South Australian Centre for Economic Studies

Economic Impact of Digital and Data Analytics Infrastructure – A Scoping Study

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Background

The South Australian Government is embarking on a $1 billion stimulus package in order to counteract the economic downturn caused by the COVID-19 pandemic. As part of these stimulus measures the South Australian Government is considering a $10 million Digital Infrastructure project that will enhance mobile connectedness across the state whilst simultaneously developing approaches to safely capture data and establish a framework for storing and distributing data collected by these systems.

The 2020 Digital Infrastructure Program comprises three main elements:

- expanding the state's existing LoRaWan internet of things (IoT) network throughout the state by establishing access to existing rural and urban government sites;
- upgrading and expanding the existing Adelaide Free Wi-Fi network to improve bandwidth, extend coverage, and enable data collection on an anonymised and de-identified basis (the existing Wi-Fi network is incapable of recording user data.); and
- development of a data utilisation project at Lot Fourteen which provides the framework and systems for data storage and access, building on the work of MIT Living Lab, which has world class experience in data trust models, would lead development of the data management trust model.

As part of the development of the business case for supporting the establishment of the Digital Infrastructure Program, DTI has commissioned the SA Centre for Economic Studies to investigate the evidence base for the economic benefits delivered by digital infrastructure investments that give rise to accessible rich data assets, including the degree to which these benefits may be realised within South Australia.

Potential forms of benefit

Expansion of the LoRaWan IoT and Adelaide Free Wi-Fi networks coupled with enhanced data collection and network integration would lead to the production of rich data assets comprising sensory data and user spatial activity. Through machine learning, AI and other data analysis techniques, these datasets can be used to analyse patterns and trends, solve-complex problems, and make evidenced based decisions. This would in turn provide government agencies, research institutions and industry with various potential benefits, including:

- enhanced operational efficiencies across a range of services and activities, including agriculture, improved city planning and emergency services;
- development of new or enhanced products and services;
- cost savings for those using mobile data in the Adelaide CBD; and
- local researchers in the machine learning and AI fields may obtain a competitive advantage in earning research and commercial income (including the ability to generate spin-off companies) from gaining access to large data sets.

Approach taken in this report

As there are currently no large scale studies identifying the scale of the potential benefits from an initiative of this type the analysis has been reliant on impacts identified through case studies, combined with analysis of the scale of potential beneficiaries in South Australia.

Chapter 2 sets out the estimated scale of the potential benefits that are readily quantifiable, together with some assessment of the scale of harder to quantify impacts.

Chapter 3 summarises the studies that have been drawn on to identify evidence for the economic impact of digital infrastructure investments that deliver data assets, including those users who are most likely to benefit. Chapter 4 explores those businesses in South Australia which are most likely to benefit from access to large data sets comprising user activity and sensory data.

Findings

The broad scope of the proposal in terms of the range of applications that could be facilitated by the digital infrastructure investments and data trust model, and inherent challenges associated with tracking and measuring outcomes that flow directly from adoption of new technologies and solutions present significant challenges in terms of quantifying the potential benefits to South Australia.

Two of the potential forms of benefit are more straightforward to quantify as the current stage of the project development, namely:

- Productivity improvements in agriculture enabled by the expansion/opening up of the LoRaWan;
- Potential efficiency gains in delivering services in the CBD

This suggests plausible annual benefits from precision agriculture are likely to be in the range of $835,942 if 5 per cent of farms adopt precision agriculture to $6,839,525 if the adoption rate is 25 per cent, with numbers at the lower end of the scale more likely in the short-to-medium-term.

Case studies suggest that a rate of return from improved management of infrastructure and traffic flows in cities can plausibly deliver a 4 per cent annual rate of return (1.8 per cent for 'followers', 5 per cent for early adopters). This suggests benefits from these types of outcomes of could plausibly be around $0.4 million per year.

Drawing together the benefits which could be plausibly quantified, then the expected annual benefit from the digital infrastructure initiative is $1,235,942 to $7,239,525.

This does not include the potential benefits of data analytics/open data which could be substantial if an effective trust relationship is established with consumers, and businesses recognise the benefits that could arise from the use of AI and data analytics combined with open data. The potential scale of these unquantified benefits is discussed in section 2.4.

1. Introduction

1.1 Background

The South Australian Government is embarking on a $1 billion stimulus package in order to counteract the economic downturn caused by the COVID-19 pandemic. As part of these stimulus measures the South Australian Government is considering a $10 million Digital Infrastructure project that will enhance mobile connectedness across the state whilst simultaneously developing approaches to safely capture data and establish a framework for storing and distributing data collected by these systems. The resulting data would be accessible to Government agencies, researchers and businesses who could apply the data to Artificial Intelligence, machine learning and other data analysis techniques in order to enhance existing activities and services, and develop new products and services. By building a rich data asset through enhanced data collection, distribution and data analytics capability, these investments would help to establish South Australia as a leading Data Analytics hub.

The 2020 Digital Infrastructure Program comprises three main elements:

- Expanding the state's existing LoRaWan internet of things (IoT) network throughout the state by establishing access to existing rural and urban government sites.[1] The number of gateways would be increased from a current number of 70 to over 400, resulting in one of the largest LoRaWan IoT networks in the world. The network would be designed in a resilient manner to ensure that it maintains operations during emergencies and power outages.
- Upgrading and expanding the existing Adelaide Free Wi-Fi network to improve bandwidth, extend coverage, and enable data collection on an anonymised and de-identified basis (the existing Wi-Fi network is incapable of recording user data.). The system would be built in a modular basis so that it could eventually expand to other council areas and along transport corridors. User data from the Wi-Fi network and Bluetooth beacons would be channelled into an Amazon Web Services cloud data sharing environment to provide researchers, organisations and government with unprecedented data about people movement and visitation within the city.
- Development of a data utilisation project at Lot Fourteen which provides the framework and systems for data storage and access. This project may take the form of an incubator or institute that would involve collaboration across various partners. MIT Living Lab, which has world class experience in data trust models, would lead development of the data management trust model. Other key partners would include SA-based universities, the Things Network, and Amazon Web Services, who would establish a cloud data sharing environment.

The proposed infrastructure investments would leverage existing infrastructure, such as the Government Radio Network (GRN) and Adelaide City Council's Ten Gigabit Adelaide fibre-option network which provides businesses with access to ultra-fast broadband connections.

Beyond the direct economic impacts in terms of employment and regional product associated with establishing and maintaining the communications and sensing infrastructure, data assets and data exchanges services, these investments would create a digital asset (i.e. "Data As Infrastructure") that could be used by government, researchers and industry to build more efficient and modern digital solutions.

As part of the development of the business case for supporting the establishment of the Digital Infrastructure Program, DTI has commissioned the SA Centre for Economic Studies to investigate the evidence base for the economic benefits delivered by digital infrastructure investments that give rise to accessible rich data assets, including the degree to which these benefits may be realised within South Australia. As the proposed investments form part of an urgent stimulus proposal, the time available to conduct the research was severely limited. As a consequence it was only possible to conduct an initial scoping of the potential benefits of digital infrastructures investments. The analysis was informed by SACES past assessments of proposed information and communications technology investments, including Ten Gigabit Adelaide, high performance computing, and other gigabit capacity networks.

1.2 Potential benefits that will flow from the 2020 Digital Infrastructure Plan

The infrastructure investments will give rise to direct economic impacts in terms of employment and gross state product during the construction and operational phases of the various investments, including in relation to ongoing management of the data collection and data exchange services. However, any form of government investment and ongoing operation provision will produce direct economic impacts in terms of employment and value added. The extent to which such investments are justified ultimately depends on the extent to which they give rise to the prime objectives of the investments, which in this case would include, but not be limited to, the

[1] LoraWan is a low power, long range, wide area network protocol that is commonly used for applications with low bandwidth needs.

service value to users of the upgraded Adelaide Free Wi-Fi network (i.e. improved customer satisfaction), and improvements in the efficiency, quality and range of services and solutions that are provided as a consequence of gaining access to improved data systems.

Prior to considering the economic benefits that arise from developing access to large datasets of sensory data and device inter-connectivity, it is important to note that the upgrade of the Adelaide Free Wi-Fi network will provide other specific benefits. Existing residents, workers and visitors would enjoy faster connections, allowing them to interact and work more efficiently, while the enhanced network would provide improved access to existing cloud services that may not always be readily accessible on the current network (and would encourage people to use paid mobile services rather than the free network). The enhanced network would also provide connectivity for vulnerable and disconnected communities, allowing them to access services which are increasingly being delivered online. Furthermore, by offloading traffic from existing mobile networks, the expanded public network would provide benefits to existing mobile service providers by allowing them to delay or even reduce the scale of proposed mobile infrastructure investments.

Expansion of the LoRaWan IoT and Adelaide Free Wi-Fi networks coupled with enhanced data collection and network integration would lead to the production of rich data assets comprising sensory data and user spatial activity. Through machine learning, AI and other data analysis techniques, these datasets can be used to analyse patterns and trends, solve-complex problems, and make evidenced based decisions. This would in turn provide government agencies, research institutions and industry with various potential benefits, including:

- enhanced operational efficiencies across a range of services and activities, including agriculture, improved city planning and emergency services;
- development of new or enhanced products and services; and
- local researchers in the machine learning and AI fields may obtain a competitive advantage in earning research and commercial income (including the ability to generate spin-off companies) from gaining access to large data sets.

In terms of the last point, to the extent that investment in the communications infrastructure and data analytics capability helps to establish South Australia as a leading Data Analytics hub, this will help to attract businesses, investment and researchers to the state. It would also help retain graduates and young professionals working in this area who may otherwise leave the state due to a lack of local opportunities.

The potential machine learning and AI applications that could result from the proposed investments are quite broad. The Australian Institute for Machine Learning (AIML)[2] has identified a range of South Australian specific potential use cases across a range of areas including:

- **Transport**
  - Optimise city-wide traffic flow through cameras and sensors placed around the city, fusing CCTV with AddInsight, SCATS, and other sensors, enabling:
    - *Live traffic management through computer vision, allowing for prediction of conditions and ultra-fast response.*
    - *Significantly reduces travel times, fuel usage, and overall emissions.*
    - *Allows identification of roads and car types most influential in congestion (e.g. trucks/caravans through city streets).*
    - *Allows prediction of crashes and other traffic hazards.*
  - Provide real time queue wait time and passenger volume at bus stops using computer vision (CV), using machine learning (ML) to inform long-term bus scheduling adjustment. This would provide benefits in terms of:
    - *Informatics for bus scheduling can reduce inefficiencies in the system.*
    - *Awareness of queue volumes could either help consumers through informing their travel plans, or backfire by causing people to be more aware of long wait times.*
  - Optimise placement of last kilometre transport solutions (scooters, bikes, etc) based on observed travel patterns and government objectives.
  - Optimise placement of off- and on-road bike lanes to increase safety and promote riding to work.
  - In the longer term future, IoT low power nodes running ML models could facilitate ground- and air-based autonomous vehicles.

[2] DTI (2020), *Pers. comm.*

- **Agricultural**
  - Monitoring of remote water sources through IoT and weather data fusion, including edge-based ML model training and application.
  - Irrigation volume sensing and distribution through IoT sensors or CV, enabling better understanding of efficiency of water spread and connection to various aspects of crop growth.
  - Crop spraying and soil conditions, fused with other data types, to help inform yield and growth rates through ML at different stages in crop life.
  - Crop and animal health through IoT connected animal tags and other sensors.
  - Pest detection (using CV) and pest/disease spread analytics (with ML).
- **Business analytics**
  - Based on Bluetooth data, monitor group sizes and time at venues in order to use information to supply niche analytics (i.e. "this venue is appropriate for/favoured by large groups of 6+, and generally visited by people that also visit ___ type of venue" etc).
  - Obtain demographic data of foot traffic to inform business placement and grant incentives.
  - Cluster venue types to align them more accurately than current labels may allow ("nightclub", "Asian-fusion", etc may be less accurate for recommendation systems than a ML informed method).
  - Use movement data to provide incentives to increase city culture and efficiency
    - *Award for venues and other business types with most loyal customer base.*
    - *Award for takeaway business of different types with fastest turnaround.*
- **Public health**
  - Automated pedestrian crossings using CV to detect people approaching/waiting (utilise same cameras as those for traffic monitoring – can be integrated with traffic management).
  - Monitoring of human movement for informing disease transmission vectors (not limited to COVID).
    - *Note: other data points behave and can be analysed similarly to disease in terms of transmission, like word-of-mouth spread of information on venues, roadworks, etc, allowing for the identification of optimal marketing methods for public awareness and local economic campaigns (e.g. MIT Atlas of Inequality).*
  - Prediction using spatio-temporal thermal heat maps for informing where to place trees or otherwise proactively prepare for heatwaves.
  - Detect popular smoking areas using CV and use data to inform placement of public services like cigarette bins and no smoking zones.
- **Parking**
  - Use ML and CV to optimise routes taken by parking inspectors, garbage trucks, and other roaming assets, increasing efficiency.
  - Optimise parking time allocations and prices to allow more throughput or revenue
  - Locate parking spaces that could be used more effectively.
  - Optimise placement of bike racks to further promote riding to work and social events.
- **Optimisation/prediction**
  - Optimise rent and council rates based on road/foot traffic and demographics, as well as other objectives and data.
  - Measure energy usage and predict peak times to inform proactivity by energy sector (likely from weather sources, movement data, and IoT sensors measuring energy consumption).
- **Public arts**
  - Use the Rundle Lantern to display a heat map of foot traffic or other data/models generated from around the city. Showcase the smart city technology to the public.

1.3 Approach taken in this report

As there are currently no large scale studies identifying the scale of the potential benefits from an initiative of this type the analysis has been reliant on impacts identified through case studies, combined with analysis of the scale of potential beneficiaries in South Australia.

Chapter 2 sets out the estimated scale of the potential benefits that are readily quantifiable, together with some assessment of the scale of harder to quantify impacts.

Chapter 3 summarises the studies that have been drawn on to identify evidence for the economic impact of digital infrastructure investments that deliver data assets, including those users who are most likely to benefit. Chapter 4 explores those businesses in South Australia which are most likely to benefit from access to large data sets comprising user activity and sensory data.

2. Potential Benefits to South Australia

The broad scope of the proposal in terms of the range of applications that could be facilitated by the digital infrastructure investments and data trust model, and inherent challenges associated with tracking and measuring business outcomes and quality of life improvements that flow directly from adoption of new technologies and solutions – which is expressed in a lack of transparent and credible studies – present significant challenges in terms of quantifying the potential benefits to South Australia.

The extent of benefits from the data analytics components of the initiative will also depend on the extent to which the initiative manages to successfully foster trust relationships with South Australians

There are several potential means of quantifying the potential benefits that may flow from the proposed digital infrastructure and data trust management framework investments. These can generally be separated into two broad approaches: bottom-up approaches that seek to quantify the benefits for particular use cases where the scope of the local use case and the broader evidence base for impact are better defined, and top-down approaches which seek to apportion broader level (e.g. national) estimates of the benefits resulting from related digital infrastructure investments and provision of open data resources to South Australia. Both approaches have their relative weaknesses. For example, bottom-up approaches will only provide partial coverage of the potential impacts, while studies used in top-down approaches may not have the same coverage as the current proposal in terms of potential applications across industry, technologies covered etc. Nonetheless, these approaches are useful for assessing the lower and higher bound range of the potential benefits.

Two of the potential forms of benefit are more straightforward to quantify as the current stage of the project development, namely:

- Productivity improvements in agriculture enabled by the expansion/opening up of the LoRaWan;
- Potential efficiency gains in delivering services in the CBD

This impacts are assessed in the remainder of this chapter, together with an assessment of the potential scale of other benefits.

2.1 Productivity improvements in agriculture

Expansion of the public LoRaWan has the potential to facilitate greater adoption of automation technologies and more efficient and effective practices, increasing net returns and operating profit for farms.

ABARES (2020) data identifies the potential agricultural beneficiaries of precision agriculture enabled by a LoRaWan, see table 2.1. As the available data does not include fruit growers (including grape growers) or nut growers estimated benefits derived from this survey data are likely to be understated.

Table 2.1: Characteristics of South Australian farms,

Type of farm	Number of farms	Ave. farm cash income ($)	Potential benefit per farm	
			Low bound ($)	High bound ($)
Broadacre farms	5,862	234,790	2,582.69	4,226.22
Dairy farms	230	253,230	2,785.53	4,558.14
Vegetable growing[a]	344	248,000	2,728.00	4,464.00

Note: a the ABARES farm survey data does not include farms growing fruit or nuts.
Source: ABARES (2020).

In its assessment of the economic value of unlicensed spectrum in the United States, Telecom Advisory Services (2018) assumed that the producer benefits in agriculture resulting from automation were US$20 per hectare. Meanwhile, Schimmelpfennig (2016) estimates that adoption of certain forms of precision agriculture – i.e. GPS soil/yield mapping, guidance systems, and variable rate technology – increase the net returns to U.S. corn farmers by 1.1 to 1.8 per cent, and farm operating profit by 1.1 to 2.8 per cent.

Assuming the latter set of estimates can be transferred to alternative use cases (and assuming that farm cash income is a reasonable proxy for the farm operating profit used by Schimmelpfennig), the remaining unknown is the expected take-up by farmers. As take up will depend on existing use of precision agriculture; how the availability of the LoRaWan compares to the location of farms; on awareness of the potential of technology by farmers; and on the willingness and ability of farmers to fund any associated technologies needed to take advantage of the potential benefits of precision agriculture point estimates are not reasonable. Instead, table 2.2 sets out the potential benefits by type of farm under three take-up scenarios, 5 per cent, 10 per cent and 25 per cent. Low bound benefits are an increase in average farm cash income of 1.1 per cent, high bound is an increase of 2.8 per cent. This suggests plausible annual benefits are likely to be in the range of $835,942 if 5 per cent of farms adopt precision agriculture to $6,839,525 if the adoption rate is 25 per cent, with numbers at the lower end of the scale more likely in the short-to-medium-term.

Table 2.2: Potential annual benefits of precision agriculture enabled by LoRaWan

Type of farm	5% Adoption		10% Adoption		25% Adoption	
	Low bound	High bound	Low bound	High bound	Low bound	High bound
Broadacre farms	756,986	1,238,705	1,513,973	2,477,410	3,784,932	6,193,525
Dairy farms	32,034	52,419	64,067	104,837	160,168	262,093
Vegetable growing	46,922	76,781	93,844	153,562	234,609	383,906

2.2 Returns on smart city hyperconnected investments

In section 2 we reviewed a credible study (ESI ThoughtLab, 2019) that asked city leaders to quantify the returns on investment achieved by various hyperconnected projects in their cities, which are similar in nature to those proposed under the digital infrastructure program. These estimates provide a guide towards the lower bound of the benefits that may be realised by the digital infrastructure program to the extent they do not capture any benefits associated with an open data framework which is a central element of the South Australian proposal. They will also be conservative to the extent they do not capture any economic or social benefits that could not be quantified due to an absence of hard data and qualitative attributes, which was raised as an issue by city leaders.

As we saw earlier, the mean return on investment for hyperconnected initiatives generally ranged from 3 to 4 per cent across the cities. Rates of return were higher for hyperconnected leaders (5 per cent) than implementers (1.8 per cent). Unfortunately we do not know the timeframes over which these returns are realised.

To the extent that the current proposal would push South Australia toward being a hyper-connected leader, we have assumed an average return on investment of 4 per cent (i.e. the higher end of the central range). Applying this to the proposed funding amount for the initiative ($10 million) implies an **annual financial return of $0.4 million**. It is important to note that this return does not include any social, environmental or quality of life benefits that may flow from the current proposal. Nor does it include any benefits associated with the open data aspects of the digital initiative, which as we saw above could be quite significant.

2.3 Scale of quantifiable benefits

Drawing together the benefits which could be plausibly quantified, then the expected annual benefit from the digital infrastructure initiative is $1,235,942 to $7,239,525.

This does not include the potential benefits of data analytics/open data which could be substantial if an effective trust relationship is established with consumers, and businesses recognise the benefits that could arise from the use of AI and data analytics combined with open data. The potential scale of these unquantified benefits is discussed in section 2.4.

2.4 Broader potential benefits of the initiative

The value of the Adelaide Free Wi-Fi network

The value of the network to consumers may be quantified in terms of the consumer surplus benefits that are derived (i.e. the difference between what consumers would be willing to pay and what they do pay). The maximum wiliness to pay would be considered to be the median retail cost of data for mobile phone services, which we estimate to be $3.0 per gigabyte (GB) in 2018-19 based on a weighted average of the median retail cost for post-paid and prepaid services in 2018-19.[3] To derive an estimate we need information on the volumes of data downloaded on the current network, which has so far not been provided. A weakness of this approach is that we do not know how data usage may change with the provision of an improved network in terms of performance and coverage. There are also complications here associated with dealing with the decline in prices over time (i.e. falling at an annual average rate of 40 to 50 per cent over the last four years) and rapid growth in data usage.

Value of investment in digital technologies including AI

As noted earlier in the report, AlphaBeta (2018) estimates that digital technologies, including AI, could generate $315 billion in gross economic value to Australia over the decade to 2028. This estimate is predicated on the basis of Australia closing the capital to advanced economies in terms of ICT investment, multifactor productivity,

3 Weightings based on the number of retail prepaid and post-paid services in operation at 30 June 2019 (ACCC, 2019, *Internet Activity Report*, June 2019).

contribution from domestic digital industries and digital exports, which as we argued earlier would tend to overstate the potential benefits due to the inclusion of the U.S. within the advanced economies, which is an outlier given the presence of Silicon Valley. It would also overstate the potential benefits to the extent it includes forms of digital technology that may not be directly relevant to the digital and data analytics digital infrastructure initiative proposed for South Australia (e.g. includes ICT investment and software development not related to machine learning, AI, or deployment of sensor networks within the public sphere).

Nonetheless, the South Australian proposal represents a major initiative that would be required to fully exploit the potential benefits associated with expanding digital technologies. Apportioning these benefits to the state would in turn provide a guide towards the upper bound of the benefits. There are various means which can be used to allocate higher level estimates to South Australia, such as the state's share of GDP or capital expenditure on intellectual property products. For our purposes we have used the South Australian information media and telecommunications industry's share of value added for the corresponding national industry, which over the decade to 2018/19 averaged 5.1 per cent (ABS 2019). This is considered a reasonable assumption given the direct (but imperfect) connection of this industry to the current proposal. It is also broadly in line with the proportion of expenditure on research and development by Australian businesses in 2017/18 that was located in South Australia (4.6 per cent) (ABS, 2019a).

On the basis outlined above, the benefits to South Australia associated with expanding digital industries, including AI, are estimated to be $15.9 billion over a decade in present value terms. This value is equivalent to an annual average figure of $2.6 billion.[4] If the current proposal were only able to unlock 1 per cent of these attributed benefits, the total benefits would be $159 million in present value terms over a decade ($26 million per annum). These benefits well exceed the estimated funding cost of $10 million, although it should be noted that additional investments may be required to unlock the quantified benefits (e.g. staff training, internal investments by companies on staff and equipment used to process the data, costs associated with integrating with existing company proprietary sensor networks etc.).

Value of open data

A similar approach to the one just discussed can be used to apportion higher level estimates of the value of open data to South Australia. In section 2 we briefly reviewed a Lateral Economics (2014) study that estimated that a doubling of accessibility and use in respect of government and research data would give rise to $19 billion over 5 years, equivalent to an additional 0.27 per cent of Australia's GDP over five years (ranging from a low of 0.14 per cent to a high of 0.41 per cent). Taking a broader approach to include the benefits that would arise from business data in addition to government and research data, the economic contribution of open data policies to Australia's cumulative GDP growth was estimated to be equal to around 1 per cent of GDP.

Given that the digital information plan is focused on increasing data collection from the urban environment rather than private business, we have assumed that the benefits that would arise from a doubling of accessibility and use in respect of government and research data in South Australia would be equivalent to 0.27 per cent of Gross State Product. On the basis of reported Gross State Product for South Australian in 2018/19 ($110.4 billion), this would be equivalent to an annual benefit of $298.1 million. If this value was realised on a consistent basis over a ten year period, it would be equivalent to $2.1 billion in present value terms.[5]

While the above approach provides as estimate of the value of doubling accessibility and use of open data, we do not know the degree to which the proposed digital and data analytics infrastructure would contribute to realising this value. However, we note that if it only makes a 1 per cent contribution the benefits would be equivalent to $21 million in present value terms over a ten year period. This compares with an estimated direct funding cost of $10 million.

[4] Calculated using a 10 per cent discount rate over 10 years (i.e. discount rate used by the authors of the original study).

[5] Calculated using SA Treasury's preferred 7 per cent discount rate. A consistent annual value basis over the 10 year period is a conservative assumption to the extent it assumes no growth in GSP.

3. Economic Impact of Digital Infrastructure Investments and Associated Data Assets – Review of Evidence

Although governments around the world have undertaken or facilitated considerable investment in digital infrastructure technologies, there are few contemporary studies that thoroughly and transparently assess the economic benefits delivered by digital infrastructure investments that are specifically designed to produce data assets that can be used by government, research institutions and industry use. The lack of studies reflects several factors. Firstly, IoT and Big Data are to a large degree emerging sectors, and the full impacts from these activities will take time to be realised and therefore properly understood. Secondly, the broader information communication and technology sector is characterised by rapid evolution and market development, meaning studies can quickly become outdated. A relevant example is the rapid decline in the cost of mobile data which is a substitute for Wi-Fi data access. For example, the Australian Competition and Consumer Commission (2019) estimates that the median price of data for post-paid mobile phone services on a per GB basis decreased by 88 per cent between 2014-15 and 2018-19. Finally, there are significant challenges associated with measuring, tracking and quantifying innovation, business outcomes and quality of life improvements that flow directly from adoption of particular technologies and solutions. In the following section we identify the range of potential benefits that could arise from the types of investment that comprise the 2020 Digital Infrastructure Program, and then briefly review existing studies that attempt to identify and quantify the benefits of these investments, particularly in respect of public Wi-Fi, and applications resulting from machine learning, artificial intelligence and the IoT.

3.1 Assessment of the current and future economic value of unlicensed spectrum in the United States (2017)

Telecom Advisory Services (TAS) was commissioned by WifiForward – an ‘ad hoc’ industry group of companies and public sector institutions dedicated to expanding unlicensed spectrum for Wi-Fi – to update previous studies of the value of Wi-Fi spectrum in the United States. The report seeks to assess the value of Wi-Fi and other technologies that depend on unlicensed bands, including Bluetooth-enabled applications and RFID. This includes services such as free public Wi-Fi, and applications using IoT networks such as agricultural automation, smart cities etc., which are central objectives of the 2020 Digital Infrastructure Plan.

TAS estimated the economic value of mobile network off-loading to free Wi-Fi sites using the standard economic concept of consumer surplus, which represents the difference between what a consumer would be willing to pay for wireless data access and what they actually pay. Willingness to pay was assumed to be equivalent to the average price of mobile network data, which was estimated to be US$5.16 per GB in 2017. The rationale for adopting this value is that consumers would be forced to pay for mobile data in the absence of having access to free Wi-Fi. However, it would be more accurate to interpret this figure as being the maximum willingness to pay since some consumers would not be prepared to pay for mobile data in the absence of free Wi-Fi. Hence the true willingness to pay would be lower than US$5.16 per GB. That said, in calculating consumer surplus TAS subtracts the cost of Wi-Fi provisioning (estimated to be $US2.50 per GB), which is unusual to the extent that users of free Wi-Fi networks do not face any direct data or access costs when using free public Wi-Fi networks, meaning the resulting value (US$2.66) is not strictly a pure consumer surplus measure. Unfortunately, the author does not explicitly state the rationale for subtracting the cost of Wi-Fi provisioning. It could reflect an attempt to capture the indirect costs faced by consumers in respect of having access to free public Wi-Fi services. That is to say, government and organisations who provide free Wi-Fi services will generally seek to recoup or subsidise the costs associated with providing free network services through other means, potentially leading to higher costs for consumers, either in terms of higher taxes, or higher prices for goods and services.

While one may disagree with the exact parameters used by TAS to estimate the economic value of public Wi-Fi networks, the general approach used is sound. However, it does not necessarily lend itself well to determining the incremental benefits associated with improvements to the quality or capacity of public Wi-Fi networks, which is the focus of the planned upgrade to the Adelaide Free Wi-Fi network. Indeed, to estimate the economic value of speed associated with offloading data from slower, mobile networks, to faster Wi-Fi networks, TAS used an alternative approach. They estimated the average differential between average mobile network and Wi-Fi access speeds, and then used this differential to estimate the impact on Gross Domestic Product (GDP) using existing estimates from the literature on the effect of increased broadband speeds on GDP, after making an allowance for Wi-Fi’s share of network traffic. In particular, it used an estimate from Roham and Bohlin (2012) who found that a doubling of broadband speed increased economic growth by 0.3 per cent.

Turning to the impact of IoT applications, TAS estimated the economic value of a range of technologies that utilise unlicensed spectrum to fulfil IoT functions, including:

- advanced meter infrastructure;
- energy demand side management;
- security;
- telehealth;
- smart city applications; and
- precision agriculture.

Benefits in terms of smart city applications and precision agriculture are particularly relevant to the 2020 Digital Infrastructure Program 2020 to the extent it is focused on connecting various government networks and extending the LoraWan network to cover rural and regional areas.

Among the potential smart city applications that wireless sensor networks could provide included:

- *"Citizens can monitor the pollution concentration in each street of the city or they can get automatic alarms when the radiation rises to a certain level;*
- *Municipal authorities can optimize the irrigation of parks or the lighting of the city;*
- *Water leaks can be easily detected or noise maps can be generated;*
- *Vehicle traffic can be monitored in order to modify the city lights in a dynamic way;*
- *Traffic can be reduced with systems that detect the nearest available parking space; and*
- *Motorists can get timely information so they can locate a free parking space quickly, saving time and fuel. This information can reduce traffic jams and pollution, while improving the quality of life."* (Telecom Advisory Services, 2018, p.38).

Beyond the information value and efficiencies associated with these applications, such digital intelligence can provide benefits to cities in terms of improved quality of life, enhanced competitiveness and economic growth (TAS 2018). TAS estimated that the benefits to Smart Cities in terms of the consumer surplus associated with reductions in pollution concentration, optimisation of public irrigation and lighting, and traffic optimisation were in the order of $15.1 billion. Unfortunately the report does not provide an explanation regarding how this estimate was determined, meaning that it cannot be easily transferred to another context, and should be treated with some scepticism. The corresponding economic benefits in terms of contribution to GDP were estimated based on revenues for the wireless sensor network market that are accounted for by infrastructure sales (estimated to be US$793 million). The report advised that a more refined estimate could not be derived given the "still embryonic stage of development" of this sector.

The benefits to agriculture resulting from automation and precision farming facilitated by the deployment of sensors and associated communication systems were estimated on the basis to which these technologies contribute to an increase on total factor productivity in terms of more efficient use of labour, intermediate inputs and timeliness of operations. An average benefit of US$20 per hectare was assumed based on producer benefits observed in field research. Adjusting for the exchange rate and inflation, this value equates to an Australian value of $10.9 per acre in 2019 prices.

In terms of other technologies that utilise IoT functions that were analysed by TAS – advanced meter infrastructure, demand side management, security and telehealth – the 2020 Digital Infrastructure Program would only partially overlap with these use cases. Moreover, the economic value of these forms of machine-to-machine (M2M) communication were calculated by estimating the proportion of total M2M connections accounted for by these four applications, which was then applied to the total estimated value of the total M2M market. Hence these estimates are backwards looking and do not provide a basis for estimating future values based on proposed investments. Furthermore, they do not capture net benefits to the extent that they do not include consumer surplus values associated with cost savings and use of new services and products.

3.2 Building a hyperconnected city (ESI ThoughtLab)

This report comprises an extensive study into how smart cities are becoming hyperconnected by using data and technology to interconnect the various parts of their urban ecosystems (e.g. roads, cars, buildings, energy, citizens). The research comprised in-depth interviews with qualified government officials, benchmarking of 100 cities (including three Australian cities but not Adelaide), development of a hyperconnected cities index, and analysis of existing city data from trusted sources. One significant advantage of this study is that it one of the few that not only provides insight into adoption of particular technologies, it estimates of the returns on investment that have been achieved across various areas of the urban ecosystem.

One of the notable findings of the study is relatively high levels of existing adoption of technologies such as IoT and AI among hyperconnected cities. More than 90 per cent of cities in the study were currently using IoT in some fashion, with adoption being most pronounced in areas such as information and communications infrastructure, mobility and transportation, payments and financial systems, and physical and digital security. Meanwhile, AI technologies were being used by 82 per cent of cities, with usage being most advanced in those same areas just mentioned where IoT adoption is relatively high. Adoption of these technologies are expected to grow strongly over coming years, including in areas where their penetration is currently low. For example, adoption of AI is expected to grow relatively strongly in respect of ‘public safety, health and well-being’, ‘water and waste management’, and ‘governance and funding’, while IoT is expected to expand sharply in the areas of ‘environment and sustainability’, ‘talent and education’, ‘energy and electricity’, and ‘buildings, schools and public spaces’.

City leaders were asked to estimate the return on investment achieved by hyperconnected projects rolled out in their city. The authors advise that the estimates likely represent conservative or lower bound estimates of the potential returns since “many of the social, health, environmental, and business benefits are difficult to quantify” (ESI ThoughtLab, 2019). The returns on investment not only include these forms of benefit where they can be quantified, but also other economic and financial benefits, such as increased revenues and cost savings.

Based on the responses provided, the mean return on investment for hyperconnected initiatives generally ranged from 3 to 4 per cent across the cities. The average rates of return across cities by targeted urban area were as follows (figures in brackets correspond to average rates of return for cities classified as implementers and leaders respectively):

- Public transit: 3.4 per cent (1.5 and 5.3 per cent);
- Water: 3.1 per cent (0.8 and 5.2 per cent);
- Energy and electricity: 3.2 per cent (1.8 and 4.3 per cent);
- Public health: 3.9 per cent (1.9 and 5.6 per cent);
- Traffic management: 3.3 per cent (2.0 and 4.4 per cent);
- Waste collection and environment: 3.5 per cent (2.0 and 5.2 per cent);
- Public safety: 3.1 per cent (1.5 and 4.5 per cent); and
- E-governance: 4.1 per cent (2.6 and 5.6 per cent).

Rates of return varied from a low of 3.1 per cent for water and public safety initiatives, to a high of 4.1 per cent for e-governance initiatives. Returns on investment also vary for specific initiatives within these particular urban areas. For example, returns on investment for public transit initiatives ranged from a low of 1.6 per cent for predictive maintenance to 4.0 per cent for digital public transit payment systems.

One of the notable results from the survey is that leading cities reported higher rates of return compared to those who are considered to be implementing hyperconnected smart city strategies. For example, leaders generally reported average rates of return of between 4 and 6 per cent across the various urban areas, whereas implementers’ average estimates of return generally ranged from 1 to 2 per cent. This pattern could reflect that leaders, having implemented smart city initiatives at an earlier stage, have had more time to realise and therefore identify potential benefits. It could also reflect economics of scale effects among leaders in terms of having more connected, automated and information dense systems, providing a deeper and greater range of potential benefits.

Given the commercial value of data collected by smart cities, one downside associated with the development of hyperconnected systems is a pattern of increasing cyber-attacks. Some cities have reported significant cybersecurity losses, with losses ranging from an average $2.05 per capita for cities that are classified at the ‘implementer stage’ of hyperconnected development, increasing to $3.56 per capita for ‘leaders’.

3.3 Smart cities – case studies

A number of cities around the world have adopted smart sensor systems to improve the efficiency of operations and services, and provide quality of life improvements for their citizens. In the following section we briefly analyse the examples of Barcelona and Singapore.

The Spanish city of **Barcelona** has implemented IoT systems and associated services across a range of urban functions including park maintenance, public transport, parking, street lighting and waste management. These systems leverage an underground fibre network and connected sensor networks that “provides real-time valuable information on the flow of citizens, noise and other forms of environmental pollution, as well as traffic and weather conditions” (Kamel Boulos and Al-Shorbaji, 2014). Among the IoT systems that Barcelona has implemented include:

- connected bus stops that display real time bus timetables, tourism information, and provide USB charging and free Wi-Fi;
- smart parking spaces that monitor the presence of vehicles and a mobile smart parking system that enables users to locate available spaces, reducing congestion, and enabling them to pay online;[6]
- municipal smart bins that provide information on waste levels which can be used to calibrate collection routes, including real time changes to routes being driven by garbage truck drivers;
- streetlights are equipped with close-circuit television, air quality monitory sensors and Wi-Fi, and are able to dynamically conserve energy by adjusting lighting levels in response to the presence of pedestrians and movement; and
- water conservation through the implementation of humidity, temperature, sunlight and other sensors that enable parklands to be irrigated in an optimised manner, and water levels in fountains to be adjusted remotely.7

Beyond small quality of life improvements for citizens, these IoT systems have delivered significant cost savings. For instance, it is estimated that initial investments in irrigation systems would reduce water usage by 25 per cent, delivering a cost saving of US$555,000 per year (Laursen, 2014). Quantified benefits identified by a Barcelona government representative include US$58 million in water savings per year, a 33 per cent or US$50 million increase in revenue from smart parking systems, and the creation of an estimated 47,000 jobs in relation to the smart city initiatives (Kamel Boulos and Al-Shorbaji, 2014). However, these estimates are somewhat opaque in the sense it is not clear how they have been derived, while its it hard to reconcile some of the reported estimates such as the previously mentioned water savings. Furthermore, there do not appear to be more recent estimates of the actual savings that have been delivered in order to validate the earlier estimates.

Nonetheless, provision of data and additional support facilitated by Barcelona’s smart city initiatives has stimulated development among private enterprise. For example, Barcelona provided the company Worldsensing with permits and office space to operate a pilot program to test its Fastprk intelligent parking management system, which has since been exported overseas (Laursen, 2014).

The Internet of Things, Big Data, cloud computing and 3D modelling technologies can be combined to develop virtual versions of cities that can be used for real time monitoring and testing potential solutions in a non-disruptive manner. One example of this approach is **Virtual Singapore**, which is a 3D semantic model of the city which incorporates real-time dynamics, including information about climate, traffic, demographics, and geography that allows data to be analysed and visualised in relation to the real world. Development of the model leverages various digital investments that Singapore has made as part of its Smart Nation initiative launched in 2014. Information from this “digital twin” can be analysed and used in machine learning, AI and simulations to inform emergency management, urban planning, traffic management, and improve the effectiveness and efficiency of existing public services (Liceras, 2019). The model is also notable in that it places no limits on data access, which means the data can be used to develop third party applications that provide insights, optimisations and solutions through data analysis, machine learning and AI (Rocker, 2015). By enhancing data collection, distribution and analytics, the proposed South Australian digital infrastructure investments could be integrated into the existing 3D model of the city to develop the equivalent of the Singapore virtual twin, delivering similar benefits in terms of improving liveability, business analytics and enhanced service delivery. However, it is not possible to estimate the scale of these benefits based on the Singapore example as we are not aware of any readily available studies that have sought to quantify the economic impacts of Singapore’s digital twin initiative (nor its broader Smart Nation initiative).

3.4 Potential economic impacts of artificial intelligence

In 2019 the CSIRO released a major report (Hajkowicz et al 2019) that provides guidance and pathways for how Australia can harness AI to boost local industry and capture the full potential offered by this transformative technology. Beyond developing a technological specialist AI workforce and assisting those workers who will be impacted by AI and related technologies, the CSIRO (Hajkowicz et al 2019, p2) identifies the following actions which should be implemented to maximise the future benefits from AI technologies:

- “ensure effective data governance and access as AI is typically data hungry and machine learning algorithms need “training data” to be developed and tested;

6 Laursen (2014) and Adler (2016).
7 Laursen (2014).

- build trust in AI by ensuring high standards and transparency for all applications developed and applied in Australia because without trust people are unlikely to adopt AI technologies;
- increase the activity within the science, research and technology development pipeline to ensure advanced AI capabilities for government and industry in the future;
- improve digital infrastructure (for data transmission, storage, analysis and acquisition) and cybersecurity so that AI can be safely and effectively used across Australian cities and regions; and
- develop appropriate systems and standards to ensure safe, quality-assured, interoperable and ethical AI is developed and applied within Australia."

We note that the proposed investment as part of the South Australian Digital Infrastructure Program align strongly with these recommended actions as they seek to establish a broader sensory network and rich data asset that can be accessed by a broad range of users, and will formulate a data management model that will ensure high standards in data storage, access and privacy.

The CSIRO identifies three areas where use of AI offers high potential for development given a combination of alignment with local comparative advantage, representing major societal challenges, and/or offering potential export opportunities. These areas comprise (Hajkowicz et al 2019):

- health, ageing and disability – using AI to improve health through prevention or treatment, facilitating healthy ageing and providing improved support for people living with a disability;
- cities, towns and infrastructure – improving the efficiency and effectiveness of built infrastructure planning, design, construction, operation and maintenance; and
- natural resources and environment – enhancing natural resources management to improve the cost efficiency and productivity of farming, mining, fisheries, forestry and environmental management.

Adoption of AI is expected to deliver a range of benefits including significant gains in productivity, improvements in people's quality of life, and the transformation of existing industries, including the development of new industries, products and service offerings.

In terms of the scale of the potential benefits, the CSIRO cites an AlphaBeta (2018) report which estimates that digital technologies, including AI, could generate $315 billion in gross economic value to Australia over the decade to 2028.[8] High-potential opportunities include precision health care, digital agriculture, data driven urban management, cyber-physical security, supply chain integrity, proactive government, legal informatics and smart exploration and production. The quantified benefits are calculated on the basis of Australia closing the digital innovation gap to other advanced economies in terms of information and communications technology capital investment, multifactor productivity, expanding domestic digital industries and increasing digital exports.[9] The report authors estimate that these sources of value account for 11.2 per cent of GDP among advanced economies, but only 7.4 per cent of GDP for Australia. As such, the estimated benefits represent an aspirational goal rather than a central scenario. Indeed, it would be difficult to match the advanced economy average in practice to the extent the United States inflates the average results as it includes Silicon Valley which is a global hub for leading technology firms, information technology start-ups, venture capital, and associated research. Another reason why the potential benefits will be overstated is that they do not take into account displacement of other activities due to the expansion of digital industries.

Turning to other general studies, a recent review of how adoption of AI will impact the UK economy noted that the majority view is that the economic impacts will be "positive, large, and widely spread across sectors", albeit with uneven rates of adoption (Hall and Presenti 2017). Although there are expected to be significant benefits, the review concluded that more work would need to be done in order to ensure the UK remains among the leaders in AI. Some of the key recommendations of the review comprised improving access to data including in a wider range of sectors; improving the supply of skills given specialist skills are currently in short supply; maximising AI research; and increasing uptake of AI through efforts to increase demand, such as by providing guidance to industry on the challenges and opportunities afforded by AI (Hall and Presenti 2017). The current HPC proposal for Lot Fourteen aligns with this last pillar, although we note the lessons from the UK review are that maximising the benefits afforded by AI involves a more holistic approach involving skills development, improved data availability and research efforts.

An analysis of the potential economic impact of AI by PwC (2017) using dynamic economic modelling estimated that global GDP would be 14 per cent higher by 2030 as a consequence of accelerating development and take-up of AI. There are two mains forms of economic benefit arising from AI adoption: productivity gains

[8] In net present value terms over a 10 year period calculated using a 10 per cent discount rate. Digital industries are defined as those involved in the creation of computer hardware, software and communications technology.

[9] Digital industries are defined as comprising the information, communications and technology industry, manufacturing of computer equipment, and software engineering services.

from businesses automating processes and augmenting their existing labour force with AI technologies, and increased consumer demand resulting from the provision of higher quality and personalised products and services due to AI derived enhancements. Labour productivity gains are estimated to make up the bulk of the initial economic impacts and a slight majority of the estimated GDP gains (55 per cent) over the entire analysis period from 2017 to 2030. The gains from product and service enhancements are expected to increase over time as new technologies are increasingly adopted and consumer demand increases in response to exposure to these technologies. Such consumption side impacts are estimated to account for a majority of the GDP gains by the end of the analysis period (58 per cent).

3.5 Potential economic impacts of large data

Lateral Economics (2014) was commissioned by Omidyar Network to quantify the potential economic value of open data to the G20 and Australian economies. The provision of open data is considered to create value in the following ways:

- “reducing the cost of existing government and private services (enhancing efficiency, doing more with less);
- enabling new services and improved quality of services (enhancing innovation);
- improving transparency and accountability (enhancing consumer empowerment and governance); and these effects contribute to
- engendering greater trust in government, which engenders further benefits, such as greater participation.” (Lateral Economics, 2014, p.viii)

The authors estimate current returns in investment in government- and publicly-funded research data are equivalent to $240 billion over 20 years, which is a mid-point ranging from $120 billion to $360 billion. These estimates were derived using a perpetual inventory method based on returns to research and development as indicated by existing studies (20 to 60 per cent), estimates of expenditure on Australian government and research data collection ($11 billion per annum), and other simplifying assumptions. They are considered to be indicative only. Given the above figures, Lateral Economics estimates that a 50 per cent increase in access and use would provide value equivalent to $120 billion over 20 years. Alternatively, a doubling of accessibility and use in respect of government and research data would give rise to $19 billion over 5 years, equivalent to an additional 0.27 per cent of Australia’s GDP over five years (ranging from 0.14 per cent to 0.41 per cent based on low and high return assumptions).

While we do not have the resources to critically assess the Lateral Economics approach, one apparent weakness is that it exaggerates the ease with which government and research data can be expanded to the extent that existing open data already includes the highest value uses (e.g. ABS statistical data).

Lateral Economics also estimated the benefits that would arise in Australia if open data provisioning was extended beyond government and research data to include business data. These estimates were derived by apportioning estimates from a McKinsey Global Institute study on the potential value across seven global economic domains based on GDP shares.[10] On this basis the potential value of open data to Australia was estimated to be $64 billion per annum. As this estimate is based on output rather than value added and does not specifically relate to the value derived from adopting open data policies, Lateral Economics made a number simplifying assumptions to quantify the contribution that a shift to open data policies would make to Australia’s GDP.[11] The economic contribution of open data policies to Australia’s cumulative GDP growth was subsequently estimated to be equal to $16 billion per annum or around 1 per cent of GDP.

3.6 Impact of the Hartree Centre (HPC and data analytics research)

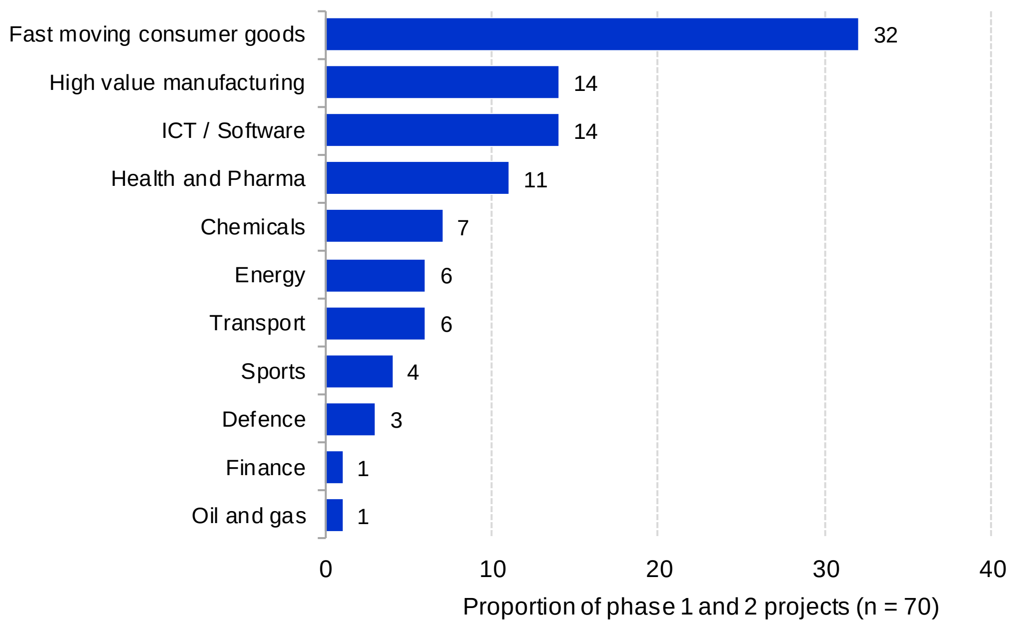
A credible baseline evaluation of the Hartree Centre, which is a High Performance Computing (HPC) and data analytics research centre located in Cheshire, United Kingdom, provides some tangentially related insight into the potential economic impact of technologies such as AI. The Hartree Centre was established with government support in 2013 to improve the competitiveness of UK industry by hastening the adoption of HPC, big data and cognitive technologies. While HPC has traditionally focused on computer heavy uses such engineering simulations, activity is increasing shifting to data analytics that utilise big data and AI. In addition to providing access to powerful supercomputer and data analysis infrastructure, the Hartree Centre provides specialist people to deliver related services including software development, code optimisation, research and development and consultancy services (Simmonds *et al.* 2018).

[10] These domains comprise education, transport, consumer products, electricity, oil and gas, health care and consumer finance.
[11] These assumptions include that value-added comprises two-thirds of the impact, half is attributable to open data policies, and three-quarters of the impact remains to be realised.

In its first four years of operation the Hartree Centre completed 167 projects with around 60 organisations including commercial businesses, various academic users and public users such as the Met Office and National Physical Laboratory (Simmonds *et al.* 2018). Of the portfolio of projects, approximately 100 were collaborative projects with commercial businesses, including larger UK-based manufacturers, smaller software developers and digital small to medium enterprises. A majority of commercial projects (80 per cent) were accounted for by larger businesses.

Reflecting the versatility of AI applications, commercial projects undertaken at the Hartree Centre have covered a broad range of application areas – refer Figure 2.1. The most common include fast moving consumer goods (32 per cent of commercial projects), high value manufacturing (14 per cent), ICT / Software (14 per cent), health and pharma (11 per cent) and chemicals (7 per cent). Unfortunately the extent to which projects specifically focused on AI and/or IoT applications is unknown. One example given was a start-up working on a security product for IoT which trialled a network of sensors at the local campus and worked with the Hartree Centre on various activities including the system integration of AI security agents (Simmonds *et al.* 2018).

Figure 3.1 Distribution of Hartree Centre commercial project portfolio by broad application area



Source: (Simmonds *et al.* 2018).

The main types of commercial benefits reported by users as a consequence of their work with the Hartree Centre include improved innovative capacity (54 per cent), increased international competitiveness (42 per cent), enhanced reputation and global brand value (42 per cent), and increased sales income (33 per cent). A significant proportion of respondents anticipated they would receive commercial benefits in the future in terms of productivity (21 per cent), profitability (21 per cent) and sales income (17 per cent), but had not yet experienced any effects to date.

Commercial benefits for users arise primarily through improvements in productivity that reduce costs and time-to market, and development of innovations and new products that lead to higher sales income. Several examples of productivity benefits related to implementation of faster research and engineering processes were identified, including new product development processes, improved in-house engineering software, and more comprehensive product testing. Examples of innovations and new products that were developed include tools to model power outputs for different configurations of offshore wind farms, and a flood management tool to assist local government and emergency services.

The evaluation quantified the economic impact of the Hartree Centre in terms of the additional gross value added generated within industry users as a consequence of their participation in HPC projects, and the induced and indirect impacts through the broader economy. While a majority of those surveyed reported that their work with the Hartree Centre had a positive impact on their commercial performance, most found it difficult to quantify these benefits. On the basis of a few case studies, it was assumed that participation in HPC projects leads to an increase in turnover of 0.01 to 0.05 per cent for large companies, and between 1 to 5 per cent for small to medium enterprises, and that these benefits would only persist for three years on average (due to eventual erosion by competitive and market forces).

4. Who Might Benefit from Sensory and Spatial Open Data?

The digital infrastructure investments planned by the South Australian government will make a range of user spatial data and sensory data available which can be analysed through traditional and sophisticated data techniques such as AI and machine learning to identify relevant patterns, insights and optimisations. This would not only enable government and industry to improve the efficiency and effectiveness of existing services and digital solutions, it can increase local AI and machine learning capability, improving the competitiveness of local providers.

The aggregate size of the potential benefits will depend on the level of potential use, which will in turn depend on the scale of the potential user base, associated applications and take up. A variety of factors will influence adoption including the costs to access the data (although data may be free, organisations may face costs associated with implementing systems and processes that will be required to access, store, process and manage the data), internal expertise including staff resources and technical capability to apply machine learning and AI data analysis techniques, and competitive pressures that will influence adoption of leading technologies. For example, large companies and those at the leading edge may be compelled to explore AI and machine learning applications, whereas smaller companies and existing laggards may not feel they have the resources or capability to compete.

In the absence (to our knowledge) of any South Australian specific studies that have sought to quantify the benefits associated with adoption of smart city solutions, or the demand for AI and machine learning among local businesses, we need to turn to other data sources that provide insight into the scale of the potential user base. As these alternatives are not specifically designed to gauge the use of open data generated by urban sensor networks for use in AI and machine learning environments, they can only be used to provide a rough guide towards the potential scale of take up, and any assumptions based on these sources need to be interpreted with care.

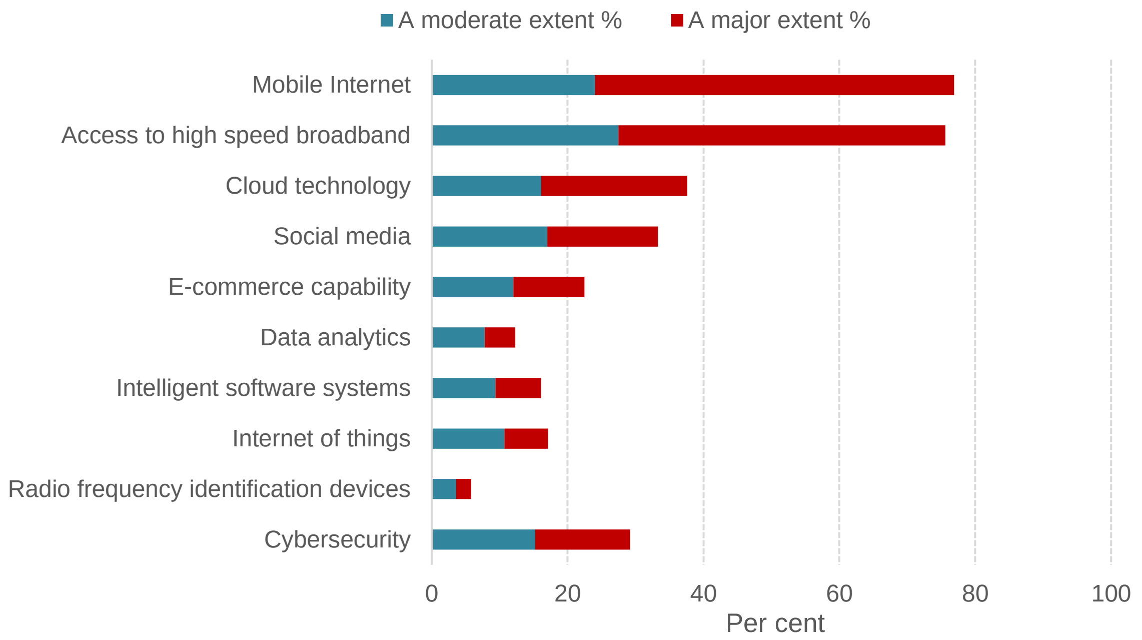
A special survey conducted by the ABS as part of its 2015-16 Business Characteristics Survey (BCS) that investigated business use of information technology provides some insight into the potential adoption of technologies relevant to the digital infrastructure program. The survey has several weaknesses from the perspective of this project. These weaknesses include that it has little to no state detail; does not capture use of technologies in an open data context; and excludes the public administration and safety and education and training sectors, which would be key users of the data for smart city and research applications respectively. Nonetheless, it captures perceptions of the relative importance of certain digital technologies that are relevant to the digital infrastructure program.

General mainstream technologies such as mobile internet, high speed broadband and cloud technology were rated as being the most important digital technologies (in terms of being important “a moderate extent” or “a major extent”) by Australian businesses – refer Figure 4.1. The high rating of these technologies highlights the importance of digital communication, including the ability to access information quickly and easily, to the modern economy.

The survey of information technology use captures several technologies which are more directly relevant to the proposed digital and data analytics investments, including the internet of things, data analytics (e.g. big data and geospatial technology), intelligent software systems (i.e. software that uses AI that “assists a business to satisfy the goals of their clientele”, such as enterprise resource planning systems), and radio frequency identification devices (RFID) (ABS, 2017). Among all businesses, 17 per cent rated the internet of things as being of moderate or major importance; 16 per cent rated intelligent software systems as being of moderate or major importance; 12 per cent considered data analytics as being of moderate or major importance; and 5.8 per cent rated RFIDs as being of moderate or major importance.

Use of digital technologies that are relevant to the digital infrastructure program tends to be higher among larger businesses. For example, 44 per cent of Australian businesses with 200 or more employees identified the internet of things as being important (either to ‘a moderate extent’ or ‘major extent’) compared to 15 per cent of those businesses with 0 to 4 employees. This differential is even larger for intelligent software systems (66 per cent compared to 13 per cent) and data analytics (51 per cent compared to 10 per cent), but lower for RFIDs (22 per cent compared to 4.6per cent).

Figure 4.1 Importance of digital technology importance by type – proportion of business, 2015/16



Note: Businesses can identify multiple technologies as important.
Source: ABS, Business Use of Information Technology 2015-16.

There is naturally considerable variation in the importance of these digital technologies across industries. For example, the internet of things was considered most important (either to a moderate or major extent) for businesses in financial and insurance services (33 per cent), mining (29 per cent), information media and telecommunications (28 per cent) and retail trade (21 per cent), but of less importance for businesses in construction (12 per cent), health care and social assistance (13 per cent), transport, postal and warehousing (15 per cent), and manufacturing (15 per cent). Intelligent software systems were considered of most importance for firms in financial and insurance services (30 per cent), mining (30 per cent), rental, hiring and real estate services (24 per cent), wholesale trade (23 per cent), information media and telecommunications (23 per cent) and electricity, gas, water and waste services (21 per cent).

Table 4.1 Self-assessed importance of selected digital technologies to Australian business by firm size

Employment size	Not at all	A small extent	A moderate extent	A major extent
	Data analytics			
0–4 persons	77.7	11.8	6.4	4.0
5–19 persons	71.3	17.4	6.8	4.5
20–199 persons	47.8	23.9	20.9	7.4
200 or more persons	17.3	31.3	31.9	19.4
	Intelligent software systems			
0–4 persons	74.6	12.5	7.5	5.4
5–19 persons	68.2	14.3	10.5	7.1
20–199 persons	44.9	23.4	18.2	13.5
200 or more persons	13.6	20.6	32.0	33.8
	Internet of things			
0–4 persons	69.7	15.7	9.3	5.3
5–19 persons	62.0	19.5	10.9	7.5
20–199 persons	45.4	24.5	20.1	10.1
200 or more persons	20.8	34.8	28.0	16.4
	Radio frequency identification devices			
0–4 persons	87.0	8.1	3.0	1.9
5–19 persons	84.1	10.0	3.4	2.5
20–199 persons	72.3	16.0	8.4	3.3
200 or more persons	53.6	24.0	15.1	7.2

Note: Businesses can identify multiple technologies as important.
Source: ABS, Business Use of Information Technology 2015-16.

Based the data from the ABS Business Use of IT survey, combined with data on the types of firms that made use of advanced data analytics through the Hartree Centre (see Section 3.6 for a discussion of the Hartree Centre case study) there are a number of industry sectors that are considered to have high use potential for advanced data analytics.[12] These sectors would include:

- fast moving consumer goods (e.g. food and beverage products, toiletries, and other consumables);
- manufacturing, which encompasses those aforementioned fast moving consumer goods products (i.e. low price – quick selling consumables) and high value manufacturing (e.g. automotive, aerospace, scientific, medical etc.);
- information and communication technology and software;
- life sciences / health and pharmaceuticals;
- financial products or services;
- mining, especially oil and gas and exploration activities;
- energy generation, transportation and distribution;
- transportation and logistics; and
- research, including scientific and technical services.

Whilst mining and resources firms are important potential users of machine learning and other advance data analytics this is in terms of geophysical data, not consumer data, and so they are unlikely to be potential beneficiaries from the open data elements of the initiative. As such they have been excluded from this analysis. Equally we have excluded forms of manufacturing that are not focussed on meeting variable consumer demand.

The remaining potential high priority sectors were mapped the above industry sectors to sectoral counts of business by industry subdivision for South Australia using data from the ABS Business Register. While these mappings will be imperfect, they should provide a reasonable upper limit for the potential user base for HPC in South Australia.

Table 4.2 shows business counts by employment size range for those select industry subdivisions that are considered to have high use potential for advanced data analytics, excluding non-employing businesses (e.g. sole traders). Due to the diverse nature of the sub-sectors within it, Professional, Scientific and Technical Services was disaggregated to the 4-digit level and those industry classes which were unlikely to benefit from data analytics based on open data platforms, such as law firms and accountancy firms, were excluded.

Table 4.2 Business counts for HPC relevant[(a)] industry subdivisions and employment size range, non-employing businesses excluded, South Australia – at 30 June 2018

	1-19 Employees	20-199 Employees	200+ Employees	Total
Food Product Mfg	481	101	5	587
Beverage and Tobacco Product Mfg	251	55	4	310
Electricity Supply	24	3	0	27
Gas Supply	5	0	0	5
Road Transport	1,274	91	6	1,371
Postal & Courier Pick-up & Delivery Services	385	0	0	385
Transport Support Services	119	3	3	125
Telecommunications Services	60	0	0	60
Internet Service Providers, Web Search Portals and Data Processing Services	44	3	0	47
Finance	417	12	3	432
Insurance and Superannuation Funds	621	3	6	630
Auxiliary Finance and Insurance Services	1,198	36	0	1,234
Selected Professional, Scientific and Technical Services	.	.	.	.
Engineering Design and Engineering Consulting Services	725	42	9	776
Other Specialised Design Services	251	3	0	254
Market Research and Statistical Services	35	4	0	39
Computer System Design and Related Services	775	32	3	810
Sub-total: HPC high use potential	**6,665**	**388**	**39**	**7,092**
Other industry sectors	39,840	2,690	144	42,674
Total	47,462	3,136	189	149,877

Source: ABS, Counts of Australian Businesses, Cat. No. 8165.0.

12 This analysis is modified from earlier analysis undertaken for the (then) Department for Trade, Tourism and Investment assessing the potential beneficiaries of high performance computing in SA.

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