The contribution of Google to Australia's post-Covid recovery

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GREEN SQUARE ASSOCIATES

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This Report

This report was commissioned by Google and has been prepared by Henry Ergas AO supported by a small team of experienced economists, including Dr Stephen Beare (macroeconomic modelling), and Sabine Schnittger and Joe Branigan (economic research and analysis).

Henry Ergas AO is an economist who has worked at the OECD, Australian Trade Practices Commission (now the ACCC) as well as heading a number of economic consulting firms. He chaired the Australian Intellectual Property and Competition Review Committee set up by the Australian Federal Government in 1999 to review Australia's intellectual property laws as they relate to competition policy. He was Adjunct Professor of Economics at the National University of Singapore and has taught at the Kennedy School of Government at Harvard University, the Centre for Research in Network Economics and Communications at the University of Auckland, Monash University and at the École nationale de la statistique et de l'administration économique in Paris. From 2009 to 2016, he was Professor of Infrastructure Economics at the University of Wollongong, and also served as Senior Economic Adviser to Deloitte Australia. He was an independent contributor to a paper submitted to the U.S. Federal Communications Commission on net neutrality. In 2013, Henry was appointed a member of the NBN Cost-Benefit Analysis and Review of Regulation Panel of Experts. In the 2016 Australia Day awards, Henry was made an Officer of the Order of Australia for "distinguished service to infrastructure economics, and to higher education, to public policy development and review, and as a supporter of emerging artists". He is a weekly columnist for The Australian newspaper.

Dr Stephen Beare is the director and principal of ANALYTECON, a boutique consulting firm that specialises in the quantitative and strategic analysis of market, resource and investment issues for public and private sector clients. Prior to forming ANALYTECON Stephen was a Principal at Concept Economics where his work focussed on the telecommunications industry, resources industries and competition issues. Prior to joining Concept Economics Stephen was the Chief Economist of the Australian Bureau of Agricultural and Resource Economics (ABARE) where he had oversight of a wide range of research into issues faced by the agriculture and resource industries. Stephen holds a B.Sc. degree from the University of California and M.Sc. and PhD degrees from Oregon State University.

Sabine Schnittger and Joe Branigan are experienced economists and long-time associates of Green Square Associates.

Abbreviations

AI	Artificial intelligence
APAC	Asia-Pacific
CS	Computer science
CSIRO	Commonwealth Scientific and Industrial Research Organisation
GCP	Google Cloud Platform
GDP	Gross Domestic Product
GGC	Google Global Cache
GPT	General purpose technology
GRH	Google Research Hub
ICT	Information and communications technology
IO	Input-Output (analysis)
IXP	Internet Exchange Points
POP	Points of Presence
R&D	Research and development

Key Points

$1 billion

Google plans to **invest more than $1 billion in Australia** over the next five years under its Digital Future Initiative.

$1.3 billion

The direct economic impact of these investments amount to **$1.3 billion in additional GDP and 6,500 jobs** across the Australian economy.

The investments include:

1. a significant expansion of Google's digital infrastructure and a sizable increase in Google's local engineering capability and office space.

2. the establishment of an Australian Google Research Hub to add to similar research hubs overseas.

3. partnerships with CSIRO, commercial partners, and other leading Australian research institutions.

The flow-on economic impact amounts to a **further $3.5 billion in GDP and 21,500 jobs** supported across the Australian economy as a result of Google's investments.

More than these macroeconomic impacts, Google's investment in digital infrastructure will **enable businesses to innovate and raise their productivity, supporting higher economic growth in the future.**

$1.5 billion

R&D benefits

The establishment of research partnerships and the Google Research Hub will bring significant additional research capability to Australia and produce spillover benefits to the national economy, which could amount to **$1.5 billion in net present value terms over 10-years.**

$447 million

Consumer benefits

Further, consumers benefit from recent Google investments in network infrastructure such as the undersea cables that connect Australians to the world of information, applications and entertainment sourced from beyond our shores. We estimate a consumer surplus benefit related to a reduction in latency, not otherwise counted, of **$447 million in net present value terms over 10-years.**

Benefits of Digital Resilience

Although these broader, dynamic effects are significant, they are probably less important, in the long run, than the **benefits of digital resilience**, which have been highlighted by the current pandemic and which, we believe, will continue to be of overwhelming importance in the uncertain and complex world which lies ahead.

Increased economic flexibility

What increasingly matters to Australia's future prosperity is the capacity to adjust to shocks that are difficult to foresee, and even harder to predict with any accuracy. That capacity to absorb shocks, by altering the way everyday things are done, is at the heart of digital resilience; and if Australia weathered the pandemic as well as it has, it is in no small part thanks to the digital transformation of our economy and society, which has been, and will be, **supported by Google's significant investment in Australia's post-Covid economic recovery**.

Executive Summary

Google Australia Pty Ltd commissioned Green Square Associates to assess the economic impacts and wider economic benefits of its planned $1 billion investment in Australia over the next five years.[1]

The investment comprises a range of initiatives, including:

- a significant investment in digital infrastructure, including Google's cloud regions in Australia;
- a sizable increase in Google's local engineering capability and office space;
- the establishment of an Australian Google Research Hub to add to similar research hubs overseas; and
- partnerships with the CSIRO, industry partners and other research institutions.

Taken together, the investments have been designed to strengthen Google's capacity to meet double-digit demand growth for its suite of products and services. These expenditures represent a substantial long-term commitment whose benefits for Google will take many years to fully materialise, especially where its research and development (R&D) investments are concerned.

Economic impacts of Google's investment in digital infrastructure

Looking solely at the tangible economic consequences of these expenditures, we expect Australia to directly benefit from these investments in terms of additional employment, income and value added generated. We estimate that Google's investment in digital infrastructure and expansion in engineering expertise and office space, will increase the gross expenditure of the Australian 'digital economy' sector by around $5.3 billion, which will in turn increase gross domestic product (GDP) by $1.3 billion. The additional wages and salaries paid to workers across the Australian economy, which are a component of GDP, are expected to amount to around $620 million.

These outcomes will, in turn lead to 'flow-on' economic effects in other industries across Australia that will further add to the initial, direct impacts. If all industry effects are considered, the impact would amount to around $4.8 billion, with more than 28,000 full-time additional jobs supported by Google's investments.

1 Unless otherwise stated, figures in this report are presented in Australian dollars.

Implications of Google's investment in digital infrastructure for the productivity and resilience of the Australian economy

These direct and flow-on impacts of Google's digital infrastructure investments matter a great deal for Australia's future economic growth and prosperity, but do not capture potentially more significant broader effects.

Some of these effects have been extensively examined in the scholarly literature. Thus, Google's investment in digital infrastructure will enable businesses to deploy advanced information and communications technologies (ICTs). ICTs help businesses to innovate, for instance, by offering customers a higher quality Internet experience, and to raise their productivity to best practice. Improved business productivity directly translates into economic growth, more opportunity and an improvement in our standard of living that can be shared by all Australians.

Although these broader, dynamic effects are often hard to measure, there is little doubt that they are material. But they are probably less important, in the long run, than the impacts which have been highlighted by the current pandemic and which, we believe, will continue to be of overwhelming importance in the uncertain and complex world which lies ahead.

In effect, increasingly, what matters to Australia's future prosperity is not simply the extent to which, and the efficiency with which, resources are used at any one moment in time but the capacity to adjust to shocks that are difficult to foresee, much less to predict with any accuracy. That capacity to absorb shocks, by altering the way everyday things are done, is at the heart of resilience; and if Australia weathered the pandemic as well as it has, it is in no small part thanks to the digital transformation of our economy and society.

For example, the experience of the past two years through the Covid pandemic has proven the value of digital resilience and flexibility, enabling a profound structural change in Australia's labour and transport markets with up to 40 percent of the Australian labour force working from home (WFH) (at peak lockdowns) that would otherwise have been impossible. Moreover, it is inconceivable that the pandemic's impact on schools and universities could have been managed without a high quality digital infrastructure.

Equally, the effects on producers and retailers would have been even more adverse had online shopping (and payment) not been as high quality an alternative to "bricks and mortar" as it now is. And population health would have suffered far more had it not been for tele-medicine, as well as for the extensive digitalisation of our health sector.

In all these ways, the digital infrastructure provides what economists refer to as "option value"– that is, the value of being able to reconfigure ways of doing things as and when circumstances change. There is an important difference between the option value associated with an investment and its value as conventionally measured (say, by discounting to the present the future stream of benefits): while uncertainty reduces the value as conventionally measured (because it raises the discount rate which must be applied), it increases the value of flexibility, and hence of the option. As a result, in circumstances of acute uncertainty, the social value of an investment that increases society's margins of flexibility can be many times that of the same investment when conventionally measured.

The value of Google's investments is therefore not merely in expanding economic activity in the ways we discuss below; rather, it is every bit as much in strengthening our economic and social flexibility, at a time of far-reaching uncertainty, by making it even easier for firms and individuals to rely on the digital infrastructure to reconfigure how they carry out crucial activities.

For example, Google Cloud's regions in Melbourne and Sydney offer both large and small customers the ability to access low latency, high performance cloud services. At the same time, the availability of distributed, secure infrastructure via Google's APAC network of cloud regions and data centres protects against service disruptions and aids in disaster recovery, while maintaining data security and sovereignty.

For customers, access to these resources is scalable, meaning that Google Cloud's enterprise customers can flexibly access remote data handling capability and sophisticated applications as ever-shifting business circumstances require. Instead of having to divert resources into configuring and reconfiguring their own infrastructure, the flexibility inherent in the cloud and associated value added services enables customers to focus on their core business objectives when and as needs change. It will also reduce barriers to entry by allowing new or expanding businesses to buy cloud services rather than buy and build in-house IT infrastructure, and thereby enhance competition with all of its positive effects. And cloud computing capacity in Australia promotes competition among providers of digital infrastructure such as online payment platform services.

Consumer benefits from network infrastructure investments

Google's investments in recent years in (non-cloud) network infrastructure such as the undersea cables that comprise the fibre optic telecommunications trunks to Australia benefit consumers directly, providing increased reliability, greater bandwidth and lower latency than would otherwise be available.

During the pandemic, consumers utilised this network infrastructure more than ever to get things done online (such as for grocery shopping, telehealth appointments, working from home, or entertainment). For example, over the early months of 2020 as businesses increased their reliance on connecting an at-home workforce, Google experienced a surge in the use of Google Meet where day-over-day growth in demand surpassed 60 per cent and, as a result, by April daily usage was more than 25 times what it was in January. Despite this growth, the demand was well within the bounds of Google's network capacity.[2]

Based on monthly data collected by the ACCC, Australia's broadband telecommunications network performed remarkably well thanks in part to Google's pre-pandemic investments.

Consumers value increased reliability, higher bandwidth and lower latency to run the hundreds, if not thousands, of consumer applications that rely on the network infrastructure that connects Australia to overseas providers of internet content. To the extent that consumers rely on, and value, Google's network infrastructure (a subset of the total telecommunications network infrastructure) to run these (often) unpriced applications, the consumer benefits are not measured in the national accounts.

We have used recent estimates of the impact of Google's network investments on bandwidth and latency, and recent economic studies of WTP, to value Google's recent incremental investments to Australia's network infrastructure. We estimated an annual benefit of $58 million per year, or $447 million in net present value terms over a 10-year period.

Implications of Google's investment in research and development

The establishment of research partnerships and the Google Research Hub will bring significant additional research capability to Australia. In combination with the opportunities that Google offers highly skilled engineers, these initiatives make it more likely that Australia keeps its 'best and brightest' computer science, artificial intelligence, and quantum computing graduates and postdoctoral researchers.

R&D benefits everyone. It is, in particular, well established that R&D and the innovations it generates give rise to spillovers as new knowledge diffuses throughout the economy, and businesses and consumers benefit from cost reductions and improvements in quality. As a result, above and beyond the gains that accrue directly to the firm that undertakes it, R&D can result in large returns to society that translate into measurable productivity impacts and a higher standard of living, as well as less tangible benefits, such as new low-cost or even free services or health benefits that consumers value highly.

2 https://cloud.google.com/blog/topics/inside-google-cloud/how-google-cloud-is-helping-during-covid-19

A broad range of economic studies conclude that the corresponding social rate of return to R&D investment easily exceeds $10 per $1 spent on R&D. Accordingly, based on Google's planned investments in R&D over the next five years, we estimate that the social benefit to Australia of Google's R&D investment pipeline exceeds $1.5 billion in present value terms.

Google is vital to Australia's economic and social prosperity

The direct benefit of Google's $1 billion investment in Australia's future amounts to $1.3 billion in GDP and 6,500 additional jobs in FTE terms. The flow-on (or supply-chain) benefits of Google's $1 billion investment amount to $3.5 billion in GDP and 21,500 jobs across the Australian economy. While this is a substantial economic and social footprint, particularly for a technology company in a country traditionally focussed on agricultural and mining resources development, it is only one part of the whole story.

Taken together, the total impact of Google's $1 billion investment in the Australian economy is at least $6.3 billion, comprising:

- $4.8 billion in direct and flow-on macroeconomic impacts from the Digital Future Initiative; and
- $1.5 billion in R&D benefits from the Digital Future Initiative.
- The total number of jobs created or supported by Google's investment is in the order of 28,000 FTEs across the Australian economy.

GSA has also estimated a direct benefit to Australian consumers that is not otherwise measured in the national accounts of $447 million as a result of recent Google investments in primary network infrastructure such as the undersea cables that connect Australia to overseas markets. This estimate is based on an assumed reduction in latency of 20 milliseconds as a result of these investments, which has been previously reported by AnalysysMason (2020).

Google's overall investment—including its commitment to establish a research hub in Australia, one of only a handful around the world— is an important vote of confidence in this country's economic and social future. Above and beyond the direct effects, that vote of confidence, by one of the world's most highly respected enterprises, should help place us on the path to a full and prompt recovery from the pandemic and facilitate our smooth adjustment to the stresses and disruptions which lie ahead.

> **"During the pandemic, consumers utilised this network infrastructure more than ever to get things done online (such as for grocery shopping, telehealth appointments, working from home, or entertainment)."**

Introduction

Google is proposing to undertake a program of investment in the order of $1 billion in Australia over the next five years. Green Square Associates has been asked to prepare an economic impact analysis (EIA) of these expenditures based on information provided by Google.

1

Implications of Google's investment for Australia

Google's program of investment consists of both tangible investment in digital infrastructure, including engineering staff and office space, as well as investment in research and development (R&D).

In this report, we consider the implications for Australia of Google's planned investment from different perspectives.

Looking solely at the tangible economic consequences of these expenditures, we expect Australia to benefit from the 'direct' impacts of Google's investment program in terms of employment, income and contribution to gross domestic product (GDP). These outcomes will, in turn lead to 'flow-on' economic effects on other industries across Australia that will further add to these initial, direct impacts.

These aspects of Google's investments matter a great deal for Australia's future economic growth and prosperity. However, there is also a broader perspective that is all the more relevant given the current pandemic and increasing global uncertainties.

A large share of Google's investment relates to digital infrastructure, in the form of Google Cloud Regions in Australia. Access to this digital infrastructure and, relatedly, the value added applications the network supports, enables business customers to access secure distributed services and expertise remotely, and in a manner that can be adapted flexibly to changing circumstances. Improved digital infrastructure will also enable businesses to deploy advanced information and communications technologies (ICTs), which enable innovations that raise business productivity and benefit customers. Looking more broadly at an uncertain and complex world in which many risks cannot be predicted, the value of Google's digital infrastructure investment lies not just in its direct economic impact but additionally in strengthening Australia's adaptive capacity and digital resilience to stresses and disruptions. An important component of this resilience is the geographically distributed nature of Google's digital infrastructure.

The implications of Google's R&D program also extend beyond its immediate monetary benefit, in terms of the income that accrues to researchers. R&D benefits everyone. R&D and the innovations it generates result in large returns to society that translate into measurable productivity impacts and a higher standard of living, as well as less tangible benefits, such as new services for consumers or better health outcomes.

About this report

This report has been prepared by Henry Ergas AO, Director of Green Square Associates, supported by a small team of experienced economists, including Dr Stephen Beare (macroeconomic modelling), and Sabine Schnittger and Joe Branigan (economic research and analysis).

This report is structured as follows:

- **Section 2** describes Google's history in Australia, and the scope of Google's program of investment;
- **Section 3** focuses on the direct and flow-on impacts of Google's investment;
- **Section 4** considers the broader implications for Australia of Google's investment in digital infrastructure; and
- **Section 5** considers the impact for Australia of Google's investment in R&D.
- **Appendix A** provides a description of the methodology used in the economic impact analysis (EIA).

About Google and Google's program of investment in Australia

Google is ubiquitous in today's world. Google's name has become synonymous with its search engine, but also for the innovative products and services that it has launched around the world. Google also has a significant presence in Australia that will be further strengthened by its planned investment in digital infrastructure and support for R&D.

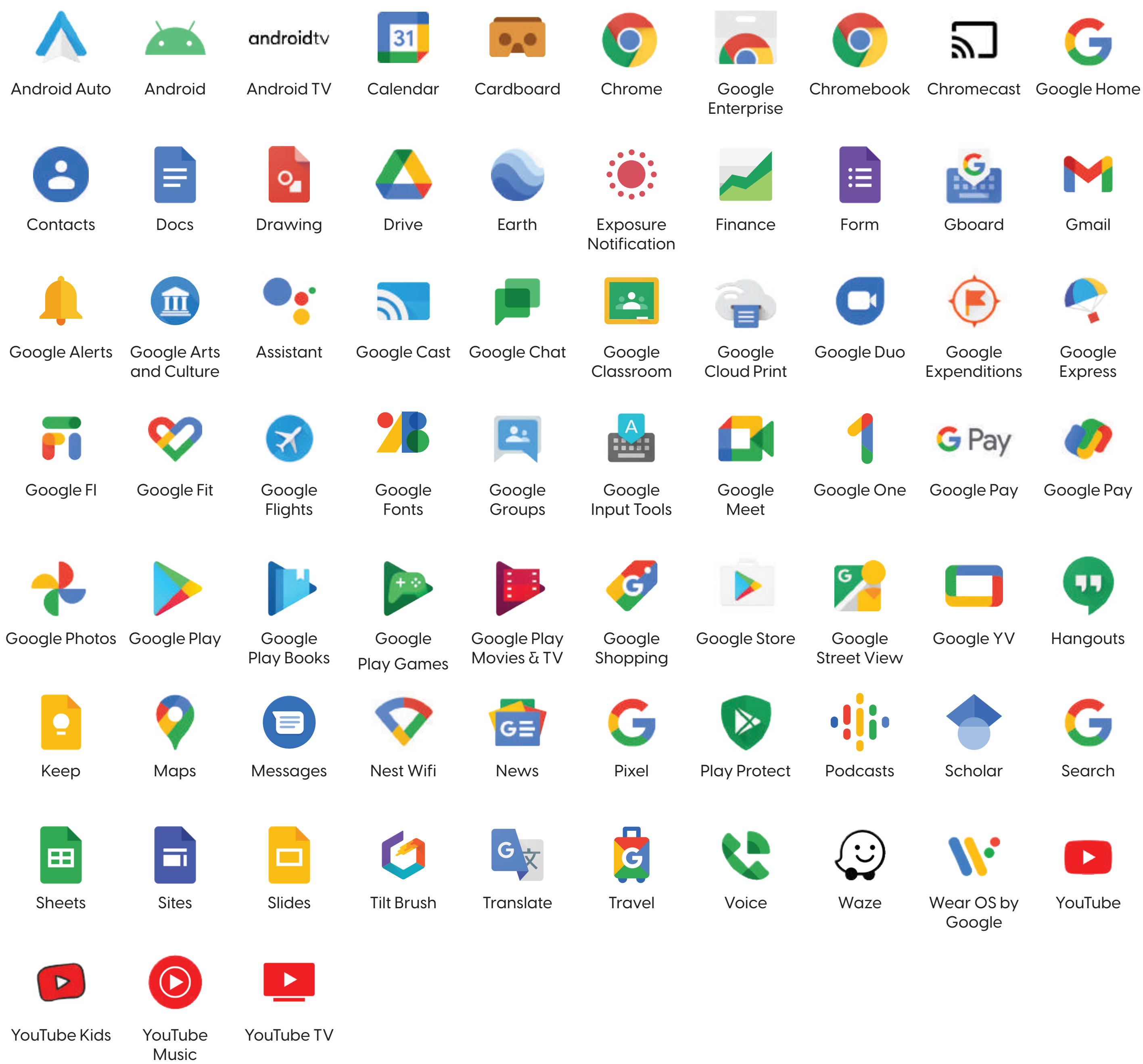
2

2.1 Google in Australia

In less than 25 years, Google's global footprint has grown to include over 4 billion Google searches per day, 2 billion YouTube users, 1.5 billion Gmail users, 3 billion Chrome users, and 1 billion Maps users.[3] Consumers are among the biggest beneficiaries of the great spectrum of products and services that have been developed and are maintained by Google, many of which are free to use for consumers (Figure 2-1). Today, Google is also a leading cloud service provider, and a leading developer globally of new computer science and artificial intelligence, machine learning, robotics, and digital technology.

FIGURE 2-1.

A schematic of Google's main products



Source: Google Australia (supplied).

3 Data sourced from various trade journals and publicly available information.

While Google's global reach is well-known, Google presence and continued engagement in Australia has been far less visible. Google started its operations in Sydney in 2000. From 2002, Australian consumers were able to use an Australian-based Google search engine to search for whatever information they wanted to know. In turn, local businesses were able to advertise their products and services locally, attract new customers and grow.

2.1.1 Google Maps

Google Maps was invented in Australia and continues to be developed locally. In 2018, Google brought wheelchair accessible routes to Sydney before other cities around the world. And building on this achievement, Google has launched indoor Street View imagery for 130 train stations and a dozen metro stations in Sydney allowing commuters to virtually navigate interactive, panoramic imagery inside Sydney stations. In addition, Google has brought navigation directions for accessible routes across 70 complex train and metro stations across Sydney to Google Maps. These tools allow all types of commuters to find the best and most accessible entrances, exits, signage and paths within the station and better anticipate in-transit travel times along these pathways.

In a world first, Google is sharing these navigation directions with Transport for NSW so it can be published to the NSW government's Open Data Portal. This will allow the transport industry and app developers to access this valuable information and find more solutions to enable accessible transit travel in the future.

The development of Google Maps in Australia has provided benefits to Australia's bushfire response and, more broadly, emergency management. Throughout the bushfire crisis, Australians searched for updates on fire conditions near them, as well as safety information. In 2019, "fires near me" was the highest Search query in Australia, highlighting the demand for accurate and timely information.

Google has also collaborated with Infoxchange to add a bushfire services section to the Ask Izzy website, which lists over 370,000 support services across Australia to connect people with help in times of need. Google also provided digital skills training for small businesses in bushfire impacted communities to help them get back on their feet and connect with customers, such as in Shellharbour in March 2020.

2.1.2 Recent investments

Google has invested more than $2 billion in network infrastructure across the Asia-Pacific (APAC) region in the past three years to support the capacity and improve the low latency of Google products and services offered in the Australian market (AnalysysMason, 2020). Key investments include two of the primary fibre optic communications links to Australia: the Japan-Guam-Australia-South (JGA-S) cable, and the Indigo West and Central cables from Singapore to Perth and Sydney (Figure 2-2). Apart from investments in international and local capacity, Google has built edge infrastructure and deployed Points of Presence (PoPs) in private peering facilities, cross-connected to Internet Exchange Points (IXPs), and has invested in content caches with GGC nodes deployed around the country.

These and other investments improve global internet connectivity. AnalysysMason (2000) estimate that Google's investments in Australia will, by 2024:

- add 72Tbits per second in additional capacity;[4]
- reduce end-user latency by 20 milliseconds;[5]
- double download speeds in the APAC region; and
- drive a 20 per cent annual reduction in IP transit prices due to strong submarine cable supply.

2.2 Google's program of investment

Google plans to increase its engagement in this country by investing in the order of $1 billion in digital infrastructure and R&D over five years. These expenditures represent a substantial long-term commitment whose benefits for Google will take many years to fully materialise, especially where R&D is concerned. This commitment should also be taken as a vote of confidence in Australia's economic and social future by one of the world's most important and successful corporations.

Google is proposing a number of substantial investments in Australia over five years. These investments focus on:

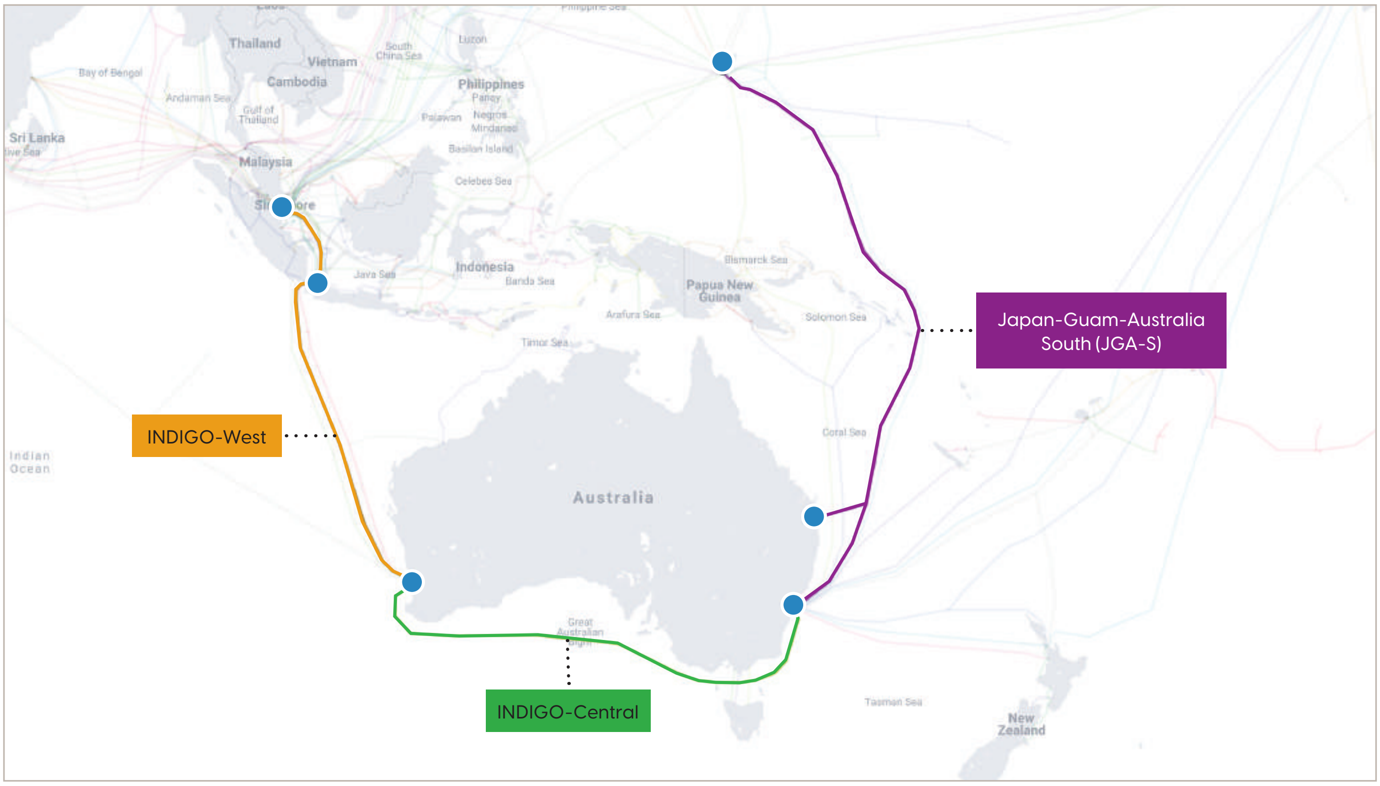
- the creation of digital infrastructure, and
- a significant program of research and development (R&D) both in the form of partnerships with Australian businesses and institutions, and by locating a Google Research Hub in Australia.

4 The transmission capacity of a connection (the quality and speed of the Internet connection) is its bandwidth. Bandwidth is measured in bits per second (bps). High capacity networks have bandwidths measured in megabits per second (Mbps), gigabits per second (Gbps), or even terabits per second (Tbps, or 1,000,000,000,000 bits per second.

5 Latency is measured in milliseconds (ms) and is the time a signal takes to travel to its destination and back. For instance, latency indicates the delay between when a user clicks a link to a webpage and when the browser displays that webpage.

FIGURE 2-2.

Google submarine cable investments to Australia



Source: https://www.submarinecablemap.com/multiselect/submarine-cable?ids=japan-guam-australia-south-jga-s,indigo-west,indigo-central TeleGeography; https://www.submarinecablemap.com/multiselect/submarine-cable?ids=indigo-central,indigo-west,japan-guam-australia-south-jga-s accessed on 7 September 2021

2.3 Summary

Google has had a presence in Australia since 2002 and is already a significant investor in the infrastructure Australians use to connect to the rest of the world. Google invented, developed and tested Google Maps in Australia, providing benefits to organisations such as Transport for NSW and aiding Australia's bushfire response. Over the next five years, Google intends to invest an additional $1 billion in digital infrastructure and R&D in Australia, commencing in 2021.

As we discuss in subsequent sections of this report, Google's investment program benefits Australia in a number of different ways. Perhaps the most apparent relates to the positive economic impact that additional expenditures on new digital infrastructure, additional local engineering capabilities, and the expansion of Google's site will have on the Australian and state/territory economies (Section 3).

In Sections 4 and 5 we consider the benefits to Australia of Google's investment in digital infrastructure and local skills, as well as its R&D investment in more depth.

Economic impacts of Google's investment in digital infrastructure

In this section we assess the economic impacts on Australia and Australian states and territories of Google's investment in digital infrastructure. These impacts consist of:

- 'direct' impacts; that is, the immediate effects of the investment, for example, in terms of jobs created, income paid to the workforce, and value added generated; and additionally,
- 'flow-on' impacts; that is, the impacts that arise because other sectors of the economy are needed to produce the goods and services for Google's investment program, in turn generating further economic activity.

Appendix A describes the methodology we have used.

3

3.1 Direct economic impacts of Google's investment

Google's (non-R&D) investment program consists of the digital infrastructure to support Google Cloud Platform (GCP), an expansion of Google's local engineering capability and investment in Google's site in Sydney. Overall, Google's non-R&D investment program will amount to around 80 per cent of its total investment.

As a result of that investment, Google can be expected to earn revenues in Australia, to generate 'value added', and thereby to contribute to gross domestic product (GDP)[6]. We have assumed that Google would aim to achieve a commercial return on that investment, and that Google would need to generate revenues to achieve that return. We note that these estimates represent an approximation; Google has not provided any financial information to Green Square Associates to support this estimate.

3.1.1 Representing the Australian digital economy

Although the Australian Bureau of Statistics (ABS) has recently published experimental estimates of digital activity, the sectors that make up the digital economy are not separately identified under conventional (and arguably dated) national accounting conventions.[7] To estimate key economic parameters implied by Google's program investment (such as compensation paid to employees and value added), we have constructed a modified 'input-output' (IO) table to incorporate a 'digital economy' sector.[8]

The modified IO table builds on the most recent (2018-19) table published by the Australian Bureau of Statistics (ABS). The 'new' digital economy sector essentially incorporates economic activity from other relevant industry sectors, such as Information, Media and Telecommunications, or Professional, Scientific and Technical Services, holding GDP constant. We have furthermore assumed that the (industry-wide) relationships between output, value added, and other economic parameters for the digital economy sector in the input-output table are approximately representative of Google's business.

A central assumption in constructing a separate digital economy sector concerns the share of GDP that the sector accounts for in Australia. The size of the digital economy has been officially measured at more than $100 billion in value-added terms, comprising about 5.5 per cent of Australia's $1.8 trillion economy in 2018-19.[9] AlphaBeta (2019) estimated the size of Australia's digital economy to be around $122 billion or 6.6 per cent of GDP in 2018. For the United States, the Bureau of Economic Analysis (2021) estimated a share of the digital economy of 9.6 per cent in 2019. Given the structural shift to online communications (e.g., Google Meet, Zoom and Microsoft Teams) and all manner of interactions as a result of the pandemic (e.g., the very rapid increase in online shopping), for this analysis we have assumed estimated that the digital economy in Australia is accounts for 7.5 per cent of GDP.

3.1.2 Direct increase in Australian production

In national accounting terms, the output that Google would need to generate to recover its investment and a return on that investment represents an increase in domestic production by the Digital Economy, specifically an increase in the 'gross operating surplus'. Based on our representation of the digital economy, we estimate that the increase in domestic output corresponding to Google's investment program is around $5.3 billion.

We are then able to derive the following direct changes in economic outcomes as a result of Google's investment in digital infrastructure, increase in engineering presence and office space:

- additional compensation of employees across the Australian economy (28 per cent of the $5.3 billion increase in domestic production) corresponding to around 1.5 billion; and
- additional value added (44.5 per cent of the $5.3 billion) corresponding to around $2.3 billion.

3.2 Flow-on impacts of Google's investment

'Flow-on' impacts refer to the adjustments in the economy that follow on from the direct effects. An initial investment sets the economy in motion as the productive sectors buy and sell additional goods and services from one another, and households earn additional incomes.

For instance, in order to generate an increase in output in the Digital Economy of $5.3 billion, Google will need to purchase a range of goods and services from other businesses, including from other businesses in the Digital Economy, and to a lesser extent, from other sectors of the economy. Some share of goods and services will also be imported. In order for these other businesses to supply the required goods and services to Google, these businesses will in turn employ workforces, buy goods and services from other businesses and so forth. In this way, an initial increase in economic activity 'boosts' the activity of downstream industries that supply the required inputs.

6 From an economic perspective, value added is a key metric of a business' contribution to the economy. A business buys 'inputs' (labour and intermediate products) to generate value added: the additional value of goods and services that are newly created in an economy, and that are available for domestic consumption or for export. Value added is a central concept in the Australian System of National Accounts. Subject to adjustments to ensure that valuations are internally consistent by accounting for various taxes and subsidies, the sum of gross value added across all industries in a country equals GDP.

7 These sectors include digital enabling infrastructure (computer hardware, software, telecommunications equipment and network support services), digital media (digital audio, video and advertisement broadcasting services that can be created, accessed, stored or viewed on digital devices); and e-commerce (ABS 2021).

8 Input-output tables are derived from national accounts aggregates and are produced by statistical agencies such as the ABS to map trade flows throughout the economy, including across industries. The 'industry by industry flow' table indicates, for each industry, the value of intermediate products purchased from other industries, how much that industry paid in wages, the various taxes that were paid, what overall output that industry produced, and what value added that industry generated.

9 https://www.abs.gov.au/articles/digital-activity-australian-economy-2018-19

3.2.1 Input-output analysis

In this report, an IO approach has been used for estimating the flow-on impacts of Google's investment program, building on the modified IO table discussed above. Economic flow-on impacts can be measured in terms of the effects on employment (the number of full-time equivalent or FTE employees), the income accruing to that workforce, and the value added (contribution to GDP) that an initiative such as Google's program of investment generates.

We have derived two types of flow-on impacts of Google's digital infrastructure investment:

- the 'initial' or 'first-round' effects, which capture the immediate impacts on income, employment and value added in all industries whose output is required for Google's investment; and
- combined initial and subsequent 'industrial support' effects, which capture subsequently impacts across industries that occur after the first-round effects have played out. These subsequent effects reflect the fact that the initial effects from an investment will induce additional output in other industries, which will in turn lead to further rounds of effects and so on.

3.2.2 Australia-wide initial and combined industry-support flow-on impacts

Table 3-1 shows the estimated flow-on impacts of Google's digital infrastructure investment for Australia. These flow-on effects are additional to the direct (employment, income and value added) impacts of the investment:

- If only 'first-round' effects on other Australian industries whose output is required for Google's investment are considered, the additional value added generated is estimated at around $1.3 billion, the additional income paid to workers at around $620 million, and expected increases in employment of around FTE 6,500 jobs.
- If the industrial flow-on effects on the Australian economy that incorporate the expanded output arising from the initial expansion needed to meet demand for inputs into the digital economy are considered, the additional value added is estimated at around $4.8 billion, the additional income paid to workers is estimated at $2.6 billion, and additional employment is expected to amount to around FTE 28,000 jobs across the Australian economy.

TABLE 3-1.

First-round and combined industrial flow-on effects of Google's investment in Australia – Australia-wide

National accounts aggregate	First-round flow-on effects	Combined industrial flow-on effects
Employment (FTEs)	6,528	28,057
Income (millions)	$620	$2,628
Value added (millions)	$1,295	$4,769

Notes: NPVs have been derived using a discount rate of 5 per cent.

3.2.3 Initial and combined industry-support flow-on impacts by State

Table 3-2 shows how the estimated flow-on impacts of Google's digital infrastructure investment are expected to be distributed by State or Territory. For this calculation we have assumed that Google would recover the value of its investment across States/Territories in proportion to the population of these jurisdictions as opposed to the exact distribution of its investments which, at this stage, is unknown in a number of cases.

TABLE 3-2.

First-round and combined industrial flow-on effects of Google's investment in Australia – by State/Territory

State/ Territory	National accounts aggregate	First-round flow-on effects	Combined industrial flow-on effects
NSW	Employment (FTEs)	2,167	9,309
	Income (millions)	$208	$879
	Value added (millions)	$378	$1,414
Victoriav	Employment (FTEs)	1,739	7,486
	Income (millions)	$165	$702
	Value added (millions)	$290	$1,106
Queensland	Employment (FTEs)	1,268	5,555
	Income (millions)	$119	$516
	Value added (millions)	$371	$1,347
South Australia	Employment (FTEs)	436	1,890
	Income (millions)	$41	$175
	Value added (millions)	$74	$278
Western Australia	Employment (FTEs)	638	2,893
	Income (millions)	$61	$272
	Value added (millions)	$137	$489
Tasmania	Employment (FTEs)	132	595
	Income (millions)	$11	$52
	Value added (millions)	$21	$86
Northern Territory	Employment (FTEs)	49	229
	Income (millions)	$5	$21
	Value added (millions)	$9	$34
ACT	Employment (FTEs)	100	100
	Income (millions)	$10	$10
	Value added (millions)	$15	$15

3.3 Summary

The analysis of the economic effects of Google's five-year program of investment in Australia suggests a direct increase in GDP of $1.3 billion, and an additional total increase in GDP increase of $4.8 billion if broader industry flow-on effects are considered.

These estimates add to a number of reports released in recent months highlighting the importance of Google's products and services globally as well as studies that are specific to Australia. The results of studies estimating the total economic footprint of Google in Australia, have correspondingly identified very large economic benefits. AlphaBeta, for example, have estimated the economic impact of Google and, in particular, its cloud infrastructure to Australia:

- the economic impact of Google Cloud's Sydney and Melbourne regions and related services was estimated at $3.2 billion in annual gross benefits, comprising $1.4 billion in reduced costs and increased revenues for Australian businesses and $1.8 billion in benefits (or 'consumer surplus') to Australian consumers (or 'consumer surplus') (AlphaBeta, July 2021); and
- Google's total economic impact in Australia has been estimated at $39 billion in business benefits and $14 billion in consumer benefits annually (AlphaBeta, December 2020).

Google's investment in digital infrastructure

In this section we discuss the implications for Australia of Google's investment in digital infrastructure and local engineering capabilities.

The share of the digital economy as a proportion of GDP has been growing in recent years, a shift to which Google's investment will further contribute. The importance of the digital economy to Australia's standard of living is heightened as a result of:

- **the flexibility and therefore resilience conferred by digital infrastructure, which has, for example, helped Australia to manage and overcome many of the disruptions wreaked by the Covid pandemic to daily life and commerce; and**
- **more generally, the effect on business productivity and therefore Australia's standard of living that is enabled by the ICTs that the digital infrastructure supports.**

4

4.1 Digital infrastructure

4.1.1 Google's investment in digital infrastructure

Google plans to invest around a third of the $1 billion into its digital infrastructure and, as part of this investment, has launched a Melbourne cloud region[10] The Melbourne Cloud Region operates alongside the Sydney Cloud Region (which opened in 2017), and nine other regions throughout the APAC region, including in Mumbai, Singapore, Hong Kong and Tokyo.

The investment in the Melbourne Cloud Region represents a second Google Cloud region in Australia and represents the 11th Google Cloud region in APAC. The Melbourne Cloud Region initially offers 23 of 39 possible services (compared to Sydney offering 37 of 39 services).[11] Connected via Google's high-performance network, the Melbourne Cloud Region offers distributed, secure infrastructure to customers to meet their IT requirements while maintaining the redundancy needed for increased reliability and business continuity (eg. disaster recovery).

4.1.2 Google Cloud Platform

The 'Cloud' refers to the delivery of on-demand computing services – including servers, storage, databases, networking, software, analytics, and intelligence – over the Internet. Rather than locating the necessary resources on-site, services are provided remotely without requiring customers to actively manage the resources they use.

Core services included as part of GCP include:

- Cloud based computing power: Google Cloud customers are able to use GCP to develop applications in a remote environment. The applications include Compute Engine, App Engine, Cloud Run, and Kubernetes Engine. Compute Engine allows businesses to remotely create and run virtual machines on Google's infrastructure. GKE allows businesses to develop, test and operate applications in a 'containerised' environment, providing benefits related to reducing system downtime and portability.
- Cloud based storage and databases: Google Cloud customers are able to store their data 'on the cloud' rather than in-house. Applications include Cloud Storage, Cloud SQL, Cloud Firestore, Bigtable, Spanner, and Memorystore to provide object, file and block storage in addition to relational and NoSQL database services that are secure, fast, and scalable.
- Utilising the Cloud Network: Applications include Virtual Private Cloud, Cloud VPN, Cloud Load Balancing, Cloud CDN, and Network Intelligence Centre. These applications provide private and secure environments that monitor and optimise the network. Content is cached in the geographic regions where end users are accessing applications by using Google's global network.
- Providing AI and machine learning (ML): Access to the GCP includes access to application programming interfaces (APIs) such as Translation API, Vision API, and Speech-to-Text API, allowing businesses to add sight, language, conversation, and structured data into their applications, along with AutoML custom model development capabilities without needing ML expertise.
- Cloud based data analytics capabilities: Includes products and services such as BigQuery, Dataflow, Pub/Sub, Data Fusion, and Dataproc, which help Google partners make data-driven decisions while eliminating constraints on scale, performance and cost.
- Security and identity: Includes services such as Cloud IAM for identity and access management, Cloud DLP for data protection, Cloud Armor for network security, and Security Command Centre for vulnerability management and security monitoring to help customers comprehensively protect their cloud deployments.

4.2 Increased local engineering capabilities

In addition to the creation of a Research Hub (see Section 5), Google plans to invest in advanced technology (or STEM) jobs. Google Australia plans to increase existing engineering headcount over the next five years including high paying advanced technology jobs such as skilled engineering, computer science and AI roles.

Combined with other growth across Google, this increase in STEM headcount would bring the number of Google employees in Australia towards 2,500 FTEs within the coming years. This significant increase in headcount aligns with Commonwealth Government policy to grow STEM jobs and the policy priorities of the leading industry association to "boost growth of the Australian tech sector; support talent attraction and development; and ensure regulatory settings across the economy work for the tech-enabled economy". (TechCouncil of Australia, 2021).[12,13]

4.2.1 Google support for STEM

Google supports the growth of STEM-based human capital in Australia in a number of ways, including sponsoring PhD students, professors; research contracts, and post-docs[14]. Additionally, the proposed Research Hub (see Section 5) will provide for a substantial increase in the number of researchers able to receive direct support from, and work with Google.

10 https://cloud.google.com/blog/products/infrastructure/the-google-cloud-region-in-melbourne-is-now-open; accessed 20 September 2021.
11 https://cloud.google.com/about/locations#regions
12 Australian Government STEM policy is set out here: https://www.industry.gov.au/policies-and-initiatives/science-technology-engineering-and-mathematics-stem
13 https://techcouncil.com.au/policy/
14 https://blog.google/around-the-globe/google-asia/australia/supporting-future-computer-science-2021-google-phd-fellowships

4.2.2 Benefits to employees

Most of the benefits of Google's significant increase in investment in human capital accrues to Google employees and Google Australia in the form of increased wages and profits. These gross returns to labour and capital are counted in the national accounts along with the taxes paid. Accordingly, these benefits are reflected in the estimates of the direct and flow-on benefits of Google's digital infrastructure investment (Section 3).

4.2.3 Education spillovers

There are also broader spillover benefits to the Australian tertiary education system labour market from Google's decision to increase its economic footprint in Australia. For young people thinking about a career in STEM, the enlarged presence of Google in Australia – in particular the establishment of another research hub, will be potentially enormously impactful.

Based on the research output and achievements of Google's global research hubs, the planned Australian research hub is likely to be a major attraction to young people thinking about a career in STEM for a number of reasons.

First, as one of the 'big five' global technology companies, the opportunities Google creates are likely to draw young people into studying STEM subjects. Second, Google's presence will improve employment prospects in STEM and hence increase the expected returns to a STEM education. Third, there is a knowledge spillover effect that occurs as people spend a stint working with Google and then work elsewhere. As a global technology leader across computer science, AI, machine learning and robotics this effect is potentially significant. And fourth, there is a signalling effect of Google's investment, both in the labour market, universities, and to other firms deciding where to locate R&D facilities.

In Australia, 65 per cent of economic growth per capita from 1964 to 2005 can be ascribed to improvements in our use of capital, labour and technological innovation—made possible in large part by STEM (Office of the Chief Scientist, 2014). International research indicates that 75 per cent of the fastest growing occupations now require Stem skills and knowledge. As the digital economy continues to grow as a share of GDP, the demand for STEM skills will only continue to grow as we compete in the emerging global economy.

4.3 Site investment

The growth in staff numbers will be matched by suitable local spaces. Google Australia plans to invest in Sydney, where it is currently headquartered, including the heritage redevelopment and in an office fit-out for its recently purchased REVY site in Pyrmont, Sydney.

4.4 Customer benefits from the Cloud

4.4.1 Flexibility and the ability to adapt

For customers, the Sydney and Melbourne Cloud Regions deliver distributed and secure resources that are scalable to suit their data handling and storage needs, as well as remote expertise in terms of system applications that suit customers' requirements.[15] Cloud services offer businesses the advantage that up-front capital expenditures on computer system resources are reduced, and that significant computing expertise is offered via a 'rent' rather than 'buy' model. Accordingly, in recent years there has been a fundamental shift towards Cloud computing for most medium to large enterprises, especially those that require large amounts of storage, privacy and/or security features, as well as merchant services for online sales.

The cloud thus promotes an economic process whose central importance was recognised centuries ago by Adam Smith: the division of labour, which combines specialisation and the partition of a complex production task into several (or many) sub-tasks. In other words, banks can concentrate on being good bankers, rather than trying to be great IT service providers to themselves.

As well as encouraging managerial specialisation, the division of labour facilitates the realisation of economies of scale in production. Thus, concentrating businesses' demand for data storage and associated services allows those services to be provided in a manner that fully exploits the efficiency gains of greater scale. Additionally and importantly, the cloud enables even smaller players to take advantage of the economies of scale in the supply of IT services, while still allowing them to differentiate their service offerings at the applications layer.

The existence of the cloud therefore yields a productive or technical efficiency resulting in cost savings, as well as promoting competition (as more players benefit from the economies of scale), which itself yields allocative, productive, and dynamic efficiencies. Overall, the cloud and the layer of services that can be provided across the cloud represent an almost classic Smithian dynamic: the growing extent of the market allows a deeper division of labour which makes for greater static and dynamic efficiency.

4.4.2 Quality of service

The additional cloud infrastructure in Sydney and Melbourne will enhance a key aspect of quality: maintaining sub-second latency. For consumers, low latency means search time savings, a more immersive gaming experience, and less buffering on video streaming services, including on video calls and other digital communication tools. In the current environment where person-to-person interactions have become problematic in many contexts, low latency implies an improved learning experience for young people being taught remotely, and more effective interactions between patients and doctors in a telemedicine context.

15 https://cloud.google.com/blog/products/infrastructure/the-google-cloud-region-in-melbourne-is-now-open; accessed 20 December 2021.

For businesses, low latency makes cloud services and applications more responsive and capable. Digital communication and collaboration tools are an essential part of an effective organisation, particularly in the current environment where the ability to work from home has become a crucial aspect of ensuring that businesses can continue to operate. Low latency services ensure near-instant access to files and information stored digitally, the faster processing of online payments, and more generally, enhanced access to real-time information and the ability to respond instantaneously to rapidly changing data. Table 4-1 provides an overview of industries where low latency is key to service quality.

TABLE 4-1.

Industries where low latency services are key to service quality

Industry	Application and services
Education	· video conferencing · live-streaming · rich learning content · dynamic e-learning platforms · presentation applications · dynamic administration tools · Cloud-based applications
Healthcare	· Picture Archiving Communications Systems (PACS) · telemedicine, telehealth applications · diagnostic imaging · Electronic Medical Records (EMR) · patient portals · mobile healthcare applications and equipment
Media and entertainment	· live-streaming breaking news · television shows · videoconferencing · movies over Internet · transfer large files, images, and videos from the field to studios around the world · real-time gaming
Government	· interaction between communities and their governments · transportation management, · emergency response and general commerce · circulation of documents · self-service portals
Legal	· sharing large, bandwidth-intensive files quickly and securely · secure and high speed access to critical files "24 hours a day, 7 days a week"
Finance	· High-Frequency Trading (HFT) and high speed information exchange · financial transactions · connections to brokers, dealers, exchanges, hedge funds and information feeds

Source: Spolitis et al. 2014.

4.4.3 Data safety, privacy and compliance

Remote storage and data handling enables businesses to manage a range of challenges and risks, ranging from compliance with regulatory requirements in relation to data privacy to physical risks that extend as far as disaster recovery. The Sydney and Melbourne Cloud Regions are certified for, and regularly undergo independent verification against, an increasing number of compliance standards.[16] For Australia, Google Cloud is audited annually for compliance with the Australian Privacy Principles, as well as for data safety, privacy and security:[17]

- GCP and infrastructure redundancy. Google's cloud regions are geographically distributed to minimise the effects of regional disruptions; in the event of hardware, software or network failure, data is automatically shifted from one facility to another. The 'redundancy of everything' model applies to the server design, how data is stored, network and Internet connectivity and the software services.
- Security. Google maintains multiple levels of control to ensure that its infrastructure security is not compromised. These controls include electronic card key and biometric access systems, 24/7 on-site security operations, and heightened controls for accessing secure floors. Electrical power systems are designed to be redundant, as well as climate and temperature controlled.
- Protection of data in transit. Data sent to Google Cloud by a customer is secured in transit with authentication, integrity and encryption protocols.
- Protection of stored data. Google Cloud automatically encrypts customer content when it is uploaded for storage. Data are broken into encrypted chunks, with the encryption keys themselves being encrypted with a higher level protocol. In addition, customers can select one of a number of data privacy management solutions.
- Data access and privacy. Google Cloud has strong authentication and access management. Customers can manage all aspects of access control with different levels of authentication protocols, while different applications assist customers in managing individual access permissions.

4.4.4 Implications for competition

Google Cloud's digital infrastructure and value added services intensifies downstream competition by providers of digital infrastructure for Australian customers. Increased competition in this space translates into pressures on prices, as well as additional impetus for qualitative improvements to the benefit of customers. As noted above, these improvements in quality include ongoing reductions in latency that are increasingly essential for businesses and valued by consumers.

Greater competition in the provision of digital infrastructure in turn fosters competition between businesses downstream. The scalable nature of the cloud and the sophisticated applications supported by Google Cloud effectively reduces entry barriers for new users of these services competitors, both in terms of hardware and software requirements, as well as IT expertise. Ready access to specialised and supporting applications enables businesses to focus on their core competencies and on their customers instead.

4.4.5 Resilient digital infrastructure

One of the key lessons from the current pandemic is the importance of a resilient digital infrastructure in helping to manage and, at least in part, overcome the enormous disruption that the pandemic has brought to all aspects of life. Australia's digital infrastructure has contributed to the resilience of the economy, in terms of reinforcing its ability to flexibly adapt in response to stresses and shocks, and to recover from these (Blum et al. 2014).

One of the key attributes of Google's cloud regions in Australia is, therefore, the increased flexibility and therefore resilience it promotes in the face of an increasingly complex and uncertain world. Resilient systems incorporate diversity, flexibility and adaptability in their components, and these attributes are readily apparent in the nature of the Cloud. The availability of distributed, secure infrastructure protects against service disruptions and aids in disaster recovery. Additional capacity enables the quality of digital services to be improved in a context where far more interactions of all kinds – be they business or social in nature – take place online. Perhaps more importantly, there seems little doubt that for businesses that have had to shift internal and customer communications online, the flexibility afforded by the cloud in terms of scalability of services has played a major role in limiting the fallout from the pandemic. In effect, the flexibility of the cloud confers an 'option value' on actual and potential users in the sense that they can incrementally scale up their online presence in response to changing circumstances.

Flexibility increases welfare but it does not necessarily increase productivity, at least as conventionally measured. For instance, a dedicated mass production line outfitted with specially designed machine tools that is designed to produce one complex output (say, a particular model of car) will always be more 'productive' than a modular arrangement where many parts interact to produce different models. However, this example also illustrates that a modular system that is essentially a collection of building blocks may be more flexible and therefore more effective in circumstances where the environment is highly uncertain. From this perspective, Google's investment in the Cloud has additional value: the value of a digital system that can flexibly adapt and that is therefore resilient against stresses and disruptions in a world in which all things Internet are increasingly essential to commerce and to our private lives.

16 https://cloud.google.com/security/compliance; accessed 20 August 2021.
17 Google, n.d. Google Cloud and Australian Privacy Principles, Cloud Whitepaper.

4.5 Digital infrastructure and the deployment of ICTs

Australian cloud regions will enable businesses to make greater use of complex ICT services, including Cloud-based computing, Cloud-based analytics, AI and machine learning (Section 2.1). ICT technologies, in turn, represent a 'general purpose technology' (GPT) that supports business productivity and innovation.[18]

4.5.1 ICTs as general purpose technologies

ICTs refer to a spectrum of technologies encompassing all aspects of computing and data management, telecommunications, broadcast media, audiovisual processing and transmission systems, as well as network-based control and monitoring functions. The ubiquity and enormous range of applications of ICTs means that these are generally viewed as 'general purpose technologies' (GPTs, OECD 2013). GPTs are 'engines for growth' (Brynjolfsson et al. 2021). These are technologies that induce substantial and long-term consequences for economic growth, because they:

- are pervasive in the sense that they can be applied in many different contexts and support many applications;
- improve over time and support ongoing experimentation; and
- lead to complementary innovations and co-inventions.

4.5.2 ICTs, business productivity and economic growth

The role of ICTs in spurring innovations, productivity gains and economic growth has been the subject of a large amount of economic research, with sometimes contradictory findings at the economy-wide level. At the level of the individual firm, however, there is clear evidence that investment and usage of ICTs raise firm output and productivity and enable ongoing innovations. As such, ICTs have set in motion four main innovative trends (OECD 2016):

- improved real-time measurement of business activities;
- faster and cheaper business experimentation;
- more widespread and easier sharing of ideas; and
- the ability to replicate and scale up innovations.

It is perhaps not surprising that those productivity gains at the firm level do not materialise immediately after the deployment of ICTs. To apply ICT effectively, businesses must change existing processes, develop managerial experience, train workers, adapt software and build other intangibles. A significant component of the value of ICT then rests in its ability to enable complementary organisational investments such as enhanced workforce skills, business processes and changed work practices. These indirect effects of ICTs on growth and productivity take time to play out, as businesses learn how to use them and learn how to improve their performance.

Large-sample empirical studies at the firm level then show a clear positive relationship between productivity and ICT investment. Digital technologies enable firms to innovate, for example by improving business processes, and to automate certain routine tasks; they also reduce the costs of interacting with suppliers and customers (OECD 2019). Empirical studies also show that the returns to ICT investment are (far) higher over a period of a number of years than they are in the short run. The lag between the time the investment is made and the time in which it becomes mostly productive is interpreted as the time needed to build the complementary human and organisational skills when businesses invest in ICT.

4.5.3 ICT and business innovation

Business innovation is a key determinant of both individual business success and national economic growth (OECD 2010). ICT supports business innovation by enabling firms to increase output quality in the form of new products or in improvements in intangible aspects of existing products like convenience, timeliness, quality, and variety. ICT further supports innovative activities via spillovers and network effects: by speeding up the diffusion of information, enabling networking among firms and closer links with customers, and by reducing or eliminating geographic limitations.

The empirical research then finds that businesses that invest in ICT are significantly more likely to engage in services innovation (Gago and Rubalcaba 2007, Polder et al., 2009), and that these firms also innovate more in terms of the management and marketing practices they adopt (OECD 2010). These effects are significant and large both in the manufacturing and services sectors.

4.5.4 Digital infrastructure and ICTs in a dynamic environment

In recent years, the importance of ICTs in enabling businesses to prosper and grow has come into sharper focus. It has been noted for some time that the uptake and diffusion of digital technologies by businesses has been uneven across OECD economies (Andrews et al. 2018, OECD 2019). At the same time, there is a pronounced and growing gap between a share of businesses that are very productive and in some sense at the forefront of the productivity frontier, and 'laggard' firms that exhibit low productivity and appear to be falling further behind. These gaps in productivity performance are associated with significant differences in the implementation of ICTs and the operationalisation of these technologies.

18 Productivity and innovation underpin a country's economic growth and prosperity, as measured in per capita income. We discuss this relationship in more depth in Section 3.

One important aspect of this outcome relates to the availability of digital infrastructure. There are other barriers to the deployment of ICTs (for instance, skills shortages), but at a basic level, investment in digital infrastructure to enable the deployment of ICTs at the business level is clearly crucial. Overall, this research point to the importance, both at the level of the individual business and from a broader economic perspective, of creating new infrastructure and supporting the deployment of new ICTs that in turn enable new and better ways of doing things.

4.6 Consumer benefits

Google's investments in (non-cloud) network infrastructure such as the undersea cables that comprise the primary fibre optic communications trunks to Australia benefit consumers directly, providing increased reliability, greater bandwidth and lower latency than would otherwise be available.

During the pandemic, consumers utilised this network infrastructure more than ever to get things done online (such as for grocery shopping, telehealth appointments, working from home, or entertainment). Based on monthly data collected by the ACCC, Australia's broadband telecommunications network performed remarkably well thanks in part to Google's pre-pandemic investments. For example, between November 2019 and May 2020, latency for most service providers increased from between 10-15 ms to 15-20 ms, which is a barely discernible increase, despite the significant increase in demand as a result of the WFH arrangements.[19]

A recent study by AnalysysMason reported that Google has invested more than $2 billion in network infrastructure across the Asia-Pacific (APAC) region in recent years (AnalysysMason, 2020). In addition, Google has built edge infrastructure and deployed Points of Presence (PoPs) in private peering facilities, cross-connected to Internet Exchange Points (IXPs), and has invested in content caches with GGC nodes deployed around the country. These investments have expanded Australia's telecommunications network capacity and improved the (already low) latency of consumer applications offered in the Australian market.

These investments have supported the hundreds, if not thousands, of popular consumer applications, including the many social media applications, requiring high bandwidth and low latency to operate as designed.

4.6.1 Consumer surplus definition

It has been shown in the academic economics literature that much of these consumer benefits are not measured in the National Accounts, which aggregates the quantity of goods and services sold in the economy by the price of those goods and services.[20] Since the monetary price of many consumer applications that Google's network infrastructure investment supports is zero (eg. 'free Apps'), the welfare benefits to consumers of these applications must be measured in a different way.

Consumer surplus can be measured via surveys of consumers' willingness to pay (WTP) for a product or service or willingness to accept (WTA), which in simple terms measures the payment that would need to be made to compensate for the service no longer being available.

4.6.2 The value of bandwidth and latency

In its 2020 report, AnalysysMason found that:

- Google's network infrastructure investments will reduce latency for information sourced from overseas by 20 ms; and
- Google's network infrastructure investments will expand bandwidth in Australia by 72 TB (or 72 million MB), (AnalysysMason, 2020).

In a recent study by Lui et al (2018), consumers in the United States were surveyed to discover their WTP for additional bandwidth and reduced latency. The study measured households' willingness-to-pay for changes in key home broadband internet connection features using data from discrete choice surveys that included features such as price, data caps, download and upload bandwidth, and latency. The author's found that households' valuation of bandwidth is higher at lower incremental increases, with relatively little added value beyond 100 Mbps.

For example, the study found that households are willing to pay USD$2.34 per Mbps monthly to increase bandwidth from 4 Mbps to 10 Mbps (or USD$14 per month in total), USD$1.57 per Mbps to increase from 10 to 25 Mbps (USD$24), and only USD$0.02 per Mbps for an increase from 100 Mbps to 1,000 Mbps (USD$19). The author's also found households' willing to pay to be USD$8.66 per month to reduce latency from levels obtained with satellite internet service (about 300-600 ms) to levels more common to a fibre optic cable service (around 10 ms).

19 See ACCC report here: https://www.accc.gov.au/consumers/internet-landline-services/broadband-performance-data
20 See, for example, Brynjolfsson (2020) and Varian (2010, chapter 14).

4.6.3 The value of Google's investments in network infrastructure

Based on the two studies highlighted above, we have estimated the value of Google's investments to consumers, as follows.

The AnalysysMason study estimated the reduction in latency from Google's network infrastructure investments to be 20 ms. Based on the Lui et al study, we have estimated the value of a reduction in latency of 20ms to be $5.76 per household per year.[21]

Although the increased bandwidth to Australian households resulting from Google's undersea cable investments is material, there are issues in measuring the effect of Google's investments at a household level. These issues relate to the various types of retail broadband plans selected by households and the 'last mile' NBN network limitations. Therefore, GSA has not estimated a consumer surplus benefit from the increased bandwidth deriving from Google's undersea cable investments. Further, GSA has not estimated an improved reliability benefit, although there is a clear benefit to Australian households from increased connectivity to overseas markets.

On that basis, we have estimated the consumer surplus from Google's investment in additional network infrastructure to Australian consumers, solely based on the reduced latency benefit, to be $58 million per year. Over a 10-year period, in net present value terms using a 5 per cent discount rate, the total consumer surplus is estimated to be $447 million.

4.7 Summary

Business customers and consumers benefit from Google's digital infrastructure investments in a number of ways. These include the flexibility with which this technology can be deployed, the range of sophisticated applications that customers can make use of, enhanced quality of service, and the many requirements around data security that are managed within the Google Cloud ecosystem. The expansion in Google's digital infrastructure will also add to competitive pressures on other digital service providers, which will in turn translate into pressures on prices and improved quality of service. To the extent that Google's digital network infrastructure enables business customers to deploy advanced ICT technologies, there will also be an additional impetus on business productivity and innovation. Household consumers also benefit from the augmentation of Australia's digital infrastructure from reduced latency, increased bandwidth and greater resilience.

Taking a broader perspective, the addition of flexible digital infrastructure capacity will strengthen the adaptability and resilience of the digital economy in Australia, an outcome that is especially valuable in today's uncertain and risky world.

21 The ABS has estimated the number of households in Australia to be just over 10 million. See here: https://www.abs.gov.au/statistics/people/population/household-and-family-projections-australia/latest-release

Google's R&D investment

In this section we discuss the implications for Australia of Google's planned R&D investments in research partnerships and a Google Research Hub. The broader importance of this investment arises because R&D and the new technologies and innovations it spurs is essential for raising productivity. Productivity, in turn, is a central determinant of a country's standard of living.

5

5.1 Research partnerships and Google Research Hub

Google's investment in digital infrastructure and the capability to develop and support it is supplemented by a significant investment in R&D, representing around 20% of the total $1b commitment:

- Google will invest in partnerships with CSIRO, industry partners and other public and non-profit organisations, to bring Google's broad and deep capability to bear in addressing in pressing Australian economic, environmental and social problems; and
- Google Australia has committed to establish a Google Research Hub based in Australia.

Google's partnership efforts seek to apply Google capabilities to issues of national importance. Areas currently being explored span energy, natural hazard management and food waste. Google is already partnering with the CSIRO to help map the incidence of the Crown of Thorns starfish on the Great Barrier using machine learning. Google has for some time partnered with Australian Universities on Quantum research but will substantially increase these investments in the coming years.

Google Research Hubs are at the core of Google's worldwide research activities. Google maintains significant computer science, AI, and machine learning research capabilities across the globe, including at its research hubs in Bangalore, Zurich, New York and Accra. The R&D undertaken at Google's Research Hubs has four dimensions:

- basic and fundamental applied research; this is the primary focus of Google's research hubs, has no immediate commercial benefit and is comparable to academic research;
- new product innovation; focused on demonstration versions and prototypes of new products and services;
- critical product contributions; work is characterized by deep, essential contributions to products. Progress is measured against product metrics, although research publications are often a side effect.
- infrastructure; such projects create reusable components that enhance the work of (product and research) teams that adopt them, multiplying everyone's impact.

The quality and scope of the research conducted in these hubs easily matches and exceeds that of well-known universities. Google's AI research output, for instance, is ranked first in the United States, and exceeded that of the next two institutions combined (Stanford University, and the Massachusetts Institute of Technology).[22] Most of the research produced by Google Research Hubs is published and free to access by the scientific research community. To that extent, it is what economists term a 'public good' in the sense of being non-excludable (all those who want access can obtain it) and non-rivalrous (use of the good by one user does not reduce its availability to others), with implications we discuss below.

5.2 R&D spillovers

R&D and the innovations it generates are crucial to a country's standard of living. R&D, resulting in new goods, new processes and new knowledge, is a central source of technological change and of improvements in productivity.[23] Productivity is simply the ratio of outputs to inputs. Labour productivity, for example, measures the output per worker or per hour worked, and is an indication of how efficiently labour is used to produce a given level of output. An economy that raises its productivity is able to produce more or better goods and services with the same resources, making the average consumer better off. Over the long run, increasing per capita incomes cannot be sustained without increasing productivity. Taken over many years, even small changes in productivity have a large effect on economic growth and a country's standard of living.

To understand why R&D is so closely tied to economy-wide improvements in productivity, it is important to see that R&D and the innovations it generates result in 'spillovers' that benefit parties other than the innovator. An innovating business may itself profit from an innovation, but the existence of spillovers generates 'social' returns to R&D that extend far beyond those captured by the original innovator in most industries (Hall et al. 2010, Jones and Summers 2020). The innovative investments made by one firm will thus not only raise the investing firm's productivity, but also raise the productivity of other firms:

22 https://chuvpilo.medium.com/ai-research-rankings-2020-can-the-united-states-stay-ahead-of-china-61cf14b1216; accessed 20 August 2021.
23 The OECD (1993) defines R&D as "creative work undertaken on a systematic basis in order to increase the stock of knowledge and the use of this stock of knowledge to devise new applications".

- 'User' spillovers are those that benefit other firms (but also to consumers), for instance if more advanced computing capabilities increase the productivity of firms that deploy these technologies.
- 'Knowledge' or 'imitative' spillovers occur when an R&D project produces knowledge that can be useful to another firm. Knowledge spillovers occur because patent protections may not work all that well, innovations cannot be kept secret, and because new products can be reverse engineered and imitated. Knowledge spillovers are key to growth and development because they result in the diffusion and further creation of knowledge. In the case of research that is freely available, the knowledge spillovers can be very large, as any one user's access to the research does not reduce access by others.
- 'Intertemporal' spillovers occur when a particular advance or innovation lays the foundation for future advances. For example, technologies such as computers and mobile phones serve as platforms for enormous arrays of future innovations, but basic research which is intended to advance understanding and introduce new ideas also represents a central source for intertemporal spillovers.

5.3 The social return to R&D

The social returns of R&D and innovations as a result of spillovers then accrue to all types of agents across society, including to the imitators who earn additional profits, and to consumers who benefit from price reductions and improvements in quality.

A great deal of research has been done to estimate the returns to society from R&D and innovations. The precise estimates depend on many factors, including how R&D is measured, whether spillovers are assessed at the firm, industry or country level and others. However, the overarching conclusion is that society benefits a great deal from R&D, and that the social returns to innovation generally far exceed the private return captured by the innovator.

Jones and Summers (2020), for example calculate a baseline average social return to innovative investments from a macroeconomic perspective. Taking this baseline, $1 of R&D investment today produces, on average, $13.3 in future benefits, corresponding to an internal rate of return of 67 per cent. There are some considerations that may reduce this social rate of return – for instance if there are large delays in reaping the benefits of R&D, or if the gains from innovation are embodied in new forms of capital. Conversely, there are other factors that raise the social rate of return on R&D even higher, for instance, because national accounting measures do not properly reflect improvements in quality and overstate inflation (a claim that has been well documented, including in Australia), or because health benefits accruing as a result of innovations are not accounted for. Thus, Jones and Summers (2020) conclude:

"Overall, we find that the average social returns to innovation investments appear very large. If formal R&D and new venture creation drive the bulk of productivity gains, then the social returns to these investments appear enormous. If a much broader set of investments, including capital embodiment, are needed to fulfill these productivity gains, then the social returns to these broader activities still appear large. Even under very conservative assumptions, it is difficult to find an average return below $4 per $1 spent. Accounting for health benefits, inflation bias, or international spillovers can bring the social returns to over $20 per $1 spent, with internal rates of return approaching 100%."

5.4 Implications of Google's R&D investment for Australia

High social rates of return to R&D imply that Google's investment in research will flow through the economy and benefit Australians broadly. One of the factors that will determine the size of these benefits is the delay between an investment in R&D and the time the innovation is brought to the market. Here, most studies suggest that these delays between up-front costs in R&D and market payoffs are relatively short and in the range of three to six years, although the lags until basic research pay off tend to be around 20 years (Jones and Summers 2020). Given the nature of the digital economy, where many innovations concern information which is intrinsically hard to appropriate, delays are likely to be shorter. Information is expensive to produce and inexpensive to reproduce, and the low costs of imitation, transmission, and distribution of ICTs are likely to erode the value of property rights in intellectual property (Nordhaus 2005).

To estimate the return to Australia from Google's program of R&D investment, we have therefore conservatively assumed a delay of five years until other businesses and consumers benefit from innovations. In reality, many new products and services may come to market more quickly, but given the broad focus of the research partnerships and Google Research Hubs (including on basic research), a five-year lag was deemed more appropriate. A five-year lag implies an average social benefit-cost ratio of 10.4 (Jones and Summers 2020), so that Google's expenditures on research partnerships and an Australian Research Hub would correspond to a combined social benefit to Australia of around $1,509 million in NPV terms

5.5 Summary

Google plans to invest almost 20% of the $1b commitment in a program of R&D in Australia, including in research partnerships with industry and Australian research institutions, and a Google Research Hub.

R&D and the resulting new technologies and innovations give rise to spillovers as new knowledge diffuses throughout the economy, and businesses and consumers benefit from cost reductions and improvements in quality. The corresponding social rate of return to R&D investment easily exceeds $10 per $1 spent on R&D. Accordingly, we estimate that the social benefit to Australia of Google's R&D investment exceeds $1.5 billion in NPV terms.

> **"Overall, we find that the average social returns to innovation investments appear very large. If formal R&D and new venture creation drive the bulk of productivity gains, then the social returns to these investments appear enormous."**

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Appendix A.

Analysis of direct and flow-on impacts

A.1 Specification of the digital economy

The economic impacts of Google's proposed investments, as measured in the Australian national accounts, were assessed by constructing modified IO tables that include the 'Digital Economy' as a separate ANZSIC industry.[24] The modified IO table was derived from the most recent – 2018-19 – IO tables published by the Australian Bureau of Statistics (ABS).[25] The IO tables were used to estimate the direct impacts on the Digital Economy and flow-on impacts through other industries.

In brief, a share of the ANZSIC industries that contribute to digital activity was reallocated to the Digital Economy, subject to the constraint of holding total economic activity constant. The 2018-19 industry-by-industry flow table with direct allocation of imports was first aggregated to the 19 ANZSIC industries from which a concordance between the Digital Economy and the ANZSIC industries that contributed to digital activity, as defined by the ABS, was constructed (ABS 2019). A set of assumptions were then made to reallocate the table.

First, 7.5 per cent of the value added in the economy was allocated to the Digital Economy. Second, the shares of the ANZSIC industries' contribution to the value added of the Digital Economy were specified. These were:

- Manufacturing – 14 percent;
- Wholesale Trade, Retail Trade – 10 percent;
- Information, Media and Telecommunications – 22 per cent;
- Professional, Scientific and Technical Services – 33 per cent; and
- Other Services – 7 per cent.

Employment in Digital Economy was allocated in the same proportions.

The rows of the industry-by-industry flow table were then reallocated to create the supply of intermediate inputs of the Digital Economy to other industries (and the reduced contribution of the ANZSIC industries). The columns of the flow table were then reallocated in order:

- to create the intermediate inputs used by the digital economy; and
- to break down the value added in the Digital Economy into compensation of employees, gross operating surplus, taxes and imports.

The supply of the Digital Economy to itself was then calculated to bring the flows table back into balance.

The requirements table, in which input supply, input use and the component of value added were then calculated by dividing the columns by total industry production.

The 'Digital Economy' sector is summarised in Table A-1. In 2018-19, the Digital Economy sector purchased intermediate inputs with a value of around $147 billion from other industries (including itself), paid compensation of around $86 billion to its workforce, earned a gross operating surplus and mixed income of around $46 million, with Australian production of around $308 billion. The value added generated by the Digital Economy is estimated at around $137 billion or 44.5 per cent of Australian production.

TABLE A-1.

Structure of the digital economy in the modified IO table

	Digital Economy ($ millions)	Share of Australian production (Per cent)
Total Intermediate Use	$146,960	47.7%
Compensation of employees	$86,253	28.0%
Gross operating surplus and mixed income	$46,437	15.1%
Taxes less subsidies on products	$1,555	0.5%
Other taxes less subsidies on production	$4,291	1.4%
Complementary imports	$0	0.0%
Competing imports	$22,554	7.3%
Australian production	$308,051	100.0%
Value Added	$136,982	44.5%

Notes: # In the national accounts, the gross operating surplus is the portion of income derived from production that is earned by the capital factor. In the above table, the GOS also includes 'Mixed Income', which refers to the capital and owner returns of non-incorporated enterprises.

24 The conceptual framework for the economic impact modelling was developed by Dr Stephen Beare. The modelling was undertaken by Sabine Schnittger. The model outputs were checked (quality-assured) by Dr Stephen Beare and Joe Branigan.

25 5209.0.55.001 Australian National Accounts: Input-Output Tables, 2018-19.

A.2 Derivation of input-output multipliers

We note that the input-output methodology is underpinned by various strong assumptions; these assumptions result in the impacts of an investment being overstated if they are breached (Bess and Ambargis, 2011). The key assumptions and limitations that apply to IO analysis are that:

- inputs are used in fixed proportions to one another to generate an output;
- all firms within an industry are characterised by a common production process;
- prices are fixed; and
- there are no supply constraints.

The multipliers used here were derived from the modified 2018-19 industry-by-industry flow input-output tables published by the ABS. Two types of multipliers have been derived in this analysis:

- 'Type IA' multipliers refer to the 'initial' or 'first-round' effects arising from an increase in demand generated by an investment. Type IA multipliers capture the immediate subsequent impacts on income, employment or value added on all industries whose output is required for Google's investment.
- 'Type IB' multipliers refer to the combined initial and subsequent 'industrial support' effects. Industrial support effects capture the subsequently induced effects across industries that occur after the first-round effects have played out. These subsequent effects reflect the fact that the initial output effect from an investment will induce additional output in other industries, which will in turn lead to further rounds of effects and so on.

A.3 Australia-wide multipliers

The Type IA and Type IB multipliers for value added, income, and employment are calculated from the appropriate inversions of the requirements table.[26] In the case of value added and income, the multipliers can be used to calculate the value of the flow-on effect directly from the direct value added and income estimates. In the case of employment, we need the change in FTE employment, calculated here as the number of FTE employees per $ million in production.

Table A-2 below shows the Australia-wide multipliers for the digital economy derived in the manner described above.

TABLE A-2

Digital industry multipliers – Australia

National accounts aggregate	Multipliers	
	Type IA	Type IB
Value added	0.55	2.03
Income	0.42	1.78
Employment	0.41	1.76

26 Based on similar work completed by GSA, the multipliers derived in the model are within the reasonable range of multipliers estimated for these industries in the Australian economy.

A.4 State/Territory multipliers

It is not possible to maintain the level of consistency that exists in national input output tables at a state level. Comprehensive data on industry composition, household consumption and the flow of goods and services to and from states is not available.

A.4.1 Adjusting the State/Territory industry composition and trade

A standard approach that can be reproduced across different geographical definitions in a consistent manner is to use employment by industry data to form what are known as location quotients (LQs). Employment-based LQs are ratios that indicate the percentage of people employed in a particular industry at a state level, relative to the percentage of people employed in that industry in the national economy. Employment-based LQs are then used to proportionally adjust the contribution of an industry to the use of intermediate inputs in a state. The consequent shortfall in intermediate inputs is made up by increasing 'imports' from outside the state or region across all industries.

The use of employment LQs has a critical limitation. Input-output tables do not explicitly account for fixed capital, human or physical, although the returns to these assets are implicitly reflected in wages and operating surpluses (profits).

A raw LQ is simply the percentage of FTE employment in a given industry and region, divided by the percentage of FTE employment in a given industry at the national level. This may be written for the ith industry and the jth region as:

$$LQ_{i,j} = \frac{\dfrac{employment_{i,j}}{\sum_i employment_{i,j}}}{\dfrac{\sum_j employment_{i,j}}{\sum_i \sum_j employment_{i,j}}}$$

The LQ has a natural interpretation for an industry within a state:

- if the LQ is less than one, the goods and services from that industry will tend to be imported into the region to meet demand; while
- if the LQ is greater than one, the goods and services from that industry will tend to be exported into the region to meet demand elsewhere.

Given that goods and services and labour requirements are the same in all states, the relationship will tend to be proportional so long as the actual size of the labour force does not represent a constraint.

A.4.2 State/Territory multipliers

Table A-3 shows the state multipliers for the digital economy.

TABLE A-3

Digital industry multipliers – Australian states and territories

National accounts aggregate	Multipliers	
	Type IA	Type IB
NSW		
Employment	0.43	1.83
Income	0.44	1.86
Value added	0.57	2.11
Victoria		
Employment	0.42	1.80
Income	0.43	1.82
Value added	0.53	2.03
Queensland		
Employment	0.39	1.72
Income	0.40	1.72
Value added	0.56	2.01
South Australia		
Employment	0.40	1.71
Income	0.40	1.71
Value added	0.51	1.92
Western Australia		
Employment	0.38	1.74
Income	0.40	1.76
Value added	0.63	2.24
Tasmania		
Employment	0.39	1.76
Income	0.36	1.67
Value added	0.49	1.94
Northern Territory		
Employment	0.32	1.49
Income	0.33	1.50
Value added	0.44	1.67
ACT		
Employment	0.37	0.37
Income	0.39	0.39
Value added	0.43	0.43

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