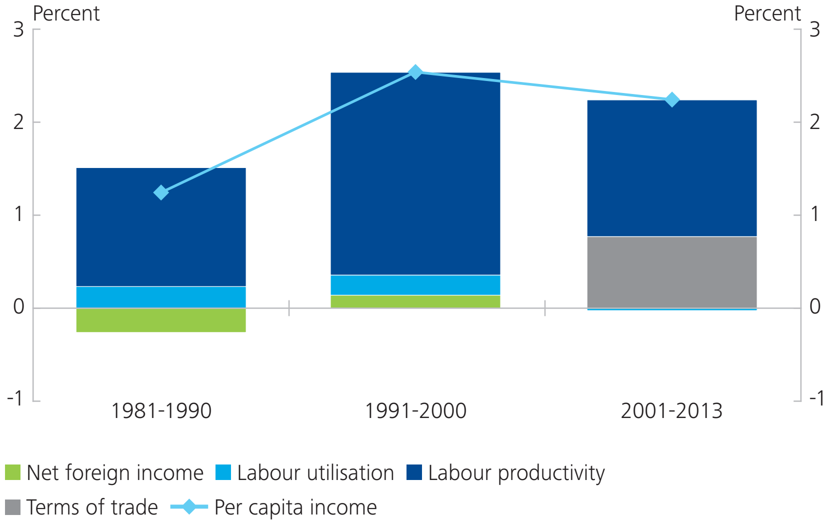
3.1 The productivity imperative

To maintain national income levels and living standards over the coming decades Australia faces a considerable productivity challenge. As commodity prices fall and the returns from the decade-long mining boom recede, Australia will need to find other areas of economic growth, principally in the form of higher levels of labour productivity.

Improving productivity is a key priority for businesses and policy makers.

As shown in Chart 3.1, improvements in the terms of trade contributed 0.7 percentage points to the total average annual income growth of 2.2% during the period 2001-2013. Unfortunately, income effects from terms of trade booms are only temporary. As the terms of trade returns to its historical long-run average over the coming years, it is expected that this same level of income gain will become an income loss. Offsetting this will require significant productivity growth. Between 2001 and 2013 labour productivity contributed approximately 1.5% to growth, less than the 2.2% contribution over the period 1991-2000.

Chart 3.1: Annual growth in gross national income per person by source



Source: Deloitte Access Economics estimates using ABS data

3.2 Mobile and productivity

Mobile technology has played a key role in stimulating labour productivity growth over the past few years. It is a driving force in connecting people and businesses, stimulating innovation and technological progress, and transforming industries. Future development of mobile technologies will continue to help shape the Australian economy and drive productivity improvements.

This section outlines the benefits of mobile technologies to productivity in the Australian economy. Mobile technologies can increase productivity by:

- increasing the effectiveness of employees or managers, or by saving them time (labour productivity); or
- by increasing the effectiveness or reducing the need for computers, vehicles, office space or other capital (capital productivity).

Improvement in multifactor productivity is when a business achieves an increase in output with the same level of labour and capital; that is, it has become more effective in generating income.

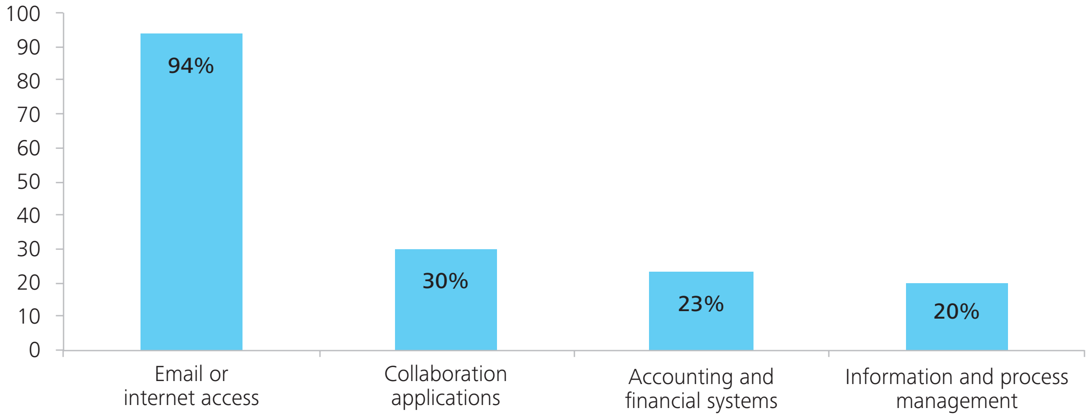
Mobile technologies can increase labour productivity by allowing communication on the go. Workers can utilise these technologies to engage with others in and out of the office as well as accessing information and knowledge through their smartphones during business meetings. Mobile technologies can also increase the effectiveness of employees by reducing or eliminating the down time associated with commuting. Deloitte University Press (2013) examined the productivity benefits of mobile for United States government employees who spend much of their time in the field. It was found that mobile adoption can increase caseworkers' productive time by 45%, and that use of mobile data can save law enforcement officers around 30 minutes each day.

Also, these technologies can increase capital productivity through facilitating teleworking and reducing the need for physical office space, vehicles and computers.

For businesses, new generations of mobile technology could help improve the effectiveness of businesses in managing remote assets, communicating with employees and customers, and reduce cost of travel. In 2014 research for the ACMA, The Centre for International Economics conducted a survey of 1,000 businesses, which found that business that take up mobile broadband reported average time savings of 2.3%, cost savings of 1.4% and increases in sales of 1.1%.

More than 94% of Australian organisations in 2012 have email or internet access available over the corporate network for mobiles, smartphones and tablets. Businesses have also been making collaboration applications, accounting, financial systems, information processes, and management available on the corporate network (Optus, 2012). The adoption of commercial mobile devices has significantly increased in the past few years. Chart 3.2 shows the adoption of different technologies across Australian businesses.

Chart 3.2: Productivity applications made available on the corporate network for mobiles, smartphones and tablets



Source: Optus Future of Business Report: Research and Findings, 2012

Mobile technologies help facilitate communication and the creation of new knowledge through improving the efficiency of collaboration and information processing. This can allow firms to develop new methods of communication with suppliers or distributors, and reduce co-ordination costs and the number of supervisors required (Kretschmer, 2012).

Figure 3.1: Productivity gains from mobile devices

Source: Mobile Nation (2013), Deloitte Access Economics

Overall, there is significant productivity potential that can be derived from mobile technologies. Australia's rapid adoption of mobile technologies in the past decade has played a key role in supporting our economic growth. Previous reports by Deloitte Access Economics have quantified the impact of mobile technologies on productivity. As the capabilities of mobile devices have expanded from calls to SMS and then to smartphone functionality, *Mobile Nation* reports have looked at the additional benefit that each of these functions provide.

3.3 Econometric modelling

Three decades after the introduction of the first commercially available mobile phone, this report looks back to consider how mobile devices – with all of their features – have contributed to the Australian economy.

In the last edition of *Mobile Nation,* Deloitte Access Economics estimated the productivity impact of mobile technologies as a share of broader impact from ICT investment. The study reflected the best available information at the time, including an estimated economic impact of ICT investment by the Productivity Commission in 2004 (PC, 2004). As in a number of studies of the Australian economy in the past, the research uses a single country firm level data to isolate the impact of ICT investment on productivity and economic growth. While the findings are useful and informative, the approach lacks the ability to account for the impact of other policy and institutional settings that are homogenous within the same country.

This research seeks to take advantage of the increasing availability of cross country macro-economic time series data set, and use a refined approach to estimate the contribution of various policy and institutional developments to Australia's economic development. In particular, we use a pooled cross-country time series data set of 34 OECD countries to explain both cross-sectional differences in economic growth performance as well as the evolution of performance over time in each country.

In line with a large body of economic development literature, this report seeks to quantify the effects of evolving mobile technology on economic growth using a neo-classical production function; the formal framework is first set out by Mankiw et al (1992) and its augmented-form was implemented by OECD (2001). The models used in this report adhere closely to the existing literature, with modifications provided to accommodate the focus on mobile technology and other productivity enhancing factors. Details of the model can be found in Appendix A. Specifically, econometric analysis is used to model the relationship between mobile technology take-up (measured by mobile phone penetration rates) and productivity across 34 Organisation for Economic Co-Operation and Development (OECD) countries.

Using data from OECD, World Bank and Barro-Lee (2010), the model estimates the share of income growth attributable to the productivity benefit derived from model technology adoption. The model controls for primary factor inputs (physical capital, labour and human capital) as well as other productivity-enhancing factors including urbanisation, openness to trade, and research and development activities.

Modelling results show that the Australian economy was around 2.04% or $34 billion larger in 2015 than it would otherwise have been as a result of long-term productivity benefits generated by mobile technology take-up.

It is important to note that, in addition to the adoption of mobile devices, productivity-based mobile applications have also proliferated in recent years. These devices have therefore transformed from tools primarily used for voice calls to smart devices which act as a powerful, essential, personalised multimedia device to interact with businesses and services. Today, people can perform much more complex tasks with their mobile devices, including interacting with business services such as Uber and Airbnb. The benefits of these applications and sophisticated use of mobile devices are likely not captured by the mobile phone penetration rate used in the model.

It should also be noted that the results from this analysis rely on the estimated long-run elasticity of mobile penetration on economic growth derived from our macro-econometric cross-country model. This model is not without its limitations – set out in Appendix A of this report – which should be considered when interpreting the results from this analysis.

Mobile technologies – value added

In addition to the profound impact mobile technologies have on the productivity of our workers and businesses, mobile has also emerged as a significant sector of the economy that attracts enormous levels of consumption and investment.

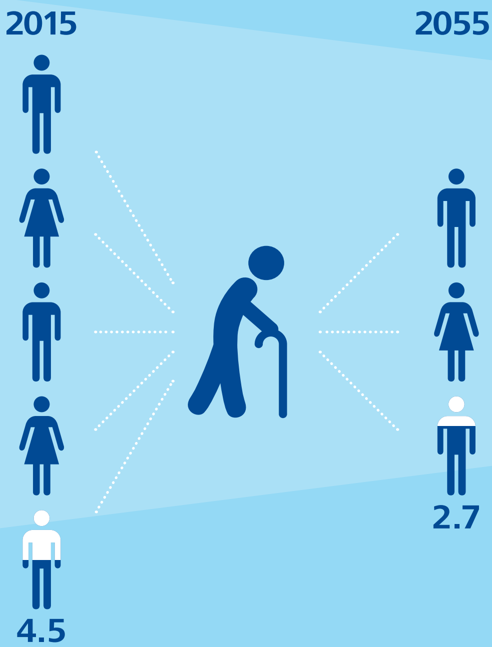
Insights on the economic importance of mobile technologies have been discussed previously and although a number of reports have recently assessed the benefits of mobile technologies to the broader economy, these have primarily focused on the productivity benefits and future prospects of mobile devices.

Deloitte Access Economics has previously assessed the economic contribution and productivity benefits of mobile technology. In Mobile Nation (2013) we found that the mobile telecommunications' industry revenue was $22.0 billion in 2011-12. Total value added by the industry was $14.1 billion with $7.6 billion in direct contribution and $6.5 billion indirect activity. Total direct and indirect employment for the industry was 56,970 full time equivalent employees.

A 2015 report from Boston Consulting Group stated that globally, mobile communications contribute to $6.4 trillion across six countries including the US, China, India, UK, Brazil, and South Korea. It was also estimated that the annual value consumers place on mobile technologies ranges from $700 to $6,000 per user, which represents between 11% to 45% of their annual income. The mobile value chain also generated $3.3 trillion in revenue globally in 2014 and is directly responsible for 11 million jobs contributing to between 2% to 4% of each country's GDP and 11% in GDP for South Korea.

4 Mobile enabled workforce participation

Increasing labour force participation is one of the key challenges Australia faces to ensuring continued economic growth in coming decades.



Working aged Australians to support each person over **65**

Remove locational barriers

29% of those surveyed work from home at least some of the time

14.5% would work fewer hours if they couldn't work remotely

Mobile sourced jobs

80% of job seekers under the age of 25 use mobile devices

45,000 individuals in NSW earned income through the collaborative economy in 2015

Meet personal commitments whilst at work

70% of those surveyed meet personal committments whilst at work

11.1% would work less hours if they couldn't meet personal committments while at work

On average, the cohorts surveyed work **0.6** more hours every week because of mobile.

The Australian economy is **$8.9 billion** bigger than it would otherwise have been

65,000 full-time equivalent jobs were supported by this GDP

Challenges for future generations

According to the *Intergenerational Report* (2015), Australian life expectancies will continue to lengthen in coming decades. The number of Australians aged 65 and over is projected to more than double by 2055. There will be less than 2.7 working age Australians (15 to 64 years old) for each person over 65 years of age, compared to 4.5 today.

These demographic shifts will have profound implications on the workforce. The *Intergenerational Report* (2015) projects that, by 2054-55, the participation rate for Australians over 15 years old will fall to 62.4%, compared to 64.6% today. The impacts of this decreased available supply of labour potentially include reduced government revenue through less income tax, an increased burden of welfare such as income support, and ultimately a slowing pace of economic growth.

This Chapter describes how mobile technology could help alleviate the impact of changing demographic landscape, particularly by encouraging labour force participation.

The impacts of mobile on the labour market and economy are wide-ranging. Although it has improved productivity, it also contributes to workforce participation. More people can join the labour force, or work more hours, because mobile helps them to overcome some of the barriers to employment.

As noted in Chapter 2, increasing labour force participation is one of the key challenges Australia faces to ensure continued economic growth in coming decades. Using survey analysis, computable general equilibrium modelling and case studies, this chapter identifies three mechanisms through which mobile technologies have contributed to addressing this challenge.

The first of these is overcoming the barrier imposed by location. For people who live in remote areas, have difficulties with mobility or have caring responsibilities, the need to work from a certain location, and difficulties getting there, can be prohibitive. Mobile technologies have enabled people to work from anywhere at any time. This flexibility ameliorates against the barrier of location, enabling more people to join the labour force.

Second, many people have other commitments that limit their ability to participate in the workforce. This can include home duties, parenting, and looking after friends or family who are ill or have a disability. Mobiles allow individuals to meet personal obligations – such as monitoring health, checking-in with family and friends, and doing household tasks – while at work or in transit. This can help open up more time and opportunities to engage more in the workforce for citizens.

Finally, frictions and search costs associated with finding a job can be a barrier to employment. Mobile technologies have disrupted methods of finding work. It is now possible to search for and consider jobs 'on-the-go' using mobile devices. This technology means that it is faster and easier to look for more appropriate and suitable work. These reduced frictions in the labour market could enable discouraged job seekers to enter the labour market.

To explore the impact that mobile has on labour force participation, Deloitte Access Economics conducted a survey of more than 800 individuals whose labour force participation may be improved by mobile – part-time workers, carers, individuals with a disability, parents of young children, young people, individuals living in rural or remote areas, and those who are considering retirement.

Modelling the impact of mobile's contribution to overcoming barriers imposed by location and allowing people to meet personal obligations while at work, this report finds that mobile-enabled participation has created on average $8.9 billion per year in GDP for the Australian economy, and supported approximately 65,000 full-time equivalent jobs annually.

Other impacts on the workforce

Although this report focuses on the labour market opportunities and benefits created by mobile technologies, it is important to note that they may also have some negative impacts.

The emergence of innovative technologies is often accompanied by significant change in the economy. As digital disruption continues to impact on a variety of industries and occupations, there are concerns about the impact this may have on employment, particularly in occupations that involve routine tasks.

Frey and Osborne (2015) found that a decreasing real cost of computing has created economic incentives for employers to substitute labour for technology. In Australia, CEDA (2015) estimated that more than 40% of Australia's workforce is likely to be replaced by computer within the next 10-20 years.

As a core technology enabling the modern digital landscape, mobile technologies continue to play an important role in reshaping how consumers, businesses and workers interact. These disruptive forces have had an impact on the workforce. For example, in banking, the number of tellers has declined, as an increasing number of transactions are done online, through ATMs and on mobiles.

Despite these concerns, it is important to remember that technology has created new jobs, as well as destroying some old ones. The gains generated by productivity enhancing technologies also tend to create additional demand through higher incomes and lower prices. It is important to consider how the Australian economy can best adapt to new circumstances and support employment in a new range of mobile- and technology-enabled jobs.

4.1 Removing locational barriers

Mobile and computer technologies have revolutionised the way in which people complete their work, allowing many to work from anywhere and anytime. According to ACMA (2015), there are currently more than 5.7 million adult Australians (representing 49% of the total number of employed Australians) who engage in a digital working life where they use internet technologies outside standard working hours or the office to complete work.

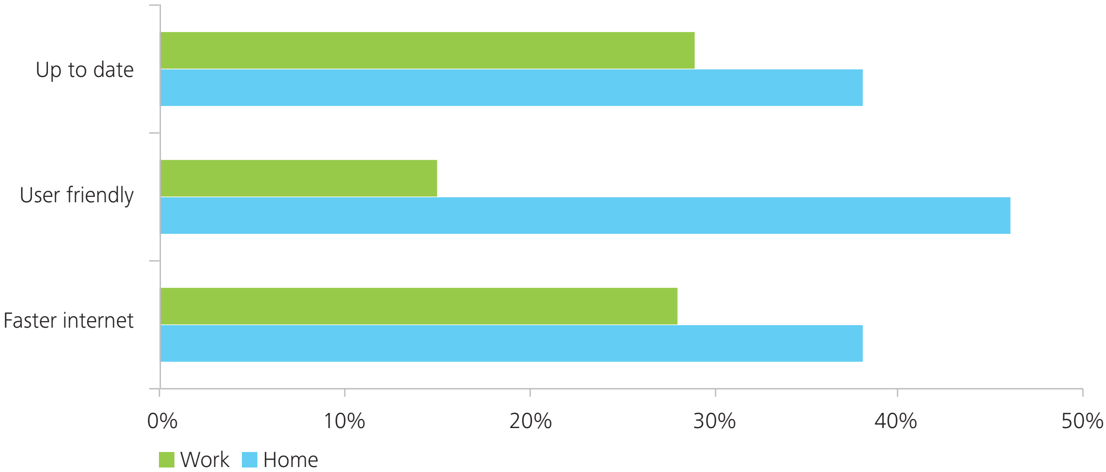
Traditionally there have been locational barriers for individuals that have limited them from working far away from their homes or offices due to travel and time related costs. Locational barriers can also affect employees in terms of workforce participation if they have ongoing responsibilities at home or suffer from unexpected illnesses or life events.

Advancements in mobile technology have now made it possible for employees to stay connected to the office via their mobile devices. This has contributed to teleworking arrangements, where an employee can perform the duties and responsibilities of their job from an approved remote worksite (such as their home), to become more available for Australians.

Teleworking has benefited individuals by allowing them to enjoy an improved work-life balance and opened up opportunities for people such as parents and carers to complete work duties while meeting their commitments at home. Locational barriers to work have also reduced for individuals with mobility related issues such as the people with a disability or elderly people by allowing them to complete work without the need for travelling.

The impact of teleworking is that it allows more individuals that were not previously in the labour force due to locational related barriers to reconsider the option of participating in the workforce as they are now able to work from their homes and meet their other commitments. *The Connected Workplace* (2013) report from Deloitte Access Economics also found on average employees were more satisfied with their home technology over technology offered in the workplace.

Chart 4.1: Digital technology – home and work (% of those surveyed)



Source: Stancombe Research & Planning and Deloitte Access Economics, 2013

Teleworking can also positively impact employers through reduced office space and equipment costs as well as the ability to expand the company's candidate pool outside local geographies.

4.2 Allowing individuals to complete personal commitments

Many individuals have personal commitments outside work such as home duties, parenting and caring responsibilities that can influence their decision to participate in the workforce. Previously, personal commitments could not realistically be completed without presence both at work or another location such as home; or completing them would incur significant travel time costs, which could reduce the ability for individuals to engage in more hours in the workforce.

Mobile devices have made a substantial impact on simplifying everyday tasks (e.g. banking and payments) and have enabled individuals to better meet their personal obligations – such as monitoring health, checking-in with family and friends, and doing household tasks – while at work or in transit.

Allowing individuals to better meet their personal obligations, mobile devices can:

- lead individuals to more conveniently monitor their health through telehealth options;
- make it easier for people to complete parenting and care taking duties and responsibilities through voice calls, video conferencing and monitoring and geo-location based mobile apps; and
- help complete community, extracurricular and other professional commitments through social media or an online presence on the go.

Developments in mobile technology have blurred the boundaries between home and work, and have allowed more individuals to complete personal obligations while at work as well as increasing the use of internet at home for work related purposes. According to Microsoft (2015), 30% of Australians are now checking work emails on mobile devices at home before they leave for work, 23% are doing work activities while they are socialising with their friends and 44% are doing work related activities after work at home. Also, 53% of those surveyed believed that mobile technology has allowed them to complete their personal commitments during work.

Able Australia – using mobile technologies to enable individuals living with multiple disabilities

Mobile technology plays a substantial role in improving accessibility and enabling participation in the workplace for individuals with disabilities. "People are in control of their accessibility and can personalise their mobile device at home and at work," explains Claire Tellefson, Digital Literacy Coordinator of Able Australia, a leading not-for-profit organisation that provides services for people living with disabilities including deafblindness.

Mobile devices can be more readily personalised, with features to meet individual needs. This makes them more appropriate than traditional desktop devices used in workplace settings, which often have more security restrictions preventing customisation, and may not have required hardware such as webcam.

Mobile devices allow individuals with deafblindness to use technologies such as speech recognition to engage, communicate and socialise with other individuals in real time. "We supported one deafblind man who had been working in packaging for 20 years. It was not until he got a mobile device that he was able to communicate directly with his colleagues for the first time. He found out that the man who worked next to him had actually been a high-school classmate," recounts Ms Tellefson.

Mobile devices have also enabled the use of customisable mouse pointers and input and output arrangements such as braille keyboards, screen colours and Australian Sign Language translation services. These have allowed individuals with disabilities to access the internet and other technologies more productively.

Mobile technologies also help individuals with a disability in their day-to-day lives. "People with disabilities spend a lot of their time on domestic chores such as shopping, banking and paying bills" says Ms Tellefson. A mobile phone can automate many of these tasks and make them much easier, freeing up time to engage in other activities.

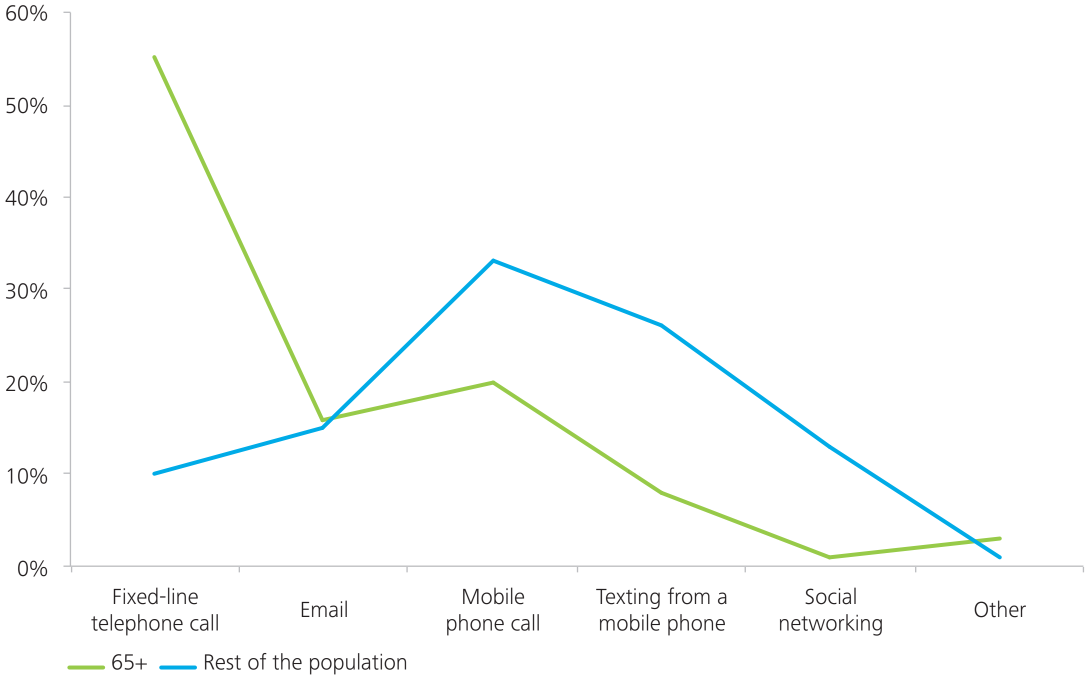
Mobile devices also allow individuals with a disability to engage more fully in society. "It can empower individuals with a disability. It provides a gateway to participating more in social activities, studying and ultimately seeking employment" according to Ms Tellefson. Mobile interactions through SMS, e-mail and social networks provide a crucial stepping stone for building confidence in engaging with others.

Individuals with a disability may face other barriers to employment. Employers can be hesitant about allowing more accessibility features in workplace IT systems, as enabling additional features and removing firewalls can increase cyber-security risks. Personal smartphones can be crucial in providing the tools to allow individuals with a disability to work effectively.

The up-front cost of investing in this technology can be prohibitive. As an example, braille readable technology can cost between $1,500 and $10,000 per unit.

Although mobile technologies have made a substantial impact on our everyday lives, the adoption of these technologies is not uniformly distributed across different age cohorts. For example, people over the age of 65 still prefer fixed-line technologies over mobile phones more than the rest of the population.

Chart 4.2: Communications services most used in the six months to May 2014, by age cohort

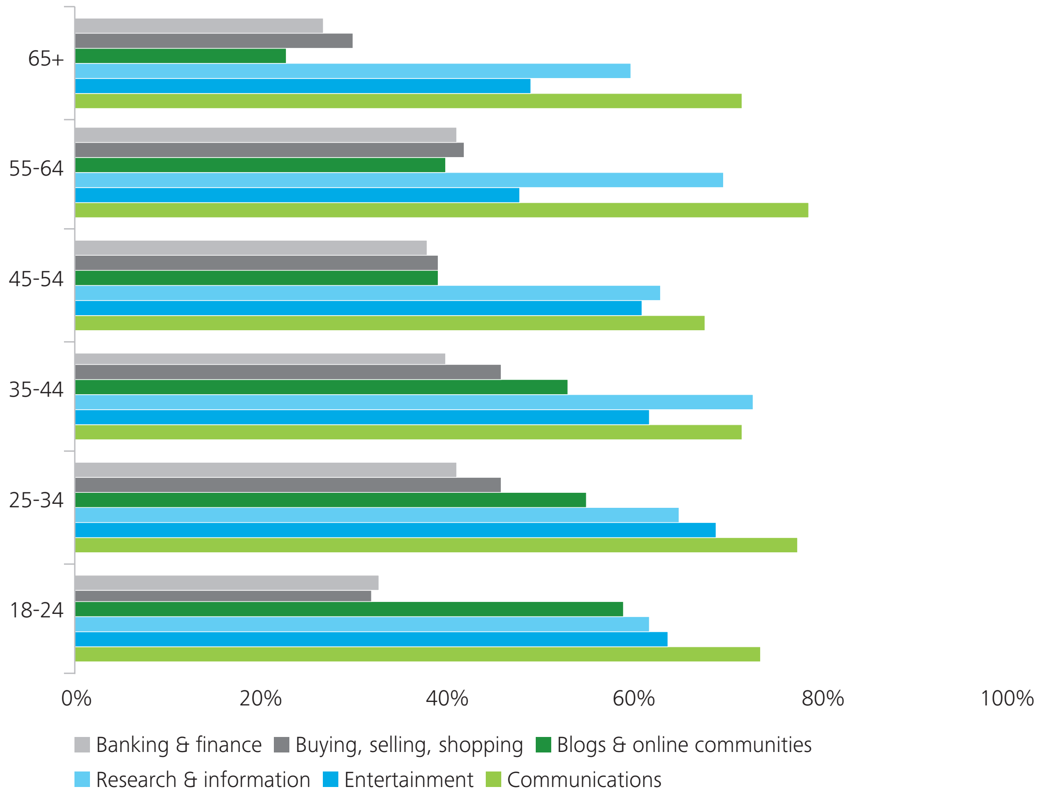


Source: Australian Communications and Media Authority (2014)

These differences for the elderly are also reflected in their use and ownership of tablet devices, with significantly fewer individuals over the age of 65 using tablets than younger age cohorts to complete a range of everyday functions such as banking, shopping, blogs and online, entertainment as well as research and communication.

Lower mobile adoption rates for the elderly could indicate that they may be less familiar with the full capabilities of mobile technology in allowing them to complete personal commitments on the go or at work as well as engage in more flexible job arrangements such as teleworking.

Chart 4.3: Internet activities performed on tablet computer by age, May 2014



Source: Australian Communications and Media Authority (2014)

Although the gap for mobile adoption between the elderly and the rest of the population has been narrowing over time (Deloitte, 2014), it is important for policymakers to continue to consider the importance of education and endorsing mobile technologies for older Australians to help them overcome the barriers towards further adoption. Some of these barriers include unfamiliarity with the full benefits of mobile technology, complexities in learning and keeping updated with new digital technologies, and physical and health related issues (which may affect their ability to read) according to Smith (2014).

Per Capita Longevity Forum – pursuing innovative policy solutions to improve the lives of older Australians

As seniors approach retirement, their preferences over work-life balance change. “Seniors want to spend fewer hours in the office. They want work arrangements that are more flexible such as working from home. Spending more time with friends and family, or going travelling, is a priority,” according to Everald Compton, Chairman of the Longevity Forum.

For those who prefer to spend less time in the office, mobile technologies have enabled individuals to work from anywhere. Travelling retirees, sometimes called ‘grey nomads’, can use roaming technology to continue undertaking some work while travelling around the country.

However, there can be barriers to seniors making these lifestyle decisions. “Employer attitudes can work against seniors – some employers believe that older people are far less productive, and won’t hire seniors as a result,” according to Mr Compton.

However, some employers acknowledge the benefits of providing more flexible working arrangements. “Hiring seniors and allowing them to telework allows companies to benefit from their experience and knowledge, while providing cost savings such as reduced desk and office space requirements,” explains Mr Compton.

Mobile technologies can also help seniors more conveniently and efficiently complete everyday tasks such as doing shopping, staying engaged with community and remembering to take medicines. The emergence of telehealth has allowed some of their treatment to be completed online, for example taking regular blood pressure, pulse and blood glucose levels; renewing prescriptions; and interacting with medical staff in real time regardless of location. Future developments in mobile technology could further improve outcomes for older Australians and it is crucial for them to learn how to use these new technologies.

Looking to the future, Everald Compton sees opportunities for the next wave of mobile technology to assist carers and seniors, particularly through the Internet of Things. “I can imagine a kettle that notifies a loved one in another location that mum hasn’t had her regular morning cup of tea, which could be a sign that she needs some help.”

With the rate of technological growth being faster now than ever before, it is important for seniors to keep up to date with developments and change. Currently, IT skill levels for seniors are dispersed – some have no or low skills, some have basic skills (such as the ability to check emails and use internet), and others have advanced skill levels.

The Blueprint for an Ageing Australia report from Per Capita identified a number of areas that policymakers should focus on to improve outcomes for older Australians, including reskilling and further education on the potential of mobile technologies.

“There is a role for government to provide constant IT and mobile training to ensure that seniors are well equipped to use the full potential of mobile technologies,” says Mr Compton. He also argues for the importance of connectivity. “Ensuring that a good Wi-Fi connection is constantly available – especially in moving vehicles such as boats and aircraft – is an important consideration for allowing the seniors of the future to stay active in the workforce through mobile.”

4.3 Mobile sourced jobs

One of the main frictions in the labour market is occupational mobility, or the ability to find, match and allocate the most suitable job opportunity or candidate at the right time.

The job search and candidate selection process has evolved from traditional methods such as newspaper ads and classifieds; and interviews that require both the examiner and job seeker to be physically present in the same place to accommodate changes in preferences (such as increased mobile ownership) and the availability of new technologies (such as videoconferencing).

For many individuals, convenience is important to the job search process. Previous studies such as the 2014 Censuswide survey found that 76% of Australians would apply to jobs on their mobile devices more if the process was simplified and that 55% of people who currently used mobile job searches did so due to convenience. The level of mobile adoption during the job search however decreases significantly with age where 80% of job seekers under the age of 25 currently use mobile devices, compared to only 52% and 31% for people aged 35-42 and 45 and above (Indeed Blog, 2014).

In terms of searching and applying for work, many Australians have been increasing their use of mobile devices. According to a 2014 survey by recruiting company Hays, 25% of respondents primarily use mobile devices during their job searches. This level of mobile adoption could further increase in the future as employers ensure that their job listings and websites are more mobile optimised.

Changing consumer trends in how people search for jobs have also led companies such as Seek, CareerOne and Australian JobSearch to make mobile options become more widely accessible.

Workible – matching job applicants based on availability, skills and preferences through mobile
"In the labour force, people today have an expectation that you already know something about them. Rather than being inundated with irrelevant offers, they want to cut down the noise and be paired with suitable jobs or candidates fast," according to Fiona Anson, co-founder of Workible, an HR technology company that is matching jobseekers and companies through mobile.

Workible allows companies and jobseekers to advertise their ideal working arrangements based on their availability, skills, location and preferences. "Because we know what both sides want, we can connect people based on suitability using our matching algorithms," says Ms Anson. The matching service can help reduce the time and cost associated with the searching process for the right job or candidate. It also allows individuals to factor in flexible working arrangements that suit their own lifestyles and preferences.

"We started off with a desktop-only business model however, after a trip to Silicon Valley we realised that not only was mobile the future, but it also allowed us to deliver results instantly, which was more closely aligned to our value proposition. Since we introduced the mobile platform, we have seen our business shift to over one third mobile use in a matter of years," notes Ms Anson.

The service is very popular among younger people looking to fit work around study, females (often with caring obligations), and high staff turnover industries such as retail. This is because it allows instant connection to suitable people or jobs including when they are on the go and even to conduct short video interviews using a mobile device. "65% of our users are female and about two thirds of our total users are between the ages of 18 and 34. Positions on our platform are typically filled in a matter of days or hours - instead of the weeks that are typical of old hiring processes," according to Fiona Anson.

However, there are still some employers who remain hesitant about participating in this mobile-centric approach towards finding suitable job candidates. One reason is reliance on heavily embedded legacy HR systems and technologies, that make changes hard to integrate or require additional programming interfaces. "For some industries and corporations that require specific qualifications, there is still a preference to use more traditional screening approaches during the hiring process," says Fiona Anson.

Although Workible has a partnership allowing easier temporary contracting, the administrative burden of hiring temps is also perceived as a barrier.

For jobseekers, mobile-first job hunting is beginning to catch on however, Workible's metrics show that two thirds of people still prefer applying through desktop or tablets and they believe that's due to limited screen real estate on mobile devices to complete relevant information.

In the future, Ms Anson sees more pickup of the use of mobile technology such as the use of video interviews through mobile and the use of Near Field Communication (NFC) technology that will allow jobseekers to 'tap' their phones to register for positions that are advertised in store and in venue.

"For consumer brands, we find that the best candidates for jobs are also regular customers. We are already working with places like Dymocks and Max Brenner to enable NFC for potential jobseekers. When you next visit as a customer, you could be asked – do you want to work here?"

Recent growth in the sharing economy, which includes "business models based on sharing underutilised assets from spaces to skills to stuff for monetary or non-monetary benefits" (Rachel Botsman, 2013), have increased the ability for individuals to use their mobile devices to search and find job opportunities.

Deloitte Access Economics (2015) found that around 45,000 individuals earned income through the collaborative economy in NSW during 2015, much of which was made possible through mobile platforms. According to the market research firm Pureprofile, in 2015 around 45% of the Australian population were aware of sharing economy platforms such as Airbnb, Uber and Airtasker and 16% of Australians had engaged in a sharing economy transaction.

An example of a sharing economy platform that is underpinned by mobile technology includes ridesharing services such as Uber. In Australia, as of the end of August 2015, the Uber platform had more than 12,000 Uber driver partners in the cities of Sydney, Melbourne, Perth and Brisbane compared to around 68,000 total drivers in the Australian taxi industry. This generated fare income for drivers of around $260 million annually, net of commission costs paid to Uber.

Sharing economy platforms have created a new market of task-based roles that were previously unavailable due to higher transaction costs. This has allowed users to outsource small tasks such as one-off cleaning services, waiting in queues as well as short-term skill-based projects in IT, marketing and design, which were previously not viable through sharing and collaborative economy platforms which include Airtasker, 99designs, TradeEzi and Freelancer.

Another benefit of sharing economy platforms is that they can offer significant flexibility benefits over traditional job arrangements by allowing individuals to offer services when it is convenient to their lifestyle rather than needing to work towards a fixed weekly working schedule. Examples include Airtasker, Freelancer, Hipages, 99designs and Expert360, which have allowed individuals to conveniently match with the right users and outsource their tasks.

4.4 Mobile participation

As at December 2015, more than one third of Australians aged fifteen and over were not employed or actively seeking employment. Further, of those who are employed, 3.7 million work part time.

Cumulatively, this means that 10.4 million Australians – nearly half of the population – do not work full-time. This may be for a number of reasons; for example, other commitments such as study or home duties, difficulties in finding employment or getting more hours, and other factors such as ill health or retirement.

Harnessing even a small proportion of this potential can have a big impact. Mobile technology enables more people to join the labour force, and allows those within the labour force to work more hours.

First, mobile allows people to work remotely. The ability to work away from the office using devices such as smartphones and tablets reduces the barriers to joining the workforce. For example, one third of individuals with a disability have difficulty using public transport, which means that getting to work could be difficult or challenging (ABS, 2013). Similarly, travel may be a major barrier for those who live in regional areas.

Mobile also provides individuals with a means of meeting personal and other commitments while at work. For example, parents of young children can monitor them remotely, and carers can check in with loved ones. People who are unwell can monitor their health throughout the day and contact medical professionals if required, and students can submit assignments.

Mobile also makes it easier to search for jobs, through tools and apps that make it easy to quickly find opportunities from any location. This reduces the frictions and costs of finding employment, which may encourage more people to join the labour force and look for a job.

Although these benefits are often discussed, they are difficult to quantify. This section uses survey data to estimate the impact of the first two of these effects on labour force participation in the Australian economy.

4.4.1 Survey results

Working-age Australians have a range of commitments and roles. People may be involved in paid or unpaid employment, home duties, study, caring responsibilities or other pursuits. For some people, barriers to entering the workforce, combined with these commitments, deter them from trying to join the labour force.

The Australian Bureau of Statistics estimated that, as at September 2013, there were more than 900,000 people who wanted to work but were not actively looking for work, 72% of whom indicated that they may enter the labour force in the next year. There were also 117,200 discouraged jobseekers – people who want to work and are available to start work within the next month but didn't look for a job because they believed they would not find it.

The barriers to entry may affect particular demographic cohorts; for example, research by the National Seniors Productive Ageing Centre in 2011 considered the barriers to mature age labour force participation in Australia. Physical illness, injury and disability, age-based discrimination, mismatched skills and care-giving responsibilities were identified as some of the greatest barriers for older workers.

It is possible that a reduction in the barriers to entry may encourage more of these people into the workforce, or increase the hours they work each week, alongside their other commitments.

Jigsaw: mobile technologies for people with disabilities

Jigsaw is a social enterprise run by Fighting Chance that provides employed opportunities for people with disabilities. It connects clients such as Holroyd and Warringah Councils and Royal North Shore Hospital with services support such as document management, information audit and paperless office services.

According to Founder Laura O'Reilly, mobile technology plays an important role in facilitating the employment of Jigsaw workers, who may otherwise not be in the labour market. Mobile devices have apps such as reading aloud, and magnifying glasses that can assist vision impaired workers with documents. Apps such as Genie can make devices simpler than traditional desktop options.

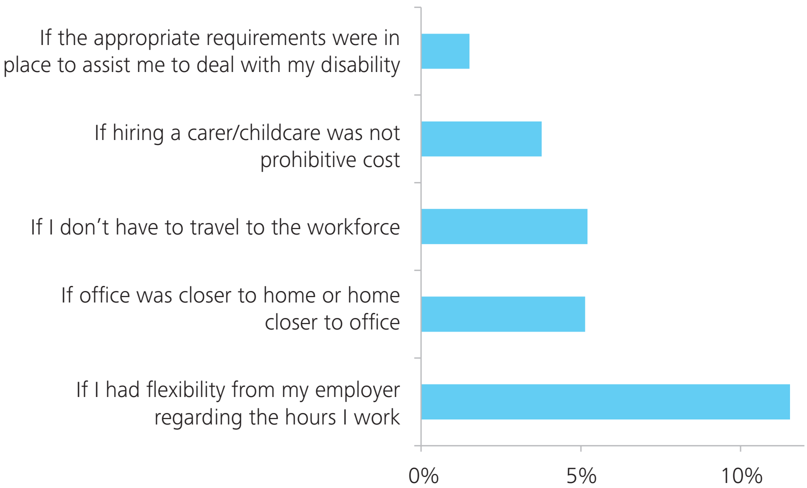
Mobiles also act as a security device – helping Jigsaw participants in travelling to work, and link to assistance if lost or in trouble. This is important, according to Laura, because while working from home is part of the solution to providing more meaningful work to people with a disability, mobile devices facilitating getting out of the home and into the workplace is also beneficial because of the broader socialising opportunities it provides.

To enumerate the impacts of mobile on labour force participation in Australia, we surveyed more than 800 individuals whose willingness to participate in the workforce could be influenced by mobile technology, including:

- part-time workers;
- individuals who live in rural or remote areas;
- individuals with a disability;
- parents of children under five years of age;
- carers;
- young people (aged between 16 and 24); and
- those who are considering retiring in the next five years.

Many of those we surveyed faced challenges in their current role such as a lack of flexibility in types of hours worked (10.9%), difficulty in finding employment which suits their availability and/or requirements (9.2%), and extensive travel to workplace from home (6.2%). Many of those who were not in the labour force cited similar issues as barriers to entering the paid workforce, as shown in Chart 4.4.

Chart 4.4: Factors which would enable individuals to enter the paid workforce

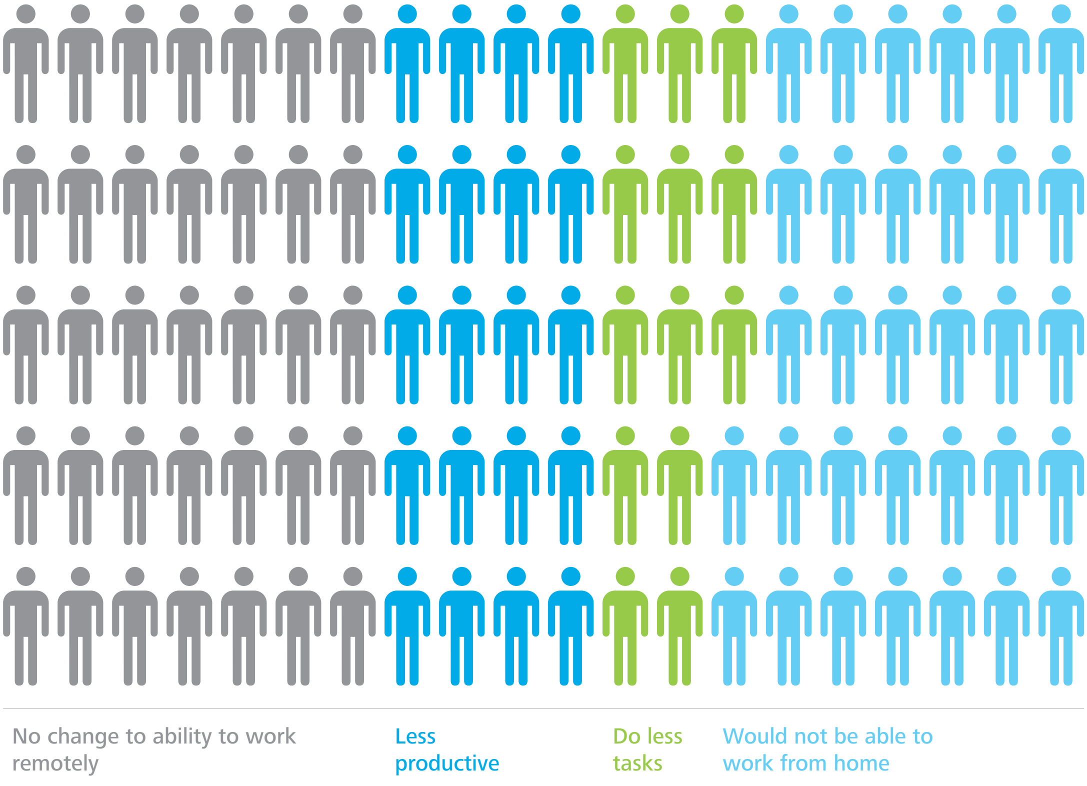


Source: Deloitte Access Economics, 2015

Of those who are currently employed, 29% of those surveyed currently work remotely, at least some of the time, and 70% meet personal commitments while at work. For many, the ability to do this is vital to the number of hours they work. 14.5% would work fewer hours if they could not work remotely, and 11.1% would work less if they couldn't meet personal commitments while at work.

It is important to note that not all of this can be attributed to mobile. However, without mobile, these activities may not be possible. When asked to what extent mobile facilitated working remotely and/or meeting personal commitments, many said that they would be able to complete fewer tasks or be less productive if they did not have access to mobile devices.

Figure 4.1: Impact of not having a mobile device on remote workers



Source: Deloitte Access Economics

Using this data, we model how many more hours mobile-enabled individuals work. We find that, on average, the cohorts listed above work **0.6** more **hours** every week because of mobile. This includes only hours worked by individuals who may not otherwise be working, as listed above.

It's not just direct hours worked that are positively affected by mobile devices. Of those who currently work remotely, one quarter said they would take more sick leave if they were not able to do so. Similarly, nearly one in five said they would take more sick leave if they were unable to meet their personal commitments at work. This could have significant impacts on the overall productivity and effectiveness of the labour force.

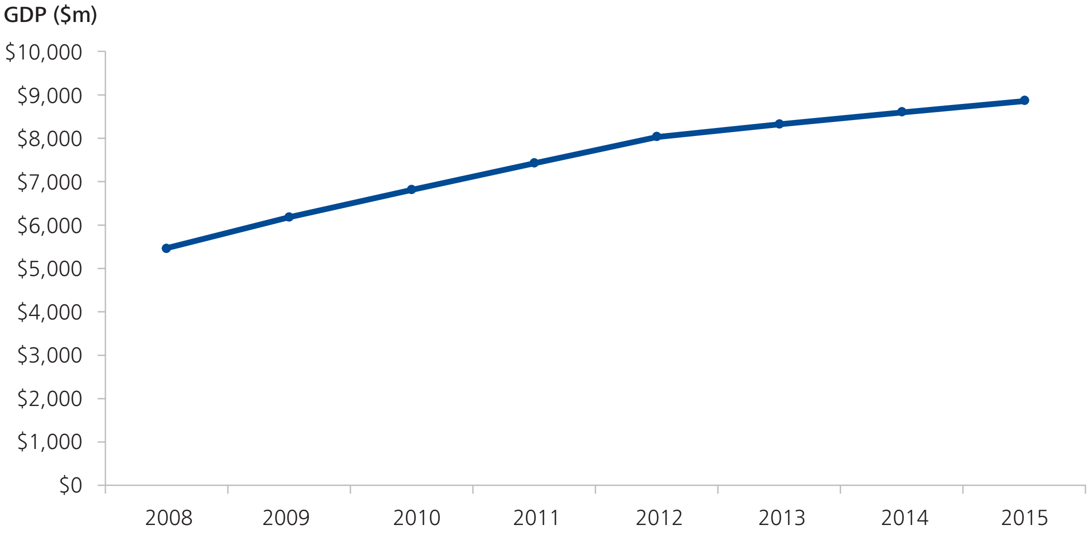
4.4.2 CGE modelling

Deloitte Access Economics has used its DAE-RGEM dynamic computable general equilibrium model to quantify the economy-wide impacts of increased participation in the workforce as a result of mobile. More specifically, this report models the impact of individuals in the workforce working fewer hours because they do not have access to mobile devices which enable them, at least in part, to work remotely or meet personal commitments while at work.

This is modelled by reducing the hours worked from 2008 to 2015 of all employed individuals by 0.6 hours weekly. Shocks are generated using Deloitte Access Economics workforce forecasts, average hours worked from the Australian Bureau of Statistics, and survey data.

We find the economy is **$8.9 billion** bigger than it otherwise would have been in 2015 if the participation benefits of mobile technologies were removed.

Chart 4.5: Impact of mobile-enabled participation on GDP, 2008-2015



Source: Deloitte Access Economics, 2015

We estimate that this additional GDP supported approximately **65,000** full-time equivalent jobs annually – about **1%** of total employment.

4.4.3 Future potential

There is the potential for more benefits to come. Most Australians have already adopted mobile technologies. However, many employers and workplaces do not yet offer roles or jobs which harness the potential of these devices. One third of survey respondents said that their employer did not facilitate working remotely, or only allowed working from home in special circumstances.

As such, there is the potential for growth in mobile-enabled participation, as employers offer more roles which provide flexibility in the workplace. Of those who are not currently employed, two in five said they would take up a paid employment opportunity if an employer offered them to work remotely regularly, or meet personal commitments at work.

In some cohorts the effect on individuals who are not currently in the workforce could be very strong:

- 58% of individuals with a disability would take an opportunity which allowed them to work remotely regularly;
- half of carers would take an opportunity which allowed them to meet personal commitments while at work; and
- 37% of those considering retirement would remain in the workforce longer if an employer allowed them to work remotely regularly.

Boosting workforce participation is important to securing Australia's future economic growth. Survey results show that mobile could play a significant role in this, by providing more flexible opportunities which appeal to many who are not currently in the labour force.

5 Conclusions

Mobile has become a ubiquitous feature of modern life. It shapes how people around the world communicate, access information and complete day-to-day tasks. It facilitates connectivity, productivity and more. Individuals, families, businesses and society are all feeling the impact of this technology.

The previous edition of Mobile Nation estimated that the mobile sector was worth $14.1 billion dollars to the Australian economy and supported more than 56,000 jobs in 2011-12.

Beyond this direct impact, mobile is contributing to the growth of the Australian economy. It contributes to growth in productivity and participation – two of the 'three Ps' of economic growth.

Mobile is building both capital and labour productivity in Australia. M2M technologies and m-commerce allow for more productive use of capital. Productivity apps and the ability to communicate on the go have created a more productive workforce.

Using econometric analysis, this report estimates the long-term productivity benefits of mobile technologies to the Australian economy to be around 2.0% of GDP each year or $34 billion in 2015.

Mobile can also facilitate participation in the labour force. It enables people to work remotely, or meet their personal commitments while at work. It can also reduce the costs and frictions associated with finding a new job.

The impact of mobile on participation has not previously been quantified. This report uses a survey of more than 1,000 individuals whose participation may be enabled by mobile to estimate extra hours worked because of the ability mobile provides to work remotely and/or meet personal commitments while at work.

On average, these individuals work 0.6 hours more per week than they would if they did not have access to a mobile device.

This extra participation has created an estimated $8.9 billion per year on average in GDP for the Australian economy.

More benefits are yet to come. The next wave of the mobile revolution is emerging, creating new technologies and prospects. The productivity and participation benefits of mobile are likely to continue to evolve as the technology advances.

This will bring both opportunities and challenges. Individuals will benefit from more flexible roles enabled by mobile in coming years, decreasing barriers to entering the labour force for those who would like to work. Businesses will have to consider how to harness the productivity benefits of mobile, while considering how best to leverage technology to give employees the flexibility they seek. Policy makers should look to the opportunities that mobile technology provides to contribute to economic growth in years to come.

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Appendix A: Econometric modelling approach

In the last edition of Mobile Nation, Deloitte Access Economics estimated the productivity impact of mobile technologies as a share of broader impact from ICT investment. The study reflected the best available information at the time. In particular, it leveraged a Productivity Commission estimate of the economic impact of ICT investment on productivity growth (PC, 2004).

The Productivity Commission's findings are informative; however, the research used firm-level data from a single country to isolate th e impact of ICT investment on productivity and economic growth. This data set means that the estimate is not able to account for the impact of policy and institutional settings, which tend to be static within a single country.

This research seeks to address this issue by using a wider dataset, consisting of cross country macro-economic time series data. This enables us to estimate the contribution of various policy and institutional developments to Australia's economic growth with a refined approach.

In particular, we use a pooled cross-country time series data set of 37 countries in the OECD database to explain both:

- cross-sectional differences in economic growth performance (that is, differences in performance between countries at a point in time); and
- longitudinal differences in economic growth performance (that is, how the performance of any given country changes over time).

This research is theoretically founded in the neo-classical production function assumption outlined by Solow's growth accounting model. Previous studies have shown that models of this nature are, to a first approximation, consistent with historical data (Mankiw et al.,1992).

The Solow model argues that economic growth is driven by the interplay between:

- labour;
- capital;
- technology; and
- the 'productivity' or effectiveness of how each of these inputs is deployed in the economy.

The model gives simple testable predictions about how the key factors outlined above influence the steady-state level of income.

This refined approach allows us to ask deeper questions about the factors influencing Australia's economic growth and be more robust in our findings. In particular, the research tested how economic growth might be driven by a range of factors, including:

- human capital;
- research and development activity;
- urbanisation;
- development of communications technology;
- macroeconomic and structural policy settings;
- trade policy; and
- financial market conditions on economic efficiency.

The determinants of economic growth

The literature on the impact of policy and institutions on economic growth is vast. However, there is little agreement on which policy and institutional settings have a material impact on growth, or the mechanisms through which transmit these impacts.

In this research, we test the impact of a range of possible macro-economic variables empirically, and attempt to shed some light on their contributions to economic growth. These are briefly described below.

Physical capital (non-residential gross capital formation)

Economists have long stressed the importance of physical capital to the process of growth. The accumulation of capital (capital deepening) increases the supply of capital stock, such as plant and equipment, for production processes. This greater availability of capital to augment production drives growth.

It is one of the main factors determining the level of real output per capita. However, the permanence of its effects depend on the extent to which innovation is embodied in new capital.

In our model, we measure capital investment as the ratio of gross capital formation to GDP. Capital investment varies significantly across countries, and is a key element of explaining the variation of income per capita across countries.

Human capital (tertiary education attainment)
Recent growth accounting literature has placed substantial emphasis on the importance of human capital in the production process. The formal skills, experiences and education attached to the workforce are often modelled as a form of intangible capital (e.g. Jones, 2014).

In the empirical analysis, we measure the accumulation of human capital as the share of the working population who are tertiary graduates.

Mobile technologies (mobile phone penetration)
The development of mobile technologies has had a significant impact on how workers, consumers and businesses communicate and interact. As discussed in the report, mobile technologies brought a range of benefits for economic agents, including the availability of new goods and services, higher quality of output, new and more efficient productions process. For example, increasing adoption of mobile banking could help banks increase the number of consumers it can serve with the same number of employees and capital, hence making the bank more productive.

Ideally, the empirical specification would capture both the pervasiveness of mobile technologies and the increasing sophistication of mobile technologies being used. The analysis of mobile technologies (proxied using the adoption rate of mobile phones within the population) in the research only captures the former due to inherent data limitations on the latter.

Research and development (higher education institution R&D, other R&D expenditure)
The effects of knowledge capital on productivity may work through various channels depending on the source of the knowledge. For example, R&D, a major component of knowledge capital, can be performed either by the business sector, higher education, public sector or beyond the borders of a country. Each of these types of R&D performers can be a source of significant domestic technological change. R&D performed by the higher education sector results in new innovative technologies which can used to produce new goods and services, improving productivity at the firm or national level.

Empirically, we separately identify the effects of R&D by higher education institutions and other sectors of the economy using their R&D expenditure to GDP ratio.

Urbanisation (share of urban population)
Urbanisation – the process of an increasing share of the national population moving to live within urban settlements – has been a key driving force in human and economic development. Settlements in urban areas are often associated with an increasing proportion of the population being engaged in non-agricultural occupations, which can serve as a proxy for underlying shifts in the economic structure of a country.

We estimate the effects of urbanisation using the ratio of urban population to total population.

Trade exposure (imports and exports share)
International trade is another factor that influences the improvements in productivity, particularly through competition and the diffusion of knowledge across borders. This is especially the case in developing countries (which do not, in general, perform research and developments). Where productivity growth depends, to a large extent, on the rate at which they can acquire technology developed by industrial countries. We measure trade exposure by taking the ratio between the value of exports and imports against the value of outputs.

Other
A range of other variables were tested as a part of this research including:

- The size of government (measured as the ratio of tax revenue to GDP)
- Levels of financial development (measured as equity capitalisation to GDP ratio)
- Monetary policy effectiveness (measured by the inflation rate)
- Broader levels of communications technology development (measured by the number of fixed broadband subscribers per 100 inhabitants).

Modelling methodology

In line with a large body of economic development literature, this report seeks to quantify the effects of policy and institutional settings on economic growth using a neo-classical production function; the formal framework is first set out by Mankiw et al (1992) and its augmented-form implemented by OECD (2001). The models used in this report adhere closely to the existing literature, with modifications provided to accommodate the focus on mobile technology and tertiary human capital. The standard neo-classical growth model is derived from constant returns to scale production function with three inputs (capital, labour and human capital) that are paid their marginal products. Production (output) at time t is given by:

$$Y(t) = K(t)^{\alpha} H(t)^{\beta} \big(A(t)L(t)\big)^{1-\alpha-\beta}$$

Where Y,K,H and L are respectively output, physical capital, human capital and labour, α is the partial elasticity of output with respect to physical capital, β is the actual elasticity of output with respect to human capital and A(t) is a measure of technological progress and economic efficiency. Detailed specification and derivation of the final functional form can be found in OECD (2001).

The final specification is the dynamic form of the augmented Solow Swan equation:

$$\Delta \ln y(t) = a_0 - \phi \ln y(t-1) + a_1 \ln s_k(t) + a_2 \ln h(t) - a_3 n(t) + a_4 t + \sum_{j=1}^{3} a_{j+4} \ln V_j$$
$$+ b_1 \Delta \ln s_k(t) + b_2 \Delta \ln h(t) + b_3 \Delta \ln n(t) + \sum_{j=1}^{3} b_{j+3} \Delta \ln V_j$$

Similar to specifications used in OCED (2001), our analysis uses a sample of 37 countries between 1980 and 2010. Where appropriate, data is converted to constant 2010 US dollars using constant Purchasing Power Parity, consistent with OECD standards.

Table A.2 outlines the parameters used in the estimation procedure. In addition to primary factors of production including physical capital accumulation, human capital and labour, the model also takes into account the contribution of productivity enhancing activities, such as research, openness to trade, mobile adoption, and urbanisation of population. It is important to note that a range of variables were tested as a part of this research, including size of government (ratio of tax revenue to GDP), financial development (equity capitalisation to GDP ratio), monetary policy effectiveness (inflation rate), fixed broadband development (No. of subscribers per 100 inhabitant), the estimated values of these coefficients were considered before arriving at the specification below.

Further, it is also important to recognise that under our dynamic model specification, the observed growth in output in any given period, abstracting from cyclical fluctuations, can be seen as the combination of three different forces: i) underlying technological progress – which is assumed to be exogenous; ii) a convergence process towards the country-specific steady-state path of output per capita; and iii) shifts in the steady state (growth or level of GDP per capita, see below) that can arise from changes in policy and institutions as well as investment rates and changes in population growth rates. This means that the exclusions institutional factors does not necessarily constitute omitted variable bias, the effect of these variables on economic growth could simply be factored in as an unidentified underlying change in the technological progress, the specification remains consistent and estimates unbiased.

Table A.2: Data sources

Parameter	Variable	Source
y(t)	Gross domestic product per capita	OECD
h(t)	Tertiary education attainment (% of 15+ population)	Barro-Lee (2010)
n(t)	Total population growth	OECD
s_k (t)	Gross capital formation (% of GDP)	OECD
V_1 (H R&D)	Expenditure on Higher education R&D per capita	OECD
V_1 (O R&D)	Expenditure on Other R&D per capita	OECD
V_3 (Trade)	Exports and Imports of goods and services (% of GDP)	World Bank
V_4 (Mobile)	Mobile phone subscription penetration rate (% of population)	OECD
V_5 (Urban)	Urbanisation (% of population in urban areas)	World Bank
t	Time trend	-

Table A.3 outlines the modelling results. Note that long-term coefficients reported below have been converted using the convergence parameter.

Table A.3: Modelling results

Parameter	Coefficient estimates	Parameter	Coefficient estimates
ln y (t-1)	-0.0566 (-3.05)	Δn(t)	1.049 (-2.12)
ln s_k (t)	0.500 (.)	Δln h(t)	-0.0216 (-0.57)
n(t)	-17.32 (-0.75)	ΔV_1 (H R&D)	-0.0598 (-2.40)
ln h(t)	0.182 (-0.7)	ΔV_2 (O R&D)	0.0593 (-1.9)
V_1 (H R&D)	0.218 (-0.58)	ΔV_3 (Trade)	-0.0233 (-1.36)
V_2 (O R&D)	0.344 (-1.22)	ΔV_4 (Mobile)	0.00494 (-1.63)
V_3 (Trade)	0.55 (-1.01)	ΔV_5 (Urban)	0.385 (-1.51)
V_4 (Mobile)	0.0375 (-0.76)	Trend	-0.0353 (-1.19)
V_5 (Urban)	0.496 (-0.32)	Constant	0.142 (-0.51)
Δ ln s_k (t)	0.243 (-9.32)		

Note: t-value reported in parenthesis. Reported coefficients are transformed to exclude the convergence term per their functional form. Coefficient for physical capital is constrained to obtain capital share of a third.

Contribution of mobile

Mobile technology has played a key role in stimulating labour productivity growth over the past three decades. It connects people and businesses, driving innovation and technological progress, and transforming industries. To capture the contribution of mobile technologies to productivity growth, we explicitly modelled the share of income growth associated with increases in mobile phone penetration rate in the economy. It is importantly to note that this measure is not perfect. For example, the adoption rate of mobile devices is likely a poor proxy for factors such as sophistication of mobile usage, availability of services through mobile devices, or the interaction between mobile devices and other technology platforms. However, in the absence of reliable data that could reflect these underlying changes in mobile technology, the adoption rate of mobile devices serves a good starting point to measure the impact of mobile device prevalent in the Australian economy.

Table A.4: Countries

Factor input	Implied share
Physical capital share (α)	33.33%
Tertiary human capital share (β)	12.13%
Residual share (1-α-β)	54.53%

Our results indicate the average share of tertiary human capital is around 12.1%, that is, around 12% of steady-state income can be attributed to tertiary human capital inputs.

Using estimates from the macro-econometric model, the share of mobile technology in income could be derived from the following equation:

$$share_{mobile} = (1-\alpha-\beta)\times p_4 = 2.04\%$$

Applying this to the 2015-16 GDP forecast for Australia, the share of mobile technology in GDP is estimated to be around $34 billion.

Two important caveats need to be borne in mind when interpreting the results. First, it is assumed that the policy and institutional variables affect only the level of economic efficiency and not the steady-state growth rate. Second, the calculations should only be taken as broad indications, given the variability of coefficients across the specifications, and interaction effects that may be important but cannot be take into account (OECD, 2001).

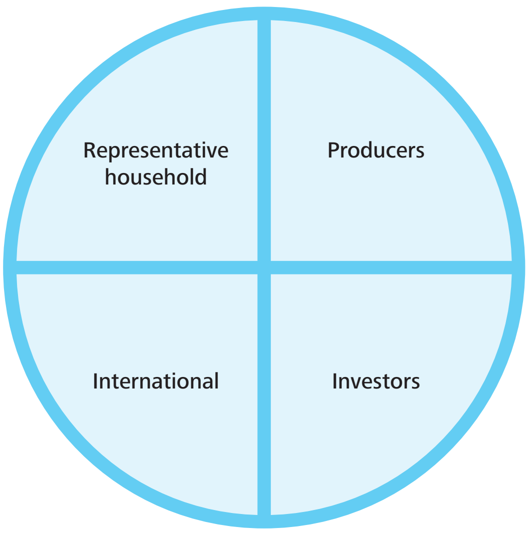
Appendix B: CGE modelling

The Deloitte Access Economics – Regional General Equilibrium Model (DAE-RGEM) is a large scale, dynamic, multi-region, multi-commodity computable general equilibrium model of the world economy. The model allows policy analysis in a single, robust, integrated economic framework. This model projects changes in macroeconomic aggregates such as GDP, employment, export volumes, investment and private consumption. At the sectoral level, detailed results such as output, exports, imports and employment are also produced.

The model is based upon a set of key underlying relationships between the various components of the model, each which represent a different group of agents in the economy. These relationships are solved simultaneously, and so there is no logical start or end point for describing how the model actually works.

Figure 5.1 shows the key components of the model for an individual region. The components include a representative household, producers, investors and international (or linkages with the other regions in the model, including other Australian States and foreign regions). Below is a description of each component of the model and key linkages between components. Some additional, somewhat technical, detail is also provided.

Figure 5.1: Key components of DAE-RGEM



DAE-RGEM is based on a substantial body of accepted microeconomic theory. Key assumptions underpinning the model are:

- The model contains a 'regional consumer' that receives all income from factor payments (labour, capital, land and natural resources), taxes and net foreign income from borrowing (lending).
- Income is allocated across household consumption, government consumption and savings so as to maximise a Cobb-Douglas (C-D) utility function.
- Household consumption for composite goods is determined by minimising expenditure via a CDE (Constant Differences of Elasticities) expenditure function. For most regions, households can source consumption goods only from domestic and imported sources. In Australian regions, households can also source goods from interstate. In all cases, the choice of commodities by source is determined by a CRESH (Constant Ratios of Elasticities Substitution, Homothetic) utility function.
- Government consumption for composite goods, and goods from different sources (domestic, imported and interstate), is determined by maximising utility via a C-D utility function.
- All savings generated in each region are used to purchase bonds whose price movements reflect movements in the price of creating capital.
- Producers supply goods by combining aggregate intermediate inputs and primary factors in fixed proportions (the Leontief assumption). Composite intermediate inputs are also combined in fixed proportions, whereas individual primary factors are combined using a CES production function.
- Producers are cost minimisers, and in doing so, choose between domestic, imported and interstate intermediate inputs via a CRESH production function.
- The model contains a more detailed treatment of the electricity sector that is based on the 'technology bundle' approach for general equilibrium modelling developed by ABARE (1996).
- Movements in the supply of labour have a negative influence on the real wage rate.
- Investment takes place in a global market and allows for different regions to have different rates of return that reflect different risk profiles and policy impediments to investment. A global investor ranks countries as investment destinations based on two factors: global investment and rates of return in a given region compared with global rates of return. Once the aggregate investment has been

determined for Australia, aggregate investment in each Australian sub-region is determined by an Australian investor based on: Australian investment and rates of return in a given sub-region compared with the national rate of return.
- Once aggregate investment is determined in each region, the regional investor constructs capital goods by combining composite investment goods in fixed proportions, and minimises costs by choosing between domestic, imported and interstate sources for these goods via a CRESH production function.
- Prices are determined via market-clearing conditions that require sectoral output (supply) to equal the amount sold (demand) to final users (households and government), intermediate users (firms and investors), foreigners (international exports), and other Australian regions (interstate exports).
- For internationally-traded goods (imports and exports), the Armington assumption is applied whereby the same goods produced in different countries are treated as imperfect substitutes. But, in relative terms, imported goods from different regions are treated as closer substitutes than domestically-produced goods and imported composites. Goods traded interstate within the Australian regions are assumed to be closer substitutes.
- The model accounts for greenhouse gas emissions from fossil fuel combustion. Taxes can be applied to emissions, which are converted to good-specific sales taxes that impact on demand. Emission quotas can be set by region and these can be traded, at a value equal to the carbon tax avoided, where a region's emissions fall below or exceed their quota.

The representative household

Each region in the model has a so-called representative household that receives and spends all income. The representative household allocates income across three different expenditure areas: private household consumption; government consumption; and savings.

Going clockwise around figure B, the representative household interacts with producers in two ways. First, in allocating expenditure across household and government consumption, this sustains demand for production. Second, the representative household owns and receives all income from factor payments (labour, capital, land and natural resources) as well as net taxes. Factors of production are used by producers as inputs into production along with intermediate inputs. The level of production, as well as supply of factors, determines the amount of income generated in each region.

The representative household's relationship with investors is through the supply of investable funds – savings. The relationship between the representative household and the international sector is twofold. First, importers compete with domestic producers in consumption markets. Second, other regions in the model can lend (borrow) money from each other.

Some detail

- The representative household allocates income across three different expenditure areas – private household consumption; government consumption; and savings – to maximise a Cobb-Douglas utility function.
- Private household consumption on composite goods is determined by minimising a CDE (Constant Differences of Elasticities) expenditure function. Private household consumption on composite goods from different sources is determined is determined by a CRESH (Constant Ratios of Elasticities Substitution, Homothetic) utility function.
- Government consumption on composite goods, and composite goods from different sources, is determined by maximising a Cobb-Douglas utility function.
- All savings generated in each region are used to purchase bonds whose price movements reflect movements in the price of generating capital.

Producers

Apart from selling goods and services to households and government, producers sell products to each other (intermediate usage) and to investors. Intermediate usage is where one producer supplies inputs to another's production. For example, coal producers supply inputs to the electricity sector.

Capital is an input into production. Investors react to the conditions facing producers in a region to determine the amount of investment. Generally, increases in production are accompanied by increased investment. In addition, the production of machinery, construction of buildings and the like that forms the basis of a region's capital stock, is undertaken by producers. In other words, investment demand adds to household and government expenditure from the representative household, to determine the demand for goods and services in a region.

Producers interact with international markets in two main ways. First, they compete with producers in overseas regions for export markets, as well as in their own region. Second, they use inputs from overseas in their production.

Some detail

- Sectoral output equals the amount demanded by consumers (households and government) and intermediate users (firms and investors) as well as exports.
- Intermediate inputs are assumed to be combined in fixed proportions at the composite level. As mentioned above, the exception to this is the electricity sector that is able to substitute different technologies (brown coal, black coal, oil, gas, hydropower and other renewables) using the 'technology bundle' approach developed by ABARE (1996).
- To minimise costs, producers substitute between domestic and imported intermediate inputs is governed by the Armington assumption as well as between primary factors of production (through a CES aggregator). Substitution between skilled and unskilled labour is also allowed (again via a CES function).

Investors

Investment takes place in a global market and allows for different regions to have different rates of return that reflect different risk profiles and policy impediments to investment. The global investor ranks countries as investment destinations based on two factors: current economic growth and rates of return in a given region compared with global rates of return.

Some detail

- Once aggregate investment is determined in each region, the regional investor constructs capital goods by combining composite investment goods in fixed proportions, and minimises costs by choosing between domestic, imported and interstate sources for these goods via a CRESH production function.

International

Each of the components outlined above operate, simultaneously, in each region of the model. That is, for any simulation the model forecasts changes to trade and investment flows within, and between, regions subject to optimising behaviour by producers, consumers and investors. Of course, this implies some global conditions must be met such as global exports and global imports are the same and that global debt repayments equals global debt receipts each year.

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