

Australian Government

Department of Infrastructure, Transport, Regional Development and Communications



# Working paper—Economic impact of ubiquitous high speed broadband: agriculture sector

May 2021



#### Ownership of intellectual property rights in this publication

Unless otherwise noted, copyright (and any other intellectual property rights, if any) in this publication is owned by the Commonwealth of Australia (referred to below as the Commonwealth).

#### Disclaimer

The material contained in this publication is made available on the understanding that the Commonwealth is not providing professional advice, and that users exercise their own skill and care with respect to its use, and seek independent advice if necessary.

The Commonwealth makes no representations or warranties as to the contents or accuracy of the information contained in this publication. To the extent permitted by law, the Commonwealth disclaims liability to any person or organisation in respect of anything done, or omitted to be done, in reliance upon information contained in this publication.

#### **Creative Commons licence**

With the exception of (a) the Coat of Arms; (b) the Department of Infrastructure, Transport, Regional Development and Communications photos and graphics; and (c) [OTHER], copyright in this publication is licensed under a Creative Commons Attribution 4.0 Australia Licence.

Creative Commons Attribution 4.0 Australia Licence is a standard form licence agreement that allows you to copy, communicate and adapt this publication provided that you attribute the work to the Commonwealth and abide by the other licence terms.

Further information on the licence terms is available from https://creativecommons.org/licenses/by/4.0/.

This publication should be attributed in the following way: © Commonwealth of Australia 2021.

#### Use of the Coat of Arms

The Department of the Prime Minister and Cabinet sets the terms under which the Coat of Arms is used. Please refer to the Commonwealth Coat of Arms - Information and Guidelines publication available at <u>http://www.pmc.gov.au</u>.

#### Contact us

This publication is available in hard copy or PDF format. All other rights are reserved, including in relation to any departmental logos or trade marks which may exist. For enquiries regarding the licence and any use of this publication, please contact:

Director—Creative Services

**Communication Branch** 

Department of Infrastructure, Transport, Regional Development and Communications

GPO Box 594 Canberra ACT 2601 Australia Email: <u>publishing@communications.gov.au</u> and <u>webservices@infrastructure.gov.au</u> Website: <u>www.infrastructure.gov.au</u>

#### Contents

Glossary	4
Executive summary	5
Ubiquitous high-speed broadband is increasingly important to economic outcomes	7
Box 1 What is ubiquitous high-speed broadband?	7
Australian agriculture and its use of digital technologies	8
Current state of agriculture, fisheries and forestry	8
Agriculture is a diverse sector	9
Productivity in the agricultural sector	9
Outlook for the AFF sector	10 11
Quantifying the impact of ubiquitous high-speed broadband on agriculture	11
How ubiquitous high-speed broadband can impact agricultural productivity	11
Box 2 Growth accounting	12
Quantifying the benefits of broadband to agriculture	14
The transformative nature of ubiquitous high-speed broadband in agriculture	16
Whole-of-enterprise connectivity drives better decision making and lower costs	16
Box 3 Internet of Things and sensor technology	16
Box 4 Sundown Pastoral Company	1/
Improved water use efficiency	18
Better supply chain management	19
Improved liveability for regional communities	19
Box 5 Murchison House Station	19
Unlocking the benefits of broadband to agriculture	21
Availability	21
Affordability	21
Ability	21
Appendix A—The Growth Accounting Model	23
An overview of the approach	23
Growth accounting approach	23
Forecasting additional investment	24
Linking the growth accounting to an agricultural output result	25
Linking growth accounting to incomes	25
Appendix B—The scenarios	26
Additional investment	26
Timing	27
Sectoral scope	28
Tables / images	
Figure 1 Ubiquity and speed—outcomes in Australia	7
Table 1: Characteristics of the scenarios	13
Table 2: Economic outcomes of ubiquitous, high-speed broadband in 2029–30 by scenario	15
Table 3: ADOPT Questionnaire responses	27

# Glossary

This glossary provides a general guide to terms used in the report.

**Agriculture, forestry and fisheries (AFF)**—covers all primary industries within the AFF sector and aligns with the ABS division.

**Blockchain**—is a distributed ledger technology that enables electronic tracking of goods with associated financial and other information.

**Broadacre agriculture**—covers livestock and cropping activities that are done on a large scale and without irrigation

Broadband-is wide bandwidth data transmission across any fixed or mobile transmission method

**Broadband-supported technologies**—are technologies that do not need broadband but for which broadband improves their effectiveness

Digital technologies—are digital-enabling infrastructure and products

**Gross value added (GVA)**—is the value of output less the value of intermediate use and is a measure of the contribution to GDP made by an individual producer, industry or sector.

**Growth accounting**—is an economic method used to calculate the contribution of different factors (such as labour and capital) to economic growth.

Internet of Things—objects that use sensors or other technologies to connect to each other and the internet.

**Multifactor productivity growth**—is a measure of productivity calculated by subtracting labour and capital input growth from output growth.

**RFID**—a radio frequency identification device uses electromagnetic signals to automatically identify and track objects

**Sensor**—is a device that detects and responds to a feature in the physical world, such as rainfall or temperature

# **Executive summary**

The National Broadband Network (NBN) will increasingly underpin the economic activity that communications services enable. With the initial volume build of the NBN completed in 2020, Australia will be the only continent where every household and business has access to high-speed broadband services, with minimum peak wholesale download speeds of at least 25 megabits per second (Mbps). This gives businesses the opportunity to harness productivity benefits by reaching new markets, developing new products and services, and using new technologies that rely on broadband access (broadband-supported technologies).

The ubiquity of access that the NBN brings is particularly relevant to the agriculture sector. For the first time, many regions that support agriculture, forestry and fishing will have access to reliable, high-speed broadband services. These services can support innovative broadband-supported technologies that can enhance productivity on farms and allow agricultural enterprises to better contribute to the ongoing digital transformation of the Australian economy. Examples of broadband-supported technologies include:

- Whole-of-enterprise connectivity solutions to improve productivity and output especially for farms which cover a broad area (mainly crop and livestock producers).
- Automation and sensor technologies to improve allocation and efficiency in the use of resources such as water.
- Real time sensor data to allow farm businesses to better prioritise when workers need to attend to issues, especially on large or multi location farm businesses.

This paper estimates the benefits of the agriculture sector's access to ubiquitous, high-speed broadband. The Bureau of Communications, Arts and Regional Research (BCARR) estimates that the additional economic benefit from broadband-supported technology could be between \$3.0 and \$10.6 billion per year (in 2017–18 dollars) for the agricultural sector by 2029–30, which represents an additional boost to economic activity in agriculture of between 4.7 to 16.9 per cent by 2030. While these benefits are significant within agriculture, the relatively small size of the sector (2.1 per cent of GDP in 2018–19) means that the benefits are likely to be limited across the economy.

There will also be broader social benefits to Australians living in rural and regional Australia enabled by ubiquitous high-speed broadband not quantified in this paper. These include the ability to better access health and education services in the rural and regional communities that are supported by agricultural workers and greater opportunities for these communities to engage across Australia and the world. Access to broadband also opens up employment opportunities in regions, including the potential to relocate to regional areas.

This paper highlights the real world benefits of high-speed ubiquitous broadband in a series of case studies of agricultural enterprises. Farmers use broadband in combination with other technologies to reduce costs, improve water efficiency and improve access to commodity and labour markets. For example, the Sundown Pastoral Company uses broadband together with sensors to manage multiple properties from a single location. The owners of Murchison House Station noted the value of access to services such as Netflix in attracting workers to the station.

The case studies draw attention to the fact AFF sectors benefit more from the ubiquity of recent improvements in broadband than from their high-speeds. The very large size of Australian agricultural enterprises means digital technologies need broadband supported by on farm communications solutions. They also highlight that ubiquitous high-speed broadband is part of the solution to achieving connectivity and that sensors, RFID and mobile technologies will all play a part.

The case studies also provide insights into focus areas for uptake. Many benefits of high-speed ubiquitous broadband require investment in additional infrastructure, technology and skills to realise the benefits. These areas of focus are summarised as follows:

- 1. Availability: whether the product or service enabled by high speed and ubiquitous broadband is available in agricultural regions.
- 2. Ability: whether the consumer has the required skills/knowledge to use the product or service.
- 3. Affordability: whether the consumer has the financial means to purchase the product or service.

For the agriculture sector, the NBN has significantly improved the availability of broadband services, with the take-up of internet services by agriculture businesses being 96.3 per cent.<sup>1</sup> While there are many broadband-supported technologies available for the agriculture sector, the overall take-up has been limited because they are not affordable for many businesses.

In general, the agriculture workforce has a relatively low digital literacy<sup>2</sup> and therefore may require support to implement broadband-supported technologies. Additionally, many broadband-supported technologies are expensive to implement, particularly if whole-of-enterprise connectivity is required, and much of the agriculture sector is likely to have limited access to capital following the prolonged drought. The Australian Government is supporting access to these technologies through programs such as the Regional Connectivity Program.<sup>1</sup>

Nonetheless, by addressing these areas, the future benefits for the agriculture sector and regional Australia from broadband are likely to be significant—both economically and socially.

This paper is the first of a series the BCARR will publish on the benefits of ubiquitous and high-speed broadband to important sectors. Future areas of analysis include education, health, tourism and digital media.

-----

<sup>1</sup> www.communications.gov.au/what-we-do/internet/regional-connectivity-program

# Ubiquitous high-speed broadband is increasingly important to economic outcomes

Communications services are a critical enabler of economic activity in Australia. Around half of Australia's gross domestic product relies on communications services,<sup>3</sup> including telecommunications services (such as internet service provision), media services (such as content production), and information services (such as data centres and cloud computing).

Broadband internet, defined in Box 1, in particular, is an important driver of economic growth. Analysis by the International Telecommunication Union (ITU) has found that improving speeds and ubiquity of fixed broadband networks is especially important for developed countries.<sup>4</sup>

# Box 1 What is ubiquitous high-speed broadband?

Different jurisdictions and entities use different definitions about what constitutes high-speed internet. In the United States, the Federal Communications Commission has defined fast broadband as connections with download speeds of 25 Mbps or faster, while the European Union has defined it at 30 Mbps.<sup>5</sup> New definitions of 'ultrafast' broadband have also started to emerge, typically described as connections with download speeds of 100 Mbps or faster.<sup>6</sup>

Ubiquity has also been discussed in different contexts. It is usually used to refer to the proportion of a country—by area or population—that has access to the internet.<sup>7</sup>

For the purposes of this paper, high-speed broadband is defined as 25 Mbps or faster, in order to encompass the broad suite of international definitions; and ubiquity refers to the availability to households and businesses of broadband internet. In Australia, there have been significant developments in the rollout of fixed broadband networks over the last decade. In large part this has been due to the rollout of the National Broadband Network (NBN). The NBN is now built and fully operational with over 99.8 per cent of premises able to order NBN services as at February 2021. The progress of the rollout of the NBN has been evident in the number of households that now have access to the network, and the rise of the speeds that Australians are taking up (Figure 1). Peak wholesale speeds of 50Mbps currently make up 69 per cent of plans.<sup>8</sup>

Telstra's 3G and 4G mobile networks in Australia provide broadband to much of regional Australia although the speed will vary.



#### Figure 1 Ubiquity and speed—outcomes in Australia

Source: ACCC Wholesale Market Indicators and NBN Co Weekly Progress Report

The NBN rollout has provided better broadband to rural and remote areas, including the major agricultural regions of Australia. The NBN comprises a multi-technology mix that, in rural and regional Australia includes fixed wireless and satellite options. Understanding the impact of faster, ubiquitous broadband on the agricultural sector—defined as the agriculture, forestry and fishing (AFF) industry—is the focus of this working paper but the role of mobile and other services is included where appropriate.

# Australian agriculture and its use of digital technologies

# Current state of agriculture, fisheries and forestry

Australia's agriculture, forestry and fisheries (AFF) sector comprises enterprises engaged in diverse activities, ranging from growing crops to harvesting timber, fish and other animals.<sup>9</sup>

The sector is a small but important part of Australia's economy, representing 2.1 per cent of GDP in 2018–19. In 2016–17 AFF accounted for 14 per cent of Australian goods and services exports. In 2019 Australia was the 12th largest exporter of agricultural products in the world.<sup>10, 11</sup>

AFF's gross value added (GVA) was \$40.6 billion in 2018–19, down from a peak of \$47.6 billion in 2016–17. Total growth in GVA in AFF across the five years to 2018–19 is marginally lower than GVA growth of all Australian industries (Figure 2). Over that time, while all industries grew relatively steadily, GVA in the AFF sector was volatile largely reflecting climatic conditions.



#### Figure 2 Gross value add for AFF and all industries, 2014–15 to 2018–19

Source: ABS cat. 5217

As at August 2020, the number of workers in the agriculture sector was 303,000 representing just under 3 per cent of Australia's workforce.<sup>12</sup> The majority of employees in the sector live in rural and regional Australia: 82 per cent of employees lived outside a capital city in 2016.<sup>13</sup>

According to ABARES, when employment in food and beverage manufacturing, fibre manufacturing and wholesale trade is also considered, the wider workforce connected with agriculture is estimated at 466,625 for 2016.<sup>14</sup>

Although AFF is a relatively small sector, it has important linkages to other sectors. That importance can be seen in the effects of drought not just on agricultural production, but through significant secondary and tertiary effects on the economy more broadly. Widespread drought in 2006–07 is estimated to have decreased economic growth across Australia by around 0.75 percentage points.<sup>15</sup>

#### Agriculture is a diverse sector

Australia's agricultural sector produces a wide array of products under diverse production systems. Figure 3 shows the contribution each commodity made to the gross value of agricultural output in 2018–19. Much of Australia's production of meat, wool, grains, oilseeds and pulses occurs in extensive (or broadacre) agriculture. Whereas, industrial crops such as cotton, sugar and wine grapes together with horticulture rely on irrigation and are considered intensive. Dairy is the largest of Australia's intensive livestock industries. The distinction between intensive and extensive production extends to the use of labour and capital. Compared with intensive agriculture, extensive agriculture has low labour and capital intensity.





#### Productivity in the agricultural sector

Australia's productivity overall has fallen relative to other countries in the current century, notwithstanding strong growth during the 1990s.<sup>17</sup> In addition, industry productivity has been volatile,<sup>18</sup> and the low average productivity growth of 1.0 per cent experienced by Australia's broadacre agriculture sector in recent years partly reflects poor climatic conditions.<sup>19</sup>



#### Figure 3 Total factor productivity in Australian agriculture

Source: ABARES 2020<sup>16</sup>

Productivity growth remains central to the continued viability and competitiveness of Australian farm businesses. Over time productivity growth has helped maintain farm profitability in the face of a declining trend in the terms of trade (output prices relative to input prices) and has driven output growth in Australia.

#### Technology is improving, but use varies across the sector

Technology advances are a key driver of productivity growth with digital technologies crucial to growth in the agriculture, fisheries and forestry sector. The use of these technologies underpins digital agriculture, which improves business outcomes by collecting and analysing data to improve on- and off-farm decision making.<sup>21</sup>

The benefits of digital agriculture include timelier decision-making, reduced costs (for example through labour savings), increased output and improved market access.<sup>22</sup> Given Information and Communication Technology (ICT) applications on farms tend to represent a relatively small share of capital assets, technology plays an enabling role—that is, it makes other assets more productive, and boosts overall business efficiency.<sup>23</sup>

However, the uptake and use of digital technologies varies across the sector.

Around 96 per cent of Australian farmers own and use ICT assets<sup>24</sup> and around 91 per cent have internet access.<sup>25</sup> Most AFF enterprises use ICT for financial activities, with a smaller proportion using ICT for communication, working from different locations, research and data exchange (Figure 5).



#### Figure 4 Share of AFF businesses using ICT for selected activities 2015-16

Source: ABS, <u>Business Use of Information Technology</u>, Characteristics of internet access, 2015-16—Table 4.

Technology adoption differs between commodities. GPS-enabled technologies are more commonly used on cropping and vegetable farms while dairy producers make more use of electronic identification for herd management.

During 2017, the adoption rate for sensor technology was 78 per cent for the cotton industry, 48 per cent for grains, 20 per cent for dairy, 12 per cent for sheep and 10 per cent for beef.<sup>26</sup> Intensive industries, such as cotton, are likely to be able to make more use of sensor technologies than broadacre industries such as livestock production.

The way in which AFF accesses the internet—using both NBN and non-NBN connections—differs from other sectors. In 2015-16, the AFF sector had the highest proportion of businesses using mobile wireless (28 per cent), fixed wireless (22 per cent) and satellite (15 per cent) as their main type of internet connection.<sup>27</sup> The use of Digital Subscriber Line (DSL) as the main type of broadband connection was significantly less for AFF than for other sectors.

# **Outlook for the AFF sector**

Australian agriculture is thought to have a relatively positive outlook. The OECD has stated that strong growth is expected in domestic demand for livestock products and wheat, and that strong cotton production growth combined with relatively flat domestic consumption will likely result in very strong export growth, as world cotton demand increases over the outlook period.<sup>28</sup>

ABARES' most recent five-year forecast estimates the value of AFF production at \$60.9b in real terms in 2025–26. (Figure 6). The ABARES forecasts for production in 2020–21 suggest that the challenges presented by the COVID-19 pandemic are outweighed by the benefits arising from the recovery from drought.



#### Figure 5 Forecast of the value of AFF production in real terms

Source: ABARES 2020, Australian Commodities, March 2021

# Quantifying the impact of ubiquitous high-speed broadband on agriculture

# How ubiquitous high-speed broadband can impact agricultural productivity

Innovation through the uptake of existing and emerging technologies can address the challenges and realise the opportunities open to the sector, particularly through supporting productivity growth. Ubiquitous high-speed broadband delivered through the NBN has the potential to play a key enabling role.

In addition to innovation, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) sees a specific role for broadband in addressing some of the identified challenges for the sector:

The rollout of Australia's next generation broadband network and the growing impact of the digital economy through the adoption of smart digital services has the potential to help the rural sector meet its productivity and sustainability challenges.<sup>29</sup>

The impact will vary by the nature of the technology, how easily it can be accessed and used, and how widespread its utility will be for the sector. The nature of the impact for different technologies will also vary, with some lifting productivity by increasing the quantity of output for given inputs, and others reducing the amount of inputs needed for the same level of outputs.

The BCARR has examined the impact on productivity by using a 'growth accounting' approach that examines the changes in inputs and outputs expected to occur in agriculture as a result of access to new technologies that make use of ubiquitous broadband. This approach allows the forecast of the impact of these technologies for agriculture and also for the economy as a whole (Box 2).

#### **Box 2 Growth accounting**

Growth accounting breaks down growth in an industry or the whole economy into its component parts, labour, capital and productivity to identify underlying drivers for economic growth.<sup>30</sup>

The BCARR has forecast multifactor productivity growth—that measures the overall productivity of labour and capital—for each industry out to 2030. These forecasts are based on the long-run average growth rates for inputs and outputs at the industry level using ABS data.

These forecasts provide a 'baseline' case for productivity growth. By examining the additional output enabled and inputs required by emerging broadband-supported technology, additional scenarios are forecast for comparison against the baseline. This difference between the scenarios and the baseline determines the additional productivity impact broadband-supported technology will have in agriculture, and its broader impact on incomes for the whole of the economy.

The full detail of the growth accounting approach used by the BCARR is provided in <u>Appendix A</u>.

The value of high-speed ubiquitous broadband will differ between industries within the agriculture sector. Ideally, different parts of the AFF sector would have been modelled separately, but this level of detail is beyond the scope of this report. The case studies in this paper highlight the differences in benefits across the sector.

The BCARR has drawn on two comprehensive reviews of broadband-supported technology in agriculture to inform its modelling and forecasts.

- The Australian Farm Institute's (AFI) Accelerating Precision Agriculture to Decision Agriculture technical report. Its key findings included that the unconstrained implementation of decision agriculture would result in a lift of the gross value of agricultural (including forestry and fisheries) production of \$20.3 billion, or around a 25 per cent increase on 2014–15 levels.<sup>31</sup>
- The United States Department of Agriculture's (USDA) *A Case for Rural Broadband* report. Its key findings included that the potential economic benefits of ubiquitous broadband infrastructure and next generation precision agriculture adoption to the agriculture sector was around US\$18–23 billion, or equivalent to around 7 per cent additional output.<sup>32</sup>

While the AFI and USDA papers comprehensively assess technologies that can be widely adopted to provide additional output and/or reduce inputs to boost productivity, the benefits cited in the USDA study depend on the composition of agriculture in the US, which is very different to that in Australia. US agriculture comprises more intensive commodities than Australian agriculture.

Further, while these papers provide insights into the benefits of technologies, including broadband-supported and digital technologies, they are less explicit about the costs and barriers that may be faced by agricultural enterprises in adopting any new technology. Additional costs of implementation, such as purchasing new capital equipment required to enable the use of the technology, may lead to a lower net impact on productivity.

There is little information about the nature of these costs of implementation, reflecting the uncertainties around cutting edge technology. The BCARR has drawn on both the AFI and USDA work to provide estimates of the benefits of broadband-supported technologies and to reflect these costs and uncertainties.

There are also uncertainties about how quickly different agricultural enterprises will take up the new technology. The impacts of new technology on the agriculture sector and economy as a whole will depend on the speed of technology diffusion. Previous experience within the agriculture sector indicates that not all new technology is taken up by all firms, nor at the same pace. This is also likely to be the case for new broadband-supported technologies.

The BCARR has applied assumptions on the:

- speed and magnitude of the uptake
- capital costs associated with implementing the new technology
- scope of industries affected by improvements to agricultural technology.

Applying these assumptions enables a comprehensive analysis of the total impact on productivity within agriculture by 2029–30 by forecasting a range of scenarios that each use different combinations of outputs and input assumptions. This means that the results from the analysis comprise a range rather than a single value, reflecting the different benefits implied by the USDA and AFI studies, and the assumptions on capital costs. Broadly speaking, the scenarios that use the larger AFI study benefits, and that assume lower capital costs, have the strongest positive impacts on productivity.

**Error! Reference source not found.** provides a brief description of the assumptions underpinning each of the scenarios and Appendix A provides more detail.

Scenario	Output	Investment	Timing
Baseline	See note below	N/A	N/A
USDA study as published	7% additional output	None	Immediate 7% increase in output from 2020–21
USDA study with low adoption	7% additional output	None	Gradual increase in output from 2019–20 based on slow ADOPT curve scenario
USDA study adapted with low costs	7% additional output	Doubling of ICT investment	Output and investment rolled out from 2019–20 based on the standard ADOPT curve scenario.
USDA study adapted with medium costs	7% additional output	Investment commensurate to replace half of machinery and equipment productive capital stock	Output and investment rolled out from 2019–20 based on the standard ADOPT curve scenario.
USDA study adapted with high costs	7% additional output	Investment commensurate with the rate of return associated with existing capital, based on the expected additional output.	Output and investment rolled out from 2019–20 based on the standard ADOPT curve scenario.
AFI study as published	25%* additional output	None	Immediate 25% increase in output from 2020–21
AFI study with low adoption	17% additional output	None	Gradual increase in output from 2019–20 based on slow ADOPT curve scenario
AFI study adapted with low costs	17% additional output	Doubling of ICT investment	Output and investment rolled out from 2019–20 based on the standard ADOPT curve scenario.
AFI study adapted with medium costs	17% additional output	Investment commensurate to replace half of machinery and equipment productive capital stock	Output and investment rolled out from 2019–20 based on the standard ADOPT curve scenario.

#### Table 1: Characteristics of the scenarios

Scenario	Output	Investment	Timing
AFI study adapted with high costs	17% additional output	Investment commensurate with the rate of return associated with existing capital, based on the expected additional output.	Output and investment rolled out from 2019–20 based on the standard ADOPT curve scenario.

N/A not applicable

Note: The baseline scenario is used to compare the additional productivity impact for each of the other scenarios, hence there are no additional inputs or outputs associated with it. The AFI study includes improvements in agricultural and downstream manufacturing sectors. Manufacturing is outside the scope of the agricultural sector defined by the ABS, the BCARR has excluded their productivity impacts in its modelling of the AFI study. This is why the additional output shock is 17%.

Source: BCARR.

To estimate the impact on AFF output, the estimated impact of technology on productivity is applied to forecast growth in output to 2030. The BCARR has extended the ABARES production forecasts (Figure 5 above) by applying the average annual growth expected between 2019–20 and 2024–25 to all years to 2029–30.<sup>2</sup>

The growth accounting method provides an indication of the *additional* multi factor productivity (MFP) growth that might be expected from ubiquitous high-speed broadband on the basis of different assumptions. This additional MFP growth is added to the GDP per capita growth baseline to provide an estimate of the effect of ubiquitous high-speed broadband on GDP per capita. Appendix A provides further information on growth accounting.

# Quantifying the benefits of broadband to agriculture

The growth accounting analysis indicates that the additional productivity benefit from ubiquitous, broadbandsupported technology in agriculture is likely to be significant and positive over the next decade.

Agricultural output is forecast to be between \$3.0 and \$10.6 billion higher (in 2017–18 real terms) in 2029–30. In proportionate terms, this means that the volume of output in agriculture is expected to be between 4.7 and 16.9 per cent higher in 2029–30 than would otherwise be the case without ubiquitous high-speed broadband, and the technologies it enables.

Assuming no investment costs and immediate implementation, the benefits of broadband-supported technology are expected to lie between \$4.6 and \$17.8 billion (in 2017–18 real terms), and using a more conservative assumption regarding adoption, benefits fall to between \$3.7 and \$8.1b. **Error! Reference source not found.** describes results for each scenario. The results are comparable to a recent AlphaBeta study that estimates that internet-enabled technologies could add \$15.6b to AFF output each year.<sup>33</sup>

<sup>&</sup>lt;sup>2</sup> This analysis was completed prior to the release of ABARES' March 2021 forecasts and therefore uses the March 2020 forecasts to 2024–25.

Table 2: Economic outcomes of ubiquitous	, high-speed broadband in 2029–30 by scenario
--	---

	Agriculture Sector output change relative to the baseline (% change)	Economy-wide impact GDP per capita change relative to the baseline (% change)
	2017–18 real \$b	2017–18 real \$
Baseline	0 (0%)	\$0 (0%)
USDA study as published with no costs	4.6 (+7.4%)	147 (+0.2%)
USDA study with low adoption and no costs	3.7 (+5.9%)	94 (+0.1%)
USDA study adapted with low costs	4.5 (+7.2%)	116 (+0.1%)
USDA study adapted with medium costs	3.7 (+5.9%)	89 (+0.1%)
USDA study adapted with high costs	3.0 (+4.7%)	64 (+0.1%)
AFI study as published with no costs	17.9 (+28.6%)	525 (+0.6%)
AFI study with low adoption and no costs	8.1 (+15.5%)	228 (+0.3%)
AFI study adapted with low costs	10.6 (+16.9%)	299 (+0.3%)
AFI study adapted with medium costs	9.7 (+15.5%)	272 (+0.3%)
AFI study adapted with high costs	8.9 (+14.2%)	246 (+0.3%)

Source: BCARR estimates based on USDA and AFI studies.

The additional productivity benefit modelled for agriculture indicates an increase in real GDP per capita in 2029–30 of around \$100 to \$300 in 2017–18 dollars—an additional increase of 0.1 to 0.3 per cent compared to the baseline forecast. While the productivity improvements in agriculture are potentially large, their impact on the overall economy is relatively small. This is because the agriculture sector comprises a small proportion of total economic activity in Australia, and any improvement within the sector will be commensurately small from a total economy perspective.

That said, the results for agriculture and the total economy are likely to be conservative in nature as they do not include all the economic benefits that will be enabled by ubiquitous, high-speed broadband in agricultural regions. These include:

- Additional 'off-farm' economic activity enabled by broadband. Investment in the digital technology within the agriculture sector could stimulate similar investment elsewhere in regional economies.
- Further productivity improvements elsewhere in the economy arising from the new technology in agriculture—for example, improvements in quality or efficiency of delivery of produce to food processors, manufacturers and retailers.
- Additional productivity improvements that rely on the prior implementation of new broadbandsupported technologies—for example, new technology standards that enable different types of capital or platforms to more efficiently communicate with each other.

Nor do these results capture the broader, social benefits enabled by ubiquitous high-speed broadband. These include the ability to better access health and education services in agricultural regions and to engage more with people, communities and families in Australia and across the world. The BCARR will investigate the benefits that ubiquitous high-speed broadband can provide to the health and education sectors. While these social benefits are often non-monetary in nature, the impact they have on wellbeing is significant and tangible.

# The transformative nature of ubiquitous high-speed broadband in agriculture

A headline number about the value of technology enabled by ubiquitous broadband does not comprehensively describe the scale and scope of new products and processes to boost the productivity of agriculture. This section looks at some of these technologies in depth and illustrates how they are enabling benefits on Australian agricultural enterprises and more broadly for regional communities. The examples are categorised by the goal they seek to achieve:

- whole-of-enterprise connectivity drives efficiency including water use
- improved market access
- better supply chain management
- improved liveability for regional communities.

Ubiquitous high-speed broadband alone does not enable digital technologies in agriculture and a key feature of this section is describing the communications technologies that together with ubiquitous high-speed broadband can drive productivity improvements. The discussion below highlights the complementary nature of digital technologies and the need to consider the whole technology solution rather than the high-speed ubiquitous broadband alone.

# Whole-of-enterprise connectivity drives better decision making and lower costs

In supporting data collection and dissemination over the whole of an enterprise (including between geographically distant properties) high-speed ubiquitious broadband can inform decision-making by producers and lead to better outcomes, including time and cost efficiencies, more targeted application of inputs, and improved understanding of resources and performance.

An example of digital technology that can be deployed to collect data is sensor technology. Sensors are devices that detect and respond to inputs from the physical environment, including temperature, moisture or pressure.<sup>34</sup> Box 3 provides more details sensor technology.

#### Box 3 Internet of Things and sensor technology

The Internet of Things (IoT) comprises a network of objects that are connected wirelessly using sensors, including all devices and objects whose state can be altered via the internet, with or without the active involvement of individuals.<sup>35</sup> During 2016–17, IoT activity contributed \$74b or 4.5 per cent to Australia's gross value added.<sup>36</sup>

Multiple types of sensors can be applied to agricultural activity including location sensors that use GPS signals, optical sensors that use light to measure soil properties, and mechanical sensors that measure soil resistance.<sup>37</sup>

Sensors and IoT devices and applications can monitor and manage resources and production, and collect data to inform better decision-making. For example sensor technology can be deployed to:

- record information on soil moisture and nutrient levels
- monitor water usage
- monitor livestock (including location, behaviour and condition)
- improve supply chains (e.g. monitor and alerts relating to commodity condition).<sup>38</sup>

IoT devices and uses will vary in their bandwidth requirements.<sup>39</sup> However, IoT devices rely on good network connectivity to function well. Many need to be able to transmit their positions to GPS satellites and some IoT devices may require Wi-Fi, Bluetooth or other connectivity.<sup>40</sup>

Sensors can improve decision making by making more, up-to-date and better information available. Dairy producers, for instance, can utilise wearable sensors to detect disease signals that are otherwise hard to notice, or to regularly measure milk fat, protein, and other health and biological information. By continuously collecting data on their stock, producers can determine which cows are able to produce more milk, and consequently take steps to improve diets that enhance productivity.<sup>41</sup>

Similarly, the availability of locational data can support better decision-making for livestock enterprises in terms of how land is used, how feed is managed, and through enabling rapid responses to vulnerable stock.

In viticulture, research being led by the University of Adelaide is seeking to support grape growers optimise their water use. It is intended that the digital platform 'VitiVisor' will collect information from vineyards via cameras and sensors and analyse the large amounts of data produced to assess vineyard performance, and to offer co-ordinated advice on management practices (e.g. irrigation, fertiliser, and pesticide applications).<sup>42</sup> This will allow growers to track and predict progress and vineyard outcomes, such as fruit yield and quality. The university anticipates that in combining this vineyard level information with market / farm cost information to provide guidance on optimal decision-making, this will allow producers to maximise farm returns and bring significant improvements to producers' bottom lines.<sup>43</sup>

In aquaculture, in-estuary sensors, cloud computing, and machine learning are being used to collect and process data to improve decision-making for oyster farmers. Farm closures caused by rainfall can cost growers up to \$100,000 per day—nationally this equates to around \$34 million annually. Analysis indicates that closures can be reduced by at least 30% using real-time salinity sensors.<sup>44</sup>

The following case study of the Sundown Pastoral Company showcases an enterprise that is making use of digital technologies in a variety of ways to inform improved decisions, and provides insight into the other benefits that ubiquitous broadband can support in conjunction with other technologies.

#### **Box 4 Sundown Pastoral Company**

Sundown Pastoral Company (Sundown) is a NSW enterprise that focuses on beef cattle production, as well as cotton and forage crops. It comprises multiple properties across a conglomerate, said to be 92,000 acres in 2017.<sup>45</sup> The enterprise's beef production alone relies on use of four separate properties that total more than 30,000 hectares of land.<sup>46</sup>

#### Technology, connectivity and decision making

Sundown makes significant use of data, and digital technologies coupled with reliable connectivity are important in this. It uses a business management database to deal with over 10,000 head of cattle,<sup>47</sup> and it is necessary for this to synchronise regularly with databases on the Gold Coast. This process previously took over an hour. In moving from a 3G service to a faster, point-to-point system the enterprise reduced the time involved to six minutes.<sup>48</sup>

The business management database is managed remotely by a staff member located in Parkes (approximately 500 km away) and voice contact is managed through a Radio over Internet Protocol (RoIP) system.<sup>49</sup> All animal movements are recorded live onto the enterprise's data management systems, including induction onto the farm (utilising RFID readers on individual animals), various on-farm operations such as weighing and drenching, movement of mobs from paddock to paddock and exit from the farm to clients.

Sundown's owner/director David Statham has said that: "The speed of all our systems on-farm, almost everything we do is linked to a database...The speed for people to open files and the speed which you can download things like weather data, tractor data which we'd send down to Narrabri—it used to take hours, now it takes less than a minute. Tractors, headers, John Deere link, pickers, they all have data capture. The more data capture we go into, speed is critical."<sup>50</sup>

The enterprise was reliant on its technology solution to connect to an online agricultural auction in 2017: 'We had international bidders and people from all over Australia logged in to the sale which wouldn't have been possible without a reliable, high-speed connection.'<sup>51</sup>

#### Resource management—efficiencies in water use

One of the properties that make up Sundown's portfolio is Keytah, near Moree. The importance of technology and its support for decision-making has been underscored by staff of the enterprise. Interviewed for an ABC report, Keytah Manager Nick Gilingham stated the enterprise had invested heavily in technology so that data could be accessed live in the field, with the availability of real-time data being critical to decisions which could cost millions of dollars in lost production.<sup>52</sup>

Keytah has used a range of technology including water and soil monitors, weather stations, remote pump site monitoring, tractor monitoring for farm management, accounting and record keeping. This has enhanced decision-making in a number of areas, for instance through use of the PCT agCloud data management software service, Keytah is able to better understand soil variability, which has improved the placement of moisture probes, site-specific drainage works have been supported by access to elevation data, and applications to improve nutrient use efficiency have been applied to support more targeted inputs such as fertiliser.<sup>53</sup>

Keytah's management considers the efficiency of the enterprise's systems could be improved with high-speed broadband connectivity,<sup>54</sup> as implementing and integrating all the components needed for full automation will require the farm to have access to reliable high speed internet. Improved connectivity to date has enhanced the efficiency of information exchange in Keytah's systems. However challenges remain, including the reliability of sensors, which are constantly being updated. Ensuring staff continue to have access to appropriate training to use and understand the systems is another issue the enterprise needs to address.<sup>55</sup>

Sources: BeefCentral.com (2017); University of New England and Cotton Research and Development Corporation (2017); Moree Champion (2017); Australian Broadcasting Corporation (2017); Gwydir Valley Irrigators Association (2018)

#### Improved water use efficiency

The role climate and water availability has on the productivity of Australian agriculture is well understood. The sensors that provide whole-of-farm connectivity provide particular benefits in improving the efficiency of water use as can be seen in the Sundown Pastoral example above, and also in examples such as NSW cotton farm Waverly which in 2015 adopted a fully automated system that used sensors and other technologies to monitor water levels. This helped Waverly achieve savings in water use of 163ML for the year, 58 per cent of which was returned to the environment.<sup>56</sup>

#### Improved market access

Ubiquitous connectivity enables engagement and opportunities that might otherwise be constrained by geography, enhancing agricultural enterprises' ability to engage new customers, expand or diversify their operations and source new streams of income.

Online livestock sales are an example of producers leveraging connectivity. Online marketplaces such as Auctions Plus pre-market livestock prior to auction, and make information available on its outcomes. This enables buyers and sellers to expand their network,<sup>57</sup> and producers can save the cost of traveling to live auctions while still participating in transactions across wide geographies.

Similarly, the enhanced connectivity and reach afforded by ubiquitous broadband can be used to source options for filling labour shortages and help workers source alternative income streams, allowing enterprises and workers to find each other from anywhere. The online initiative AgDraft allows workers to secure reliable and safe employment on farms, matching workers from anywhere with seasonal work, seeking to bring efficiency and reliability to the rural labour market by leveraging 'AirBNB-style' farmer referrals.<sup>58, 59</sup>

# Better supply chain management

Technological advances are transforming supply chain management. This is important in Australia where factors such as geography contribute to an export supply chain where transport costs are proportionally larger for the AFF sector than for many international competitors.

Distributed ledger technologies such as blockchain can provide permanent, immutable records of contracts, transactions, documents, supply chain movement and more,<sup>60</sup> enabling verification and certainty around the movement of goods, and compliance with contractual obligations.

In agriculture, strong motivators for use of this technology have included its enabling transparency regarding provenance by supporting accurate verification of the source origin of goods, offering improvements in quality/integrity, and reduced wastage: for instance through verifying that goods have been kept within required temperature ranges, and preventing counterfeit products by tracking their movement throughout the supply chain.<sup>61</sup>

The implementation of these technologies is in its early stages with the dairy sector investigating its potential. Australian Dairy Farmers, the peak body for Australian dairy producers, recently released a video describing potential of blockchain in the dairy sector, with the intention of initiating discussion about potential options to support modernisation of the industry.<sup>62</sup>

# Improved liveability for regional communities

The expanded range of opportunities arising from connectivity for enterprises and for workers in the AFF sector also has the potential for positive flow on effects top regional communities increasing the community resilience.

One example is how connectivity including ubiquitous high-speed connectivity supports the ability of workers in these communities to connect with other people, services and markets outside of their immediate geographic location. As noted by Cotton Australia in their submission to the 2018 Regional Telecommunications Review:

Increased connectivity facilitates stronger social networks between farmers, parents, children and the community. Boarding school will no longer feel so remote with Facetime or Skype videoconferencing a genuine option. Farms ability to attract and retain staff is improved now that there is connectivity; an important consideration for people looking to relocate to regional areas. Councils can enable better services.<sup>63</sup>

Further, connectivity underpins digital inclusion, which in turn provides an avenue to improve skills, enhance quality of life, drive education and promote economic well-being across all elements of society.<sup>64</sup> Thus not only can ubiquitous connectivity help build community resilience, it should be considered an essential pillar of community resilience. Ubiquitous connectivity in this case extends beyond broadband to include Wi-Fi and mobile networks.

The final case study, Murchison House Station, shows how on-farm connectivity including broadband can benefit both the farmers and the local community (Box 5).

#### **Box 5 Murchison House Station**

Murchison House Station is a 350,000 hectare, family-owned and -operated pastoral station. Run by Calum and Belinda Carruth, the enterprise's key concerns are rangeland goats, beef cattle and tourism. Its livestock herds comprise around 200 shorthorn-cross cattle and 7000 rangeland goats.<sup>65</sup>

The enterprise has worked with technology providers to develop a remote location connectivity solution across the whole farm, during the course of which it was connected to the NBN. Previously the enterprise had issues caused by limited data capacity, including drop-outs and low speeds.

The NBN connection acquired to surmount problems around reliability and capacity delivered fast broadband to the homestead and connectivity around the 'home paddocks,' supporting unlimited data and fast speeds. This is important for the enterprise as it relies on broadband access to, amongst other things, support its deployment and use of IoT to enhance operations.<sup>66</sup>

#### **Resource monitoring**

The connectivity solution implemented by the enterprise underpins the use of IoT applications. Sensors deployed to support this have been run continuously with downloads each minute.

Two remote weather monitoring stations have also been installed to support:

- **Deployment of a water monitoring system** that facilitates control over all tanks with flow meters and level switches. This is expected to reduce labour/travel costs and support improved allocation of resources.<sup>67</sup>
- **Remote livestock monitoring**—through improving mustering processes, including enabling monitoring and remote activation of gates, the enterprise expects to reduce mustering costs.

#### Benefits and costs

Mr Carruth has put the cost of installation of the solution at approximately \$130,000.

He has estimated that during the first year of the solution's implementation the enterprise achieved cost savings from it of around \$25,000-\$30,000 in vehicle running costs and maintenance alone.<sup>68,69</sup>

Mr Carruth has stated that while the investment costs are significant, so can be the value derived, and indicates a broad range of benefits including social benefits.

"But all of the sudden you're also getting some animal welfare benefits, less travel, some after-hours social benefits around having Netflix and being able to attract additional employees into your business. So I think once we start to establish some of those value propositions then this becomes a completely different commercial proposition for our producers."<sup>70</sup>

Sources: Meat and Livestock Australia (2018); Australian Broadcasting Corporation (2019); BeefCentral.com (2018)

# Unlocking the benefits of broadband to agriculture

While the potential benefits of ubiquitous high-speed broadband are potentially large, the cost analysis and case studies highlight that broadband alone will not realise these benefits. Additional capital, technologies and skills are needed to operationalise these technologies and AFF sector enterprises face three potential barriers:

- Availability: access to the goods and services that ubiquitous high-speed broadband enable.
- Affordability: the financial means to purchase the products and services needed to enable digitalisation
- Ability: the required skills/knowledge to make use of the online services.

# Availability

The NBN is now built and fully operational with over 99.8 per cent of premises able to order NBN services as at February 2021. This will provide high-speed internet to almost all businesses in regional Australia and therefore, digital technologies become more available to AFF enterprises. However, as many of the case studies demonstrate fixed broadband is an enabling or enhancing technology and additional investment may be needed to realise the benefits of digital technologies. Some of the additional technologies and services AFF enterprises will need are:

- Wi-Fi to provide connections across properties
- broader mobile coverage
- sensors to enable to IoT
- data storage capacity
- skills to analyse data.

The affordability of these services and technologies and the capacity of AFF workers to use digital technologies are two factors that will determine the extent to which the benefits of ubiquitous high speed broadband are available to the AFF sector.

# Affordability

Achieving the benefits of broadband enabled connectivity requires investment in ICT such as sensors and computing power. While estimates from Waverley put these costs at \$1000 per hectare,<sup>71</sup> the BCARR estimated sector wide scale investments of between \$275 million and \$22 billion per year may be required to achieve the productivity benefits estimated by AFI and the USDA. As indicated by the estimated range, costs are highly uncertain.

Historically, the small number of large enterprises in the AFF have invested in capital including digital technology, whereas many smaller and often less profitable enterprises in the sector invest less. Recent drought conditions are likely to have increased debt levels for many farmers and potentially made capital investment more difficult.

### Ability

Fully utilising ubiquitous and high-speed broadband requires digital literacy. Although almost all AFF enterprises have access to the internet, using the web based services and ICT technologies is less widespread in AFF than other sectors of the Australian economy. In 2016, the average age of Australian farmers was 56 years old, 17 years older than the average Australian worker.<sup>72</sup> Also, in 2016, only 45 per cent of the agricultural workforce had completed year 12 or equivalent, compared with 67 per cent of the Australian workforce.<sup>73</sup>

In general, the agriculture workforce has a relatively lower digital literacy<sup>74</sup> and does not have the required digital skills to successfully implement broadband supported technologies. Further, small enterprises with few employees may have less time to invest in learning the skills necessary to adopt digital technologies making innovation difficult for smaller enterprises. Combined these factors could limit the uptake of digital technologies in the AFF sector.

Government imposed movement restrictions during the COVID-19 pandemic have seen greater use of online markets by farmers in much the same way other Australians have moved to online shopping and seeing the potential to work from home. This uptake of digital technologies during the pandemic may lead to greater uptake following the pandemic if enterprises see the benefits. The Australian Government is funding the National Farmers' Federation to design and run a regional digital technology hub that will support regional and remote Australians to build their digital capabilities.

For the agriculture sector, the NBN has significantly improved the availability of broadband services, with the take-up of internet services by agriculture businesses being 96.3 per cent.<sup>75</sup> However, while there are many broadband-supported technologies available for the agriculture sector, the overall take-up has been limited because they are either not accessible or not affordable to many businesses. Additionally, many broadband-supported technologies are expensive to implement, particularly if whole-of-enterprise connectivity is required. Some farmers see mobile coverage as an alternative to investing in whole-of-enterprise connectivity.

# Appendix A—The Growth Accounting Model

The BCARR has used a growth accounting approach in order to estimate the potential effect on multifactor productivity (MFP) from the use of broadband enabled technologies in the Agriculture, Forestry and Fisheries industry division. It does so by assuming different changes to investment (the inputs needed to build and enable use of the new technologies) and output growth (reflecting the additional goods and services that can be generated by the new technologies). These assumptions are based on a desktop review of comprehensive reports about the potential for broadband-supported technologies in agriculture.

By deriving the effect of broadband-supported technology in agriculture on MFP, the result can then be used to assess the potential impact on GDP per capita. This, in turn, enables an assessment of the magnitude of income growth that might be expected from the use of new technologies in agriculture.

### An overview of the approach

Growth accounting is an approach used to decompose economic growth into changes in productivity, inputs and outputs. Typically, this involves an assumption about how different inputs—labour and capital—are used to produce output. By examining the movements in measured inputs and outputs, a residual measure can be calculated, which reflects changes in productivity.

One of the most common approaches, and the one used in this paper, is to assume that output growth in the Australian economy is based on labour input growth (the number of hours worked), capital input growth (changes in 'capital services'—a measure of the flow of output from the capital stock in the economy) and MFP. Growth accounting can also be used at the industry level—allowing the calculation of inputs, outputs and productivity by different industries, and their contribution to the total economy over time.

The BCARR has used growth accounting consistent with the way that the Australian Bureau of Statistics (ABS) approaches calculating MFP.<sup>76</sup> However, the BCARR has made some extensions to this:

- To get a data series long enough to consider fundamental changes, the average annual growth rates in inputs and outputs by industry have been forecast out to 2030 using a simple exponential trend based on data from 1995–96 to 2018–19 (the period over which all market sector industries have available data).
- The way that labour and capital are weighted to form inputs in the growth accounting are held at their long run averages through time. For example, if the importance of labour means that it comprises 40 per cent of inputs on average between 1995–96 and 2018–19, then this proportion is used out to 2029–30. While this sort of weight does not change much at the aggregate level, it may not be accurate for rapidly changing industries that are becoming more labour or capital intensive, or for those industries where the different *types* of capital used are changing.

### Growth accounting approach

The growth accounting approach used by the BCARR is consistent with chapter 19 of the ABS Australian System of National Accounts: Concepts Sources and Methods publication.<sup>77</sup>

Data for each of the market sector industries are sourced from the ABS' *Estimates of Industry Multifactor Productivity* release for 2018–19. (Market sector industries include all ANZSIC divisions except Public administration and safety, Education and training, and Health care and social assistance.) To derive a total economy measure of MFP, the individual industry MFP series are aggregated. The BCARR has used a different approach to the ABS in that non-market sector industries are included in the aggregate—however, these industries are assumed to have no MFP growth, consistent with ABS practice. The income share data to aggregate total economy MFP are sourced from the *Australian System of National Accounts, 2018–19* release.<sup>78</sup> The equation underlying the growth accounting function is as follows:

$$\frac{\Delta Y}{Y} = \frac{\Delta A}{A} + \alpha_K \frac{\Delta K}{K} + \alpha_L \frac{\Delta L}{L}$$

#### Where:

- Y GDP
- A MFP
- K existing capital stock
- L labour
- $\Delta Y$  change in GDP
- $\Delta A$  change in MFP
- $\Delta K$  change in capital stock
- $\Delta L$  change in size of labour force
- $\alpha_K$  share of capital in total income
- $\alpha_L$  share of labour in total income

# Forecasting

Because the BCARR modelling takes place over a long period, the BCARR has forecast the relevant series to generate productivity estimates to 2029–30.

- Output growth and labour input growth for each industry are forecast using the average annual growth rate from the ABS *Estimates of Industry Multifactor Productivity* publication from 1995–96 to 2018–19.<sup>79</sup>
- Productive capital stock growth for each asset in each industry is forecast using the average annual growth rate from the ABS *Estimates of Industry Multifactor Productivity* publication from 1995–96 to 2018–19.
- The productive capital stock series are aggregated to capital services—the capital input for the growth accounting—for each industry using fixed rental price shares from the ABS *Estimates of Industry Multifactor Productivity* publication for 2018–19.
- Value added shares, gross operating surplus and gross mixed income, and compensation of employee shares across industries—used to calculate total economy MFP—are based on the 2018–19 shares from the ABS *Australian System of National Accounts, 2018–19* publication.

This approach incorporates some simplifying assumptions made by the BCARR:

- Using the average annual growth rate is a simplifying assumption does not accommodate business, productivity and climatic volatility that are all features of Australia's economic performance. Nevertheless, the assumption is suitable for long run analysis.
- The assumption that value added shares, gross operating surplus shares, and compensation of employee shares are fixed through time means that there is no long-run change in the structure of the economy.
- The assumption that rental prices are fixed through time implies that the relative prices between different capital goods do not change.

This means that, to the extent that structural change is occurring over the forecast period, the analysis will not truly reflect the change in MFP from broadband-supported technology in agriculture. (The true effect could be more or less than what the growth accounting might suggest.) This includes any structural change that the new technologies themselves may drive.

#### Incorporating additional investment

Some of the scenarios tested by the BCARR involve additional capital inputs to be modelled. Adding additional investment to the growth accounting model occurs in several steps:

- Any additional investment is added using a perpetual inventory method—consistent with chapter 14 of *Australian System of National Accounts: Concepts Sources and Methods*<sup>80</sup>—which yields the additional productive capital stock (PKS) by year, and by industry. Additional investments made are all assumed to be of the 'electrical and electronic equipment' category of assets, which includes ICT equipment consistent with the broadband-supported technologies identified.
- This additional capital stock by year by industry is added to the existing PKS by year to derive a new value for PKS, which forms the input to capital services.
- Investment trends are assumed to be persistent, so growth in PKS is then assumed to be at the same rate as previously, but with the new level of PKS forming the base. (Without this assumption, growth in capital services after the shock is lower, as changes take place from a larger base of productive capital stock. Conceptually, the assumption is consistent with a higher level of investment required to accommodate depreciation of the new level of capital stock) This is then used to calculate a capital services index, which forms the capital input for the growth accounting.

#### Linking the growth accounting to an agricultural output result

The growth accounting approach provides an overall impact on agricultural MFP. This impact is then applied to a forecast of real agricultural output to provide a consolidated, easy-to-understand metric to explain the overall effect on the agricultural sector.

To enable this, the BCARR has extended the ABARES forecasts for real output in the agriculture sector. Each year ABARES publishes a forecast of the real gross value of production series for agriculture, forestry products and fishery products for the following five years. BCARR has extended this series to 2029–30, by applying the average annual growth rate for the 2019–20 to 2024–25<sup>3</sup> forecasts to each series, and aggregated the outcome for a total gross value of production. The impact on MFP is then applied to this series to get a total impact on the agricultural sector in terms of additional output enabled by broadband-supported technology.

#### Linking growth accounting to incomes

GDP per capita growth can be disaggregated into labour productivity growth (value added per hour worked) and labour utilisation growth (hours worked per person). Labour productivity growth itself can be decomposed into growth of MFP and capital deepening (the growth of capital per unit of labour input).

<sup>-----</sup>

<sup>&</sup>lt;sup>3</sup> This analysis was completed prior to the release of ABARES' March 2021 forecasts and therefore uses the March 2020 forecasts to 2024–25.

# Appendix B—The scenarios

The scenarios tested by the BCARR are summarised in **Error! Reference source not found.** in the main report. Broadly speaking, each scenario draws on the findings from the USDA and AFI publications about broadband enabled technologies to define the additional benefits expected from the technologies, and different cost assumptions about the investment needed to enable those technologies.

### **Additional investment**

Both the AFI and USDA studies note that their analysis of potential benefits from broadband enabled technologies are 'unconstrained'—that is, that they do not consider all the costs of implementation.<sup>81</sup> This is especially relevant when the broadband-supported technologies are themselves integrated into new capital goods themselves, such as new sensor equipment or vehicles that use broadband-supported networks to plant crops.

The BCARR has modelled three separate cases where agricultural firms make additional investment of varying scale to reflect a range of potential capital costs required to make use of the new technology. These include:

- investment required to double the Information and Communications Technology (ICT) productive capital stock—which is based on the assumption that the ICT intensity of the agriculture sector will need to expand to take advantage of broadband technology (low)
- investment required to replace half of machinery and equipment productive capital stock—which is based on the assumption that a large proportion of machinery and equipment could require replacement ahead of its scheduled depreciation to take advantage of broadband technology (medium)
- investment to a level where the additional economic output from new technology yields a rate of return equivalent to the existing level of profitability in agricultural enterprises (high).

The investment occurs according to the same rollout timetable as the adoption curve used in each scenario. That is, the benefits from adoption of the new technology are proportionate to the investment assumed to enable them. Figure 6 shows capital cost assumptions from 2019–20 to 2029–30, and the derivation of the adoption assumptions are described in the section below.



#### Figure 6 Low, medium and high capital costs by year

Source: BCARR analysis

# Timing

There is little information about the speed with which the next wave of broadband-supported technology will be adopted in agriculture. To inform the rate and penetration of these technologies, the BCARR has used the CSIRO Adoption and Diffusion Outcome Prediction Tool (ADOPT). ADOPT relies on qualitative and quantitative input on the characteristics of innovations, the target population, relative advantage of innovations and learning about the relative advantage of innovations to predict the take-up rate and peak penetration of agricultural technologies.<sup>82</sup> The BCARR considered the detailed listings of innovations described in the AFI and USDA to provide input into the ADOPT tool. **Error! Reference source not found.** shows the ADOPT questionnaire and BCARR's assumptions.

The resulting prediction from ADOPT suggests that the types of technology most likely associated with ubiquitous, high-speed broadband will be taken up by most agricultural enterprises, with a peak penetration rate of 91 per cent. However, the time taken to reach that peak penetration rate will be long—around 12 years. The fastest pace of adoption will occur around half-way through the period, see Figure 7. Given the diversity of enterprises within the AFF sector and diverse range of technologies that high-speed ubiquitous broadband support, the sensitivity analysis tests consider adoption rates where fewer enterprises benefit from the technology and enterprise owners need to develop new skills. Under this scenario the peak penetration rate of 71 per cent is reached after 14 years.





Source: Output from ADOPT tool,<sup>83</sup> based on BCARR responses to the online questionnaire.

The BCARR uses this curve to scale the additional output and investment for each scenario, with the output lagged one year following the investment. This is a stylised assumption based on investment being required before the additional output occurs. For the purposes of the modelling, any new investment is assumed to start from 2019–20, with additional output from 2020–21.

#### Table 3: ADOPT Questionnaire responses

What proportion of the target population has protecting the natural environment as a strong motivation? About half

What proportion of the target population has risk minimisation as a strong motivation? About all

On what proportion of the target farms is there a major enterprise that could benefit from the innovation? Almost all (about half)

What proportion of the target population has a long-term (greater than 10 years) management horizon for their farm? A majority

What proportion of the target population is under conditions of severe short-term financial constraints? **A minority** 

How easily can the innovation (or significant components of it) be trialled on a limited basis before a decision is made to adopt it on a larger scale? **Moderately** 

Does the complexity of the innovation allow the effects of its use to be easily evaluated when it is used? **Moderately difficult to evaluate** 

To what extent would the innovation be observable to farmers who are yet to adopt it when it is used in their district? **Moderately observable** 

What proportion of the target population uses paid advisors capable of providing advice relevant to the project? **A minority** 

What proportion of the target population participates in farmer-based groups that discuss farming? **About half** 

What proportion of the target population will need to develop substantial new skills and knowledge to use the innovation? **About half (a majority)** 

What proportion of the target population would be aware of the use or trialling of the innovation in their district? **Never trialled in their districts** 

What is the size of the up-front cost of the investment relative to the potential annual benefit from using the innovation? **Moderate investment** 

To what extent is the adoption of the innovation able to be reversed? Very easily

To what extent is the use of the innovation likely to affect the profitability of the farm business in the years that it is used? **Moderate profit advantage** 

To what extent is the use of the innovation likely to have additional effects on the future profitability of the farm business? **Small profit advantage** 

How long after the innovation is first adopted would it take for effects on future profitability to be realised? **Between 1 and 2 years** 

To what extent would the use of the innovation have net environmental benefits or costs? None

How long after the innovation is first adopted would it take for the expected environmental benefits or costs to be realised? **Not applicable** 

To what extent would the use of the innovation affect the net exposure of the farm business to risk? **Small risk** reduction

To what extent would the use of the innovation affect the ease and convenience of the management of the farm in the years that it is used? **Moderate increase** 

Note: The answers in brackets apply to the sensitivity analysis. Source: Derived by the BCARR from the CSIRO ADOPT tool.

In addition to adoption rates, international research suggests that productivity gains from global positioning technologies might take a decade or more to be observable in the data.

### Sectoral scope

The AFI study includes improvements in both the agricultural and manufacturing sectors. Within manufacturing, productivity improvements are assumed for meat processing and wood and paper product manufacturing (linked closely to beef and forestry operations). As these industries are outside the scope of the agricultural sector defined by the ABS, the BCARR has excluded their productivity impacts in its modelling that adapts the AFI productivity shock.<sup>84</sup>

# References

<sup>1</sup> ABS (2019) <u>Characteristics of Australian Business 2018-19</u>, Cat. No. 8167.0, accessed 10 November 2020.

<sup>2</sup> In a 2016–17 ABARES survey, around one third of farmers reported that a lack of skills was a constraint on their uptake of new ICT tools.

<sup>3</sup> BCARR analysis of ABS (2019) <u>Australian National Accounts: Input-Output Tables</u>, 2016–17, Cat. No. 5209.0.55.001, accessed June 2019. The contribution to GDP from an industry is deemed to be critically enabled by communications services where intermediate inputs from ANZSIC Division J comprise 5 per cent or more of the total value of intermediate inputs for that industry. This is on the grounds that communications services comprise a sufficiently large component of inputs that cannot be substituted for goods and services from other industries. More detail is available in Department of Communications and the Arts (2019) <u>2019–20 Corporate Plan</u>, accessed 6 December 2019.

<sup>4</sup> ITU (2018), Broadband and digital transformation, access 2 November 2019

<sup>5</sup> European Court of Auditors (2018) <u>Broadband in the EU Member States: despite progress, not all the Europe 2020</u> <u>targets will be met</u>, accessed 6 December 2019. Federal Communications Commission (US) (2018) <u>Broadband Speed</u> <u>Guide</u>, accessed 6 December 2019.

<sup>6</sup> Ibid.

<sup>7</sup> For example, see AIIA (2013) <u>Ubiquitous Broadband: The Great Leveller</u>, p. 16, accessed 6 December 2019.
<sup>8</sup> NBN Co, <u>NBN Co Corporate Plan 2021 to 2024</u> accessed 25 September 2020

<sup>9</sup> Australian Bureau of Statistics (2013), Australian and New Zealand Standard Industrial Classification (ANZSIC),

Division A - Agriculture, Forestry and Fishing, 2006, Australia, June 2013, cat. No. 1292.0.

<sup>10</sup> See <u>http://www.agriculture.gov.au/abares/publications/insights/snapshot-of-australian-agriculture</u>

<sup>11</sup> See <u>https://www.nbnco.com.au/blog/the-nbn-project/connected-farms-embracing-the-internet-of-things</u>

<sup>12</sup> ABS 2020, <u>Detailed labour force statistics</u>, accessed at 4 November 2020

<sup>13</sup>Department of Agriculture and Water Resources, <u>Snapshot of Australia's Agricultural Workforce</u>, December 2018.

<sup>14</sup> See: <u>http://www.agriculture.gov.au/abares/publications/insights/snapshot-of-australias-agricultural-workforce#who-are-australias-agricultural-employees</u>

<sup>15</sup> ABARES, 2014, <u>Australian agricultural productivity growth: past reform and future opportunities</u>, p8.

<sup>16</sup> ABARES 2020, Agricultural overview September 2020

<sup>17</sup> ABARES, <u>Agricultural productivity international comparisons</u>

<sup>18</sup> ABARES, <u>Snapshot of Australian Agriculture</u>, 2018, p6.

<sup>19</sup> ABARES, <u>https://www.agriculture.gov.au/abares/research-topics/productivity/data</u>, March 2020

<sup>20</sup> ABARES, <u>https://www.agriculture.gov.au/abares/research-topics/productivity/agricultural-productivity-</u>

estimates#impact-of-climate-and-drought-on-productivity-performance, March 2020

<sup>21</sup> CRDC, <u>Accelerating Precision Agriculture to Decision Agriculture: Enabling digital agriculture in Australia</u> (Summary Report).

<sup>22</sup> Department of Agriculture and Water Resources (ABARES), <u>Information and communication technology use in</u>

<u>Australian agriculture: A survey of broadacre, dairy and vegetable farms</u>, Niki Dufty and Thomas Jackson, November 2018, p2.

<sup>23</sup> See <u>http://www.agriculture.gov.au/SiteCollectionDocuments/abares/ict-use-australian-agriculture.pdf</u>

<sup>24</sup> Department of Agriculture and Water Resources (Australian Bureau of Agricultural and Resource Economics and Sciences), <u>Information and communication technology use in Australian agriculture</u> (Research Report 18.15), November 2018, p1.

<sup>25</sup> ABS, 8129.0 - Business Use of Information Technology, 2015-16.

<sup>26</sup> Rabobank, Agtech—does sensor adoption make 'cents'?, 2017.

<sup>27</sup> ABS, 8129.0 - Business Use of Information Technology, 2015-16

<sup>28</sup> OECD, Medium-term prospects for major agricultural commodities 2017-2026: Australia,

https://www.oecd.org/australia/australia-agr-outlook-country-note.pdf

<sup>29</sup> CSIRO, <u>Smart Farming: Leveraging the impact of broadband and the digital economy</u>, 2013, p3.

<sup>30</sup> OECD (2016) <u>OECD Compendium of Productivity Indicators 2016</u>. Accessed 19 December 2019.

<sup>31</sup> AFI (2017) <u>Accelerating Precision Agriculture to Decision Agriculture: Enabling digital agriculture in Australia</u>, p. 1, accessed 25 November 2019.

<sup>32</sup> USDA (2019) <u>A Case for Rural Broadband</u>, p. 24, accessed 25 November 2019.

<sup>33</sup> AlphaBeta 2020, <u>Connecting Australia: Future of farming</u>, accessed at 12 November 2020

<sup>34</sup> Rural Industries Research and Development Corporation, <u>Transformative Technologies: Sensors</u>, 2016.

<sup>35</sup> OECD, <u>Science, Technology and Innovation Outlook 2016</u>.

<sup>36</sup> BCAR, <u>Measuring Digitalisation of Australia's Economy</u>, 2020

<sup>37</sup> Steven Schriber, Mouser Electronics, <u>Smart Agriculture Sensors: Helping Small Farmers and Positively Impacting Global</u> <u>Issues.</u>

<sup>38</sup> See <u>https://www.agrifutures.com.au/wp-content/uploads/2019/01/18-048.pdf</u>, p44.

<sup>39</sup> NBN Co, <u>How much data does the Internet of Things consume</u>, 2017.

- <sup>41</sup> GHD and AgThentic, <u>Emerging Agricultural Technologies: Consumer perceptions around emerging agtech</u>, August 2018.
- <sup>42</sup> See <u>https://www.adelaide.edu.au/newsroom/news/list/2020/01/15/technology-to-transform-vineyard-management.</u>
- <sup>43</sup> See <u>https://www.adelaide.edu.au/newsroom/news/list/2020/01/15/technology-to-transform-vineyard-management</u>.
- <sup>44</sup> See <u>https://www.foodagility.com/posts/the-digital-future-of-food</u>.
- <sup>45</sup> See <u>https://www.beefcentral.com/production/satellites-and-helicopters-watch-the-grass-grow-at-sundown-valley/</u>.
- <sup>46</sup> See <u>https://www.sundownpastoral.com.au/beef.html</u>.
- <sup>47</sup> See <u>https://risingconnection.com.au/wp-content/uploads/2018/01/Sundown-Pastoral-Low-Res-OCR.pdf</u>.
- <sup>48</sup> See <u>https://risingconnection.com.au/wp-content/uploads/2018/01/Sundown-Pastoral-Low-Res-OCR.pdf</u>.

<sup>49</sup> David Lamb, <u>Accelerating Precision Agriculture to Decision Agriculture: Enabling Digital Agriculture in Australia</u>, 2017, p67.

<sup>50</sup> Moree Champion, <u>Moree Plains Shire Council partnership with JustISP providing broadband access to agribusiness</u> <u>community</u>, December 2017.

<sup>51</sup> Moree Champion, <u>Moree Plains Shire Council partnership with JustISP providing broadband access to agribusiness</u> community, December 2017.

<sup>52</sup> Australian Broadcasting Corporation, <u>Budget 2017: Data drought must come to an end to unlock agriculture's earning</u> potential, farmers say, May 2017.

<sup>53</sup> Louise Gall, Gwydir Valley Irrigators Association, <u>Setting the farm up for broadband connectivity—a Keytah perspective</u>, 2018.

<sup>54</sup> Louise Gall, Gwydir Valley Irrigators Association, <u>Setting the farm up for broadband connectivity—a Keytah perspective</u>, 2018.

<sup>55</sup> Louise Gall, Gwydir Valley Irrigators Association, <u>Setting the farm up for broadband connectivity—a Keytah perspective</u>, 2018.

- <sup>56</sup> NSW Department of Primary Industries, <u>Sustaining the basin: irrigated farm modernisation</u>, 2016.
- <sup>57</sup> See <u>https://www.abc.net.au/news/rural/2018-10-15/kerang-saleyards-told-to-tap-into-market-online/10338400.</u>

<sup>58</sup> See <u>https://home.kpmg/content/dam/kpmg/au/pdf/2016/powering-growth-realising-potential-agtech-australia.pdf</u>.

<sup>59</sup> See <u>https://www.ruralnewsgroup.co.nz/rural-news/rural-agribusiness/aussie-farm-labour-website-eyes-nz</u>.

<sup>60</sup> See <u>https://www.forbes.com/sites/andrewarnold/2018/08/29/the-agricultural-supply-chain-can-massively-benefit-from-blockchain/#20ba5bef423e</u>.

<sup>61</sup> PwC, <u>Supply chain priorities</u>, p47.

<sup>62</sup> Australian Dairy Federation ,<u>Blockchain and real time payment system</u>, accessed 15 September 2020

<sup>63</sup> See <u>submission to 2018 Regional Telecommunications Review</u>, p16.

<sup>64</sup> <u>Australian Digital Inclusion Index</u>, 2018 report.

<sup>65</sup> 2018 stock numbers. See Meat and Livestock Australia, <u>Getting Connected: On-Farm Snapshot</u>, November 2018.

<sup>66</sup> 2018 stock numbers. See Meat and Livestock Australia, <u>Getting Connected: On-Farm Snapshot</u>, November 2018.

<sup>67</sup> See <u>https://www.itnews.com.au/news/australian-farmers-are-battling-to-make-iot-work-516204</u>.

<sup>68</sup> Beef Central, <u>Agtech: WA station provides connectivity solution showcase</u>, 23 November 2018.

<sup>69</sup> ABC, <u>Poolside pastoralism brings mobile and data technology into paddocks and into the future</u>, March 2019.

<sup>70</sup> ABC, <u>Poolside pastoralism brings mobile and data technology into paddocks and into the future</u>, March 2019.

<sup>71</sup> Rural Industries Research and Development Corporation, <u>Transformative Technologies: Sensors</u>, 2016.

<sup>72</sup> ABARES 2018, <u>Australia's agricultural workforce</u>, ABARES Insights Issue 3 2018

<sup>73</sup> ABARES 2018, <u>Australia's agricultural workforce</u>, ABARES Insights Issue 3 2018

<sup>74</sup> In a 2016–17 ABARES survey, around one third of farmers reported that a lack of skills was a constraint on their uptake of new ICT tools. https://www.agriculture.gov.au/sites/default/files/sitecollectiondocuments/abares/ict-use-australian-agriculture.pdf, p.9, accessed 16 December 2019.

<sup>75</sup> ABS (2019) <u>Characteristics of Australian Business, 2017–18</u>, Cat. No. 8167.0, accessed 13 December 2019.

<sup>76</sup> Australian Bureau of Statistics (2015) <u>Australian System of National Accounts: Concepts Sources and Methods</u>. Cat. no. 5216.0, pp. 442–444.

<sup>77</sup> Ibid, pp. 424-453.

<sup>78</sup> ABS (2019) <u>Australian System of National Accounts, 2018-19</u>, Cat. no. 5204.0.

<sup>79</sup> ABS (2019) *Estimates of Industry Multifactor Productivity, 2018-19*, Cat. no. 5260.0.55.002.

<sup>80</sup> Australian Bureau of Statistics (2015) <u>Australian System of National Accounts: Concepts Sources and Methods</u>. Cat. no. 5216.0, pp. 360-376.

<sup>81</sup> AFI (2017) <u>Accelerating Precision Agriculture to Decision Agriculture: Enabling digital agriculture in Australia</u>, p. 22, accessed 25 November 2019; USDA (2019) <u>A Case for Rural Broadband</u>, p. 8, accessed 25 November 2019.

<sup>&</sup>lt;sup>40</sup> See <u>https://www.agrifutures.com.au/wp-content/uploads/2019/01/18-048.pdf</u>

<sup>82</sup> CSIRO (2019) <u>ADOPT: Adoption Diffusion Outcome Prediction Tool—CSIRO</u>, accessed 26 November 2019. See also: Kuehne G, Llewellyn R, Pannell D, Wilkinson R, Dolling P, Ouzman J, Ewing M (2017) Predicting farmer uptake of new agricultural practices: A tool for research, extension and policy, Agricultural Systems 156:115–125 <u>https://doi.org/10.1016/j.agsy.2017.06.007</u>, accessed 26 November 2019.

<sup>83</sup> CSIRO (2019) <u>ADOPT: Adoption Diffusion Outcome Prediction Tool—CSIRO</u>, accessed 26 November 2019. See also: Kuehne G, Llewellyn R, Pannell D, Wilkinson R, Dolling P, Ouzman J, Ewing M (2017) Predicting farmer uptake of new agricultural practices: A tool for research, extension and policy, Agricultural Systems 156:115–125 <u>https://doi.org/10.1016/j.agsy.2017.06.007</u>, accessed 26 November 2019.

<sup>84</sup> Specifically, this includes removing some of the gross value of production attributable to improvements in the red meat processing sector (\$2081m—described in table 3.1 of ibid), processing logs for timber (\$4103m—described in table 3.7 of ibid) and increased automation in timber/wood products (\$963m—described on page 204 of ibid.)