Why Governments Invest in the Innovation of 5G Technology: a Closer Look at the Australian 5G Innovation Initiative

Claire E. Fortin

Department of Political Science, McGill University

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Professor Debra Thompson

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Abstract

At the forefront of the digital revolution, 5G technology is transforming industries and infrastructure and generating benefits that extend well beyond the realm of telecommunications. However, the innovation and commercialization of 5G technology introduce risks. Therefore, it is interesting when governments choose to support the innovation of 5G technology in the private sector. This paper examines why, in light of the tensions with Huawei, the Australian Government has chosen to invest in the innovation of 5G technology through the Australian 5G Innovation Initiative. Guided by an original theoretical framework, the paper conducts a thematic analysis of how the Australian Government chose to describe, design, and execute the Australian 5G Innovation Initiative. The findings suggest that the Australian Government invested in the innovation of 5G technology through the Initiative to strengthen key sectors of the national economy, improve public infrastructure, and facilitate the provision of public goods. Proving an efficient means of analyzing the Government's motives, the theoretical framework can be applied to other studies of government intervention in technological innovation. However, the theoretical framework failed to account for the role of public infrastructure and intra-governmental collaboration in Australia's intervention behaviour, reflecting an important gap in the literature on which it is constructed.

Keywords: government intervention, technological innovation, 5G technology, Australian Government

À la pointe de la révolution numérique, la technologie 5G transforme les industries et infrastructure et génère des avantages qui vont bien au-delà du domaine des télécommunications. Cependant, l'innovation et la commercialisation de la technologie 5G présentent des risques. Par conséquent, il est intéressant lorsque les gouvernements choisissent de soutenir l'innovation de la technologie 5G dans le secteur privé. Cet article examine pourquoi, au vu des tensions avec Huawei, le gouvernement de l'Australie a choisi d'investir dans l'innovation de la technologie 5G par l'Australian 5G Innovation Initiative. Guidé par un cadre théorique original, l'article mène une analyse thématique de la façon dont le gouvernement australien a choisi de décrire, de concevoir et d'exécuter l'Australian 5G Innovation Initiative. Les résultats suggèrent que le gouvernement de l'Australie a investi dans l'innovation de la technologie 5G à travers l'Initiative pour renforcer les secteurs clés de l'économie nationale, améliorer les infrastructures publiques et faciliter la fourniture de biens publics. Prouver un moyen efficace d'analyser les motivations du gouvernement, le cadre théorique peut être appliqué à d'autres études sur l'intervention gouvernementale dans l'innovation technologique. Cependant, le cadre n'a pas expliqué le rôle de l'infrastructure publique et des collaborations intergouvernementales, reflétant une lacune importante dans la littérature sur lequel le cadre théorique est construit.

Mots clés: intervention gouvernementale, innovation technologique, technologie 5G, gouvernement australien.

5G – 5th generation – technology is the latest generation of connectivity and mobile networks. It is better, faster, and cheaper than previous generations, which focused on telecommunication services like messaging, calls and Internet. At the forefront of the digital revolution, 5G connectivity will transform the development of technologies and services in various industries and sectors, including agriculture, energy, healthcare, manufacturing, public safety, transport, and smart cities. Indeed, the potential benefits derived from 5G technology and infrastructure are staggering.

5G will have a revolutionary impact on quality of life, especially for rural communities and vulnerable peoples, because it "opens the door to life-saving technologies like remote operations, education, medicine and more" and improves the connectivity required to leverage these benefits (Ahmed et al., 2021, p.45). 5G technology is also more energy efficient, and "with IoT will reduce greenhouse gas emissions, reduce water and food waste, and enable more use of renewable energy" (p.7). Moreover, from an economic standpoint, "5G is expected to create $12.3 trillion in world economic output and provide 22 million occupations by 2035" (Sinan, 2022, p.47). However, 5G technology does not come without risk.

In addition to the security threats applicable to previous generations, 5G "will have a new set of security challenges due to the increased number of users, heterogeneity of connected devices, new network services, high user privacy concerns, new stakeholders and requirements to support IoT and mission critical applications" (Khan et al., 2020, p.197). The frequency and severity of cyber-attacks are expected to increase, and a serious national security concern is the risk that an external vendor operating within a country may be subject to 'extrajudicial directions,' where it is forced to share sensitive information with the intelligence agencies of a

foreign government (Dutta & Hammad, 2020; Jinsong & Yamin, 2020; Botton & Lee-Makiyama, 2018).

The responsibility of mitigating the security risks associated with 5G is shared among all stakeholders, including governments, businesses, and consumers (Batalla et al., 2020). Consequently, the more significant the role of the private sector in 5G, the more dependent a government is on the private sector's cooperation in mitigating security threats. The problem is that each stakeholder has its own objectives and risk assessments, including private firms (Batalla et al., 2020). For example, firms may be more concerned with the threat of business espionage than with national security. In some cases, firms and businesses may themselves become a threat to national security, as discussed above.

Surprisingly, rather than discouraging the role of the private sector and the innovation of 5G technology, several governments are doing the opposite; they are investing in the innovation of 5G technology, including within the private sector, even while recognizing the risks. This begs the question–why do governments invest in the innovation of 5G technology?

Drawing on the literature on government intervention in technological innovation, I develop a theoretical framework for investigating a country's motives for investing in the innovation of 5G technology. My research will focus on the case of Australia and, specifically, investigate the motives underlying the Australian 5G Innovation Initiative.

Theoretical Framework

Technological innovation, as understood in relevant academic literature, is a process that comprises not only the development, or 'invention,' of a technology but also the distribution and adoption of the innovation(s) (Salmenkaita & Salo, 2002; Gao, 2015; Greenacre et al., 2002;

Link, 2021; Chaminade & Esquist, 2010). Government intervention can take a variety of forms, such as research grants, tax policies, and international property right policies, which are applied with the purpose of facilitating technological innovation. There is an entire body of literature dedicated to government intervention in technological innovation (Greenacre et al., 2012). Over decades, this literature has evolved and expanded, becoming increasingly nuanced – conceptualizations of how the innovation process works, the actors involved, and the role of the government vary (Greenacre et al., 2002). Below, I introduce a simplified summary of some of the key theories in the literature.

Market Failure Approach

According to the market failure approach, the innovation process is linear and driven primarily by the private sector (Greenacre et al., 2002; Chaminade & Esquist, 2010; Bloom et al., 2019). Technological innovation begins with the research and development phase, followed by commercialization, and ends with the successful introduction and adoption of the technology to market (Salmenkaita & Salo, 2002; Gao, 2015; Greenacre et al., 2002; Link, 2021; Chaminade & Esquist, 2010). However, sometimes, the innovation process is derailed when market problems lead to technological market failure. In such situations, the government intervenes to correct these problems and prevent technological market failure – usually through the provision of R&D funding – to ensure the realization of public goods potentially generated by the technology. Government intervention is understood as "the mechanisms through which the government deliberately influences resource allocation decisions in order to facilitate technology development and commercialization" (Salmenkaita & Salo, 2002, p.184). The innovation policies and intervention mechanisms selected by the government are dictated by how the market is structured, and great emphasis is placed on R&D.

Systems of Innovation (SI) Approach

The systems of innovation (SI) approach perceives innovation as a complex process that takes place within a system that is comprised of a diverse set of organizations (e.g. firms, universities, NGOs) and institutions (Greenacre et al., 2002; Aubert, 2005; Chaminade & Esquist, 2010). What derails innovation are system failures, problems that undermine the efficiency of an innovation system (e.g. inadequate physical infrastructure) (Mazzucato, 2018; Greenacre et al., 2002; Chaminade & Esquist, 2010; Blind & Niebel, 2022; Chaminade & Esquist, 2010). The group of organizations and institutions in an innovation system varies with context, so there exist multiple innovation systems at any given time, each with its own characteristics. Born from the SI approach is the concept of a National System of Innovation (NSI), which is the set of actors that exists within a country (Greenacre et al., 2002; Marques et al., 2015; Jeon et al., 2022; Fu et al., 2011). Consequently, the SI approach argues that policy decisions and tools that a government selects should be contextualized and dictated by more than market structure – less emphasis is placed on R&D funding, and the goal of government intervention is to strengthen and build a stronger innovation system, not to correct market failure to secure public goods.

Mission-oriented Innovation System (MIS) Approach

Mission-oriented innovation policies (MIP)s are public policies that seek to address 'grand challenges' like climate change by facilitating technological innovations that offer potential solutions (Mazzucato, 2018; Bloom et al., 2019). Similar to the SI approach, MIS approach posits that the innovation process takes place within an innovation system comprised of different organizations and institutions. However, according to the MIS approach, successful innovations require not only the involvement of multiple organizations but also that of multiple

sectors (e.g. agriculture, health care, robotics) (Mazzucato, 2018). Unlike market failure driven-policies and SI-driven policies, MIPs are proactive – they help create and transform markets and systems, not just fix them (Mazzucato, 2018, p.807). While intervening in technological innovation to help solve big challenges may appear similar to the market failure approach's end goal of securing public goods, Mazzacuto (2018) argues that, in the context of MIPs, "The notion of public value becomes a more useful term than a public good, since missions may be transformative across the entire value chain and not be limited to negative areas where positive or negative externalities exist" (p.807).

Catching-up context

An important body of literature on government intervention in technological innovation is the study of how countries that were lagging behind in the innovation of a technology can 'catch-up' with the countries leading in that technology, both in terms of technological capability and global market influence (Gao, 2015; Lee, 2005; Lee & Lim, 2001; Li et al., 2019). Originally, the catching-up process was conceptualized as "a relative speed race in a race along a fixed track," wherein developing countries catch-up by "assimilating and adapting the more or less obsolete technology of the advanced countries" (Lee & Lim, 2001, p.461). However, in recent years, academics have proposed that catching-up by following the same steps assumed by the leading countries is not the only option available to countries looking to catch up, having observed three patterns of catching-up exhibited by countries over the years: (i) path-following, where the country follows the path (i.e. same steps) as the more advanced countries, (ii) path-skipping, where the country follows the same path but skips steps, and (iii) path-creating, where the country blazes a path to technological innovation different from those taken by the more advanced countries (Lee, 2005; Lee & Lim, 2001; Li et al., 2019)

The motive associated with the catching-up literature is that governments intervene in the innovation of a certain technology because the government wants to catch-up with one or more countries to have greater influence on the global market or because it wants to rely less on exogenous technology and vendors (Gao, 2015; Lee, 2005; Lee & Lim, 2001; Li et al., 2019).

There are no unique government intervention behaviours associated with the catching-up motive because the literature embraces fundamental elements of both the market failure and SI approach, and their associated intervention behaviours. For example, like the market failure approach, the catching-up literature views technological innovation as a linear process ending in commercialization and technological adoption, and emphasizes the role of markets and economic factors. However, like the SI approach, the catching-up literature emphasizes the role of systemic and institutional factors and embraces the concept of NSI, thus recognizing the importance of a diverse number of actors (academics, business, NGOs, government, etc.) Therefore, governments intervening in technological innovation to 'catch-up' may exhibit behaviours associated with either the SI approach and/or the market failure approach. However, what does distinguish this approach from the others is the emphasis on international positioning, which is often reflected in the discourse surrounding government intervention behaviours.

Three important takeaways from the literature on government intervention in technological innovation will inform the theoretical framework that will guide my research and analysis. First, the literature proposes three motives that can be used to explain why a government is investing in the innovation of a specific technology – to secure public or quasi-public goods, to address a grand challenge, to catch-up with more advanced countries. Second, these motives are associated with one or more approaches – the market failure approach, the MIS

approach, and the SI approach, respectively. Third, the market failure approach, the MIS approach, and the SI approach have distinct characteristics and behaviours associated with them (Figure 1).

Motives	Associated approach(es)	Key characteristics and themes
Provide public good or quasi public goods	• Market failure approach	• Provision of R&D • Targets the private sector • Encourages commercialization and adoption • Focus on the economy
Address a grand challenge	• MIS approach	• Targets variety of stakeholders • Part of a larger initiative • Encourages cooperation and collaboration • Touches multiple industries • Seeks solutions
Catch-up with other countries	• Market failure approach • SI approach	• Framing at international scale (esp. the country's status) • Targets variety of stakeholders • Encourages commercialization and adoption • Involves different levels of government • Encourages cooperation and collaboration among stakeholders • Innovation clusters

Consequently, I conclude that a government's intervention behaviour can signal, implicitly or explicitly, a government's motive(s) when intervening in the innovation of a technology. That is to say – if a government is intervening to secure public or quasi-public goods, its intervention behaviour should demonstrate themes and characteristics associated with the market failure approach. In contrast, a government intervening as part of a larger effort to address a grand challenge should demonstrate an intervention behaviour with themes and characteristics associated with the MIS approach. Finally, a government intervening as part of a larger effort to catch up with another country in the technological innovation of a technology will demonstrate an intervention behaviour with themes and characteristics associated with the NIS and market failure approach and framed within the context of international competitiveness. Therefore, by analyzing the characteristics of Australia's behaviour towards the Australian 5G

Innovation Initiative and then matching those characteristics to an intervention approach, I can gain insight into why Australia is investing in the innovation of 5G technology within the private sector.

Case study: The Australian 5G Innovation Initiative

Over the last three decades, "the Australian government has prepared a number of policy initiatives for seeking to diversify economic activities and improve the use of innovation as a tool to achieve global competitiveness" (Marques et al., 2015, p.2). Today, multiple governmental organizations play a role in executing and implementing the Australian innovation agenda; these organizations include, the Department of Industry, Innovation and Science (DIIS), the Australian Research Council (ARC), The Commonwealth Scientific and Industrial Research Organisation (CSIRO), The Chief Scientist for Australia, the Australian Taxation Office (ATO), Innovation Australia, and the Prime Minister's Science, Engineering and Innovation Council (PMSEIC).

The foundation of the government's innovation support strategy is the provision of incentive schemes. Regardless of the administrating organization, all innovation incentive programs and grants are "accessed through a single government portal named Business" and "are aimed at businesses of various sizes, in order to generate productivity, innovation, competitiveness, and create new jobs. These programmes also contain incentives for R&D, support for small businesses, tax and duty concessions, and assistance for industries in transition" (Marques et al., 2015, p.5). Rarely do these grants or programs target a specific technology, but the Australian 5G Innovation Initiative – my case study – proves to be one of the few exceptions.

The Australian 5G Innovation Initiative is a $40 million (AUD) funding program that provides competitive grants to Australian businesses and entities to support trials of new 5G technologies. It makes for a fascinating case study of government investment in the innovation of 5G technology within the private sector because the Australian government has been particularly vocal about the risks associated with 5G and demonstrated a willingness to implement extreme measures to minimize these risks.

In August 2018, following the conclusion of a government review of the national security risks associated with new 5G networks and the telecom industry, the Australian government published a joint media press release that outlined the review's key findings and new security guidelines for telecom carriers (Botton & Lee-Makiyama, 2018). The press release stated that "the Government wants to realise the benefits of 5G but acknowledges that this new technology introduces additional risk" (Fifield & Morrison, 2018, p.1). It also unveiled concerns that "the involvement of vendors who are likely to be subject to extrajudicial directions from a foreign government that conflict with Australian law, may risk failure by the carrier to adequately protect a 5G network from unauthorized access or interference" (p.3). To mitigate the risk, the government introduced new guidelines on procurement in the telecom industry, which effectively banned Chinese companies Huawei and ZTE (Botton & Lee-Makiyama, 2018).

The Australian government's ban on Huawei and ZTE is an important source of political tensions between China and Australia, and it has significant economic consequences (Botton & Lee-Makiyama, 2018). For example, a report by Oxford Economics (2019) forecasted that the delays in 5G rollout resulting from the ban on Huawei may reduce Australia's GDP in

2035 by billions of dollars (USD). Therefore, Australia has demonstrated an impressive commitment to the defence of 5G security within the country.

However, in 2020, the Australian Government announced the creation of the Australian 5G Innovation Initiative as part of the 2020-21 Budget's JobMaker's Digital Assistance Plan. The Initiative offers $40 million (AUD) in competitive grants to Australian businesses and entities to fund practical trials and testbeds of 5G technology. Administered by the Department of Industry, Science, Energy and Resources on behalf of the Department of Infrastructure, Transport, Regional Development and Communications, the Initiative runs over five years, from 2020-21 to 2024-25, and is divided into two grant opportunity rounds. The first round, which awarded $19.5 million in competitive grants, is currently funding 19 Successful Round One Projects across Australia. The second round, which offered $20 million in competitive grants, has closed, but the Successful Round Two Projects have yet to be announced.

By choosing to invest in the innovation of 5G technology within the private sector, the Australian government is acting counter to exceptions, making it an interesting case study. Why is Australia investing in the innovation of 5G technology within the private sector? Specifically, what are the motives behind the Australian government's implementation of the Australian 5G Innovation Initiative?

Moreover, the Australian 5G Innovation Initiative makes an excellent case study due to its compatibility with my theoretical framework. As previously discussed, government intervention can take various forms, including tax policies and other forms of legislation where it may be difficult to prove intentionality, both with regards to supporting technological innovation and towards supporting the innovation of 5G technology, specifically. Therefore, there is often an

inevitable level of ambiguity when trying to interpret intervention behaviour towards the innovation of specific technology. However, in the case of the Australian 5G Innovation Initiative, the intentionality and link to 5G technology are pre-established. Consequently, instead of first analyzing whether the behaviour under study is actually behaviour meant to intervene in the innovation of 5G technology, we can jump to studying the motives explaining the intervention.

Finally, the 5G Innovation Initiative makes an ideal case study due to its limited scope and the high quality and quantity of information available, allowing for a thick description. All sources of information are available in English, and everything published by the Australian government about the Initiative is subject to Australia's Freedom of Information Act. Most valuable of all is the access to the two competition guidelines, which are the documents instructing potential applicants on how to apply for the grant opportunity. The documents provide essential details about how the program, including eligibility criteria, the competition parameters, and other information about the Initiative that will prove essential to interpreting the underlying motives.

Methodology

As previously discussed, certain tools and intervention mechanisms are more closely associated with some motives over others. Therefore, certain behaviour can implicitly or explicitly signal a government's intent when intervening. In other words, how a government is intervening in the innovation of a certain technology can provide insight into why a government may want to intervene in the innovation of this technology. Consequently, by analyzing how the Australian government chose to design, describe and execute its Australian 5G Innovation

Initiative and then by framing these findings within the established theoretical framework, it is possible to identify Australia's motives for intervening in the innovation of 5G technology.

To identify themes in how the government describes and designs the Initiative, I conducted a thematic analysis of all publicly-available government documents that mention or discuss the Australian 5G Innovation Initiative. A "thematic analysis is a method for identifying, analysing and reporting patterns (themes) within data" (Braun & Clarke, 2006, p.79). Thematic analysis is a reliably versatile analytic method – it is theoretically flexible, can be inductive or deductive, can analyze semantic and latent content, and can analyze various types of qualitative data (Bruan & Clarke, 2006). For the purpose of this thesis, documents were defined as "content or objects which include written, graphical or pictorial matter, or a combination of these types of content, in order to transmit or store information of meaning" (Grant, 2019, p.11). The data set included relevant budget documents, departmental recommendations and strategies, the program website, press releases, ministerial statements, and the application guidelines for the funding opportunity. The documents were collected through a careful web search of Australian government websites and the submission of an access for information request.

The information request for "media releases, ministerial statements, and other government publications or content discussing or referencing the Australian 5G Innovation Initiative that are unavailable on the Department 's website" was submitted under Australia's Freedom Of Information Act. In response to the request, an Australian government official sent a complete list of documents comprising 21 sources. These sources include seven media releases (including ministerial statements,) two primary web pages, two grant opportunity guidelines, six

budget-related documents, an annual report, a discussion paper, and a consultation summary. My web search returned ten additional documents, bringing the total source documents to 31.

The data set was coded manually to identify themes associated with approaches to government intervention in the innovation of 5G technology. I searched for both semantic and latent themes. Semantic themes are those identified "within the explicit or surface meanings of the data" (Braun & Clarke, 2006, p.79). In contrast, latent themes are identified within "the underlying ideas, assumptions and conceptualizations – and ideologies – that are theorized as shaping or informing the semantic content of the data" (p.79). Using a top-down approach, my initial codes were inspired by characteristics associated with intervention approaches.

To identify themes in the government's execution of the Initiative, I conducted a second thematic analysis focusing on the Successful Round 1 Projects. First, I analyzed whom the government provided funding to by collecting data on the funding project recipients and their project partners, including entity type (i.e. academia, government, NGO, private sector), countries of origin, pre-existing relationships with Australian governments, and the sectors and industries they represent and services they provide. I then studied the distribution of these recipients and partners across the 19 successful projects. Second, I analyzed the locations of the successful projects, including whether the locations were classified as 'metro' or 'regional.' Third, I analyzed the content of the successful projects, including what sectors the projects fall under, the type of technology being developed, and the project purpose. My data set comprised information collected from the 'Successful Projects' webpage on the DITRDC website, relevant

news articles, content published by funding recipients and project partners, CB Insights,[1] and the Australian Business Registry.

Finally, I framed the research findings from both thematic analyses within the established theoretical framework to deduce the specific motives driving the Australian government's investment in the innovation of 5G technology through the Australian 5G Initiative. The analysis of government discourse and the design of the Initiative revealed strong parallels between government behaviour and the market failure approach, a handful of potential parallels with the catching-up context, and a strong deviation from the mission-oriented approach. The analysis of the government's execution of the Initiative largely mirrored the findings from the first analysis, differing only by revealing a potential link between the government's behaviour and the mission-oriented approach.

Ultimately, both analyses demonstrated that no single approach can be applied to explain Australia's behaviour. However, despite the inability of the theoretical framework to attach only one approach to Australia's behaviour, it nonetheless served its purpose by revealing a potential range of motives. Namely, the Australian Government invested in the innovation of 5G technology through the Initiative to strengthen key sectors of the national economy, improve public infrastructure, and facilitate the provision of public goods.

Analysis of Government Discourse and the Design of the Initiative

Central Role of the Private Sector

Three types of entities were eligible to apply as a lead organization under the Initiative: businesses, not-for-profits, and Local Governments or State/Territory Government agencies or

[1] CB Insights is a database and analytics platform that focuses on industry insights and offers information on market trends, investor activities, and tech company profiles.

bodies (Department of Infrastructure, Transport, Regional Development, Communications and the Arts [DITRDC], 2021b, p.7; DITRDC, 2021a, p.7).[2] Entities that were not eligible included publicly funded research organisations (PFRO), universities, and individuals. The Initiative accepted both individual and joint applications. Non-eligible entities were able to participate in joint applications; however, every joint application required "a lead organisation who is the main driver of the project and is eligible to apply" (DITRDC, 2021b, p.7; DITRDC, 2021a, p.7).

Despite not-for-profits and government agencies being eligible, businesses were the only entities directly encouraged to apply to the Initiative by the government. For example, in a media release, the Hon Paul Fletcher MP stated: "I encourage Australian businesses across all sectors to consider how 5G can benefit them and apply for funding through this Initiative" (Fletcher, 2021a). Meanwhile, the 'Australian 5G Innovation Initiative—round one—discussion paper,' the document circulated to introduce the Initiative and elicit feedback from stakeholders, states, "The Initiative seeks to encourage businesses to apply for funding… Applications including businesses that are not traditionally involved in telecommunications projects, and from small to medium enterprises, are encouraged" (DITRDC, 2020b, p.9). In the following sentence, the paper states that "eligible projects could also include those implemented by not-for-profit businesses where such use cases may result in productivity benefits, and meet the criteria of the Initiative" (DITRDC, 2020b, p.9). This weak encouragement is the only instance outside the competition guidelines that not-for-profits were directly acknowledged as eligible, while government eligibility is only mentioned in the guidelines.

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[2] To be eligible you must: have an Australian Business Number (ABN), be registered for the Goods and Services Tax (GST)...and be one of the following entities: an entity incorporated in Australia, a company limited by guarantee, an incorporated trustee on behalf of a trust, an incorporated not for profit organisation, a Local Government or State/Territory Government agency or body, where an application involves a partnership with at least one other eligible entity (DITRDC, 2021b, p.7; DITRDC, 2021a, p.7).

Many media releases and press documents framed the Initiative as being for businesses. A particularly striking example is a media release that announced, "Australian business can now apply for grant funding through the Australian 5G Innovation Initiative," without mentioning that other entities are eligible to apply (Fletcher, 2021a). The framing is also apparent in how the 'applicant' was positioned in relationship to the word business. For example, "Funding recipients will pilot ways of using 5G in their businesses that will help create the commercial incentive for other businesses to adopt 5G solutions and for carriers to accelerate their 5G rollouts" (Fletcher, 2020a).

Similar language patterns can be observed in the competition guidelines' explanations of the assessment criteria, reinforcing the view that the Initiative is tailored to businesses. For example, the fourth assessment criterion, 'Benefits of your project to your business,' in the Competition Guidelines - Round 1 (2021a), states that applicants must demonstrate "the contribution of your project towards business growth and/or productivity" (p.10). In the Competition Guidelines - Round 2 (2021b), the third assessment criterion, 'Benefits of your project,' states that applicants must describe "how the project will generate productivity gains for your business, such as new job opportunities, business growth or entry into new markets…[and] how you will share the benefits of the project with other businesses in Australia" (p.10). Both these criteria were clearly tailored toward businesses and made it difficult for non-businesses to meet these criteria.

Encouraging Collaboration

Government discourse and the Initiative's design facilitated collaboration within projects in two ways. First, the Initiative facilitated collaboration by accepting joint applications. Joint

applications were not explicitly encouraged by the government. However, the competition guidelines provided an incentive for joint applications by sharing that “Projects that receive grants closer to the maximum value are expected to demonstrate multiple 5G applications, 5G applications that are more complex, or involve multiple project partners (DITRDC, 2021b, p.6). The second way the government promoted collaboration was by creating “An online noticeboard to help businesses connect with other organisations interested in partnering to deliver projects” (Fletcher, 2021a). A media release stated, “Businesses can add project ideas and short descriptions to the noticeboard, or find potential 5G projects they want to partner with and start a discussion with the project owner” (Fletcher, 2021a). The notice board is another example of businesses positioned as the target applicants, with other types of stakeholders relegated to supporting roles.

Welcoming Stakeholder Input

The one area where businesses were not the focus of discourse surrounding the Initiative is the government’s invitation of stakeholder input. For both rounds of funding, the government ‘welcomed’ input on the design and scope of the competition, including how to "best encourage proposals from a range of sectors and businesses” (DITRDC, 2020c; DITRDC, 2021k; DITRDC, 2022b).

As part of the consultation process for the first round of funding, the Minister hosted ‘a 5G Innovation Initiative Forum’ to gain insight into the opportunities and barriers for the successful implementation of the Initiative and to “engage with peak bodies that represent sectors where 5G use cases have economic and productivity potential” (DITRDC, 2020b, p.16). The government also hosted two workshops –one with “peak bodies representing industry

sectors where there are potential applications of 5G" and one with "representatives from the telecommunications sector and network equipment manufacturers" (DITRDC, 2020a, p.4). Additionally, the Department published the 'Australian 5G Innovation Initiative–round one–discussion paper,' (2020b) which outlined the key elements of the Initiative and the proposed eligibility and assessment criteria. The DITRDC circulated the discussion paper among a range of peak bodies, businesses and government entities to raise awareness of the Initiative and solicit submissions with feedback on the competition's design and scope. Submissions were received from industry associations, the telecommunications industry, network equipment manufacturers, businesses, and individuals (DITRDC, 2020a, p.4)

The government published the feedback from the forum, workshops, and stakeholder submissions in the Australian 5G Innovation Initiative-Round One-Consultation Summary (2020a).[3] In the document, the government thanked stakeholders, stating how their feedback helped the government understand the needs of stakeholders and was considered it the development of the grant guidelines.

Australian Ecosystem

The word ecosystem is used seven times within the data set across four sources. The government claimed the Initiative would fund trials demonstrating 5G uses, "which will help build Australia's ecosystem" (Fletcher, 2020a; DITRDC, 2020c; DITRDC, 2020b, p.4; DITRDC,

[3] While the government enthusiastically welcomed stakeholder input for the second round of funding, no discussion paper or consultation summary is available. Nonetheless, the Round 2 Competition Guidelines state that the guidelines were created with input from stakeholders.

2021a, p.5; DITRDC, 2021b, p.5).[4] However, the government never elaborated on how these trials will help build the Australian ecosystem or which actors and institutions comprise the ecosystem. Therefore, while used several times within the data set, the term ecosystem acts more as a buzzword than an informative element of the Initiative.

Encouraging Commercialization

According to the discussion paper, "the focus of the Initiative is on supporting commercial applications" (DITRDC, 2020b, p.9 p.10). To be eligible, the project must: "conduct trials that undertake rigorous, commercial, and replicable testing of technologies that make use of 5G" (DITRDC, 2021b, p.8; DITRDC, 2021a, p.7). Moreover, much of the eligible spending centres on facilitating commercialization. For example, the only instance that R&D costs are eligible is "if 5G applications are pre-commercial and this expenditure can be directly linked to achieving commercial 5G applications during the life of the project" (DITRDC, 2021a, p.8; DITRDC, 2021b, p.8). Therefore, the emphasis on commercialization in the eligible expenses simultaneously highlights the lack of emphasis on R&D funding within the Initiative.[5]

Demonstrating Industrial Applications and Benefits

One of the most prominent themes within the dataset is the emphasis on demonstrating 5G industrial applications and their benefits. For example, an official program objective is "supporting various projects that demonstrate 5G's capability and benefits across a range of industry sectors and locations" (DITRDC, 2020a, p.5; DITRDC, 2021a, p.5; DITRDC, 2021b,

[4] The only time the word ecosystem is used in a context other than this is when the discussion paper states that "Although the deployment of large-scale mobile networks by telecommunications carriers will form an important part of the 5G ecosystem, the Government's policy objectives also seek to support smaller scale applications that may provide fertile ground for more novel applications of 5G technology" (DITRDC, 2020b, p.12).

[5] According to the competition guidelines, "significant investment in research and development into 5G applications" is not an eligible expenditure (DITRDC, 2021a, p.8; DITRDC, 2021b, p.8).

p.8; DITRDC, 2020g). The government targeted a wide variety of sectors and industries. The most cited by the government as examples of industries with potential commercial and industrial applications were agriculture, transport, manufacturing, mining, health, construction, and education/training.[6]

The emphasis on demonstrating 5G industrial applications and their benefits is reflected in the competition guidelines and assessment criteria. Under the first assessment criterion for the first round of funding, the applicant is instructed to demonstrate how their "project will demonstrate economic, productivity or other benefits derived from the applications of 5G" (DITRDC, 2021a, p.9). Meanwhile, the first assessment criterion of the second round of funding is 'Demonstrating the value of 5G' (DITRDC, 2021b, p.9). The importance of demonstrating 5G applications is also reflected in the amount of money awarded. The guideline states that "Projects that receive grants closer to the maximum value are expected to demonstrate multiple 5G applications, [and] 5G applications that are more complex" (DITRDC, 2021b, p.6). With one exception,[7] the target audiences of these demonstrations are businesses and industry (DITRDC, n.d.-r; DITRDC, 2020a, p.4; DITRDC, 2020b, p.6; Australian Government, 2020, p.17; DITRDC, 2021a, p.5; DITRDC, 2021b, p5; DITRDC, 2021h; DITRDC, 2020g; DITRDC, 2022a, p.255). This is particularly clear in the Initiative's objective of "demonstrating the value

[6] The breakdown of how often the sectors were discussed in the context of potential applications of 5G technology is as follows: agriculture (17), manufacturing (15), transport (11), construction (9), mining (5), health (5), education and training (5). *Only sectors discussed at least five times are included in this list.

[7] The Government's Response to the Inquiry into the Deployment, Adoption and Application of 5G in Australia' states, "[the trials being funded under the Initiative] will also showcase the benefits of the technology more widely to all Australians" and "The Australian 5G Innovation Initiative has been established by the Government to foster 5G Innovation and highlight the benefits of 5G to Australians and businesses in Australia" (Australian Government, 2020, P.17).

of 5G to businesses in Australia" (DITRDC, n.d.-r; DITRDC, 2020a, p.4; DITRDC, 2021a, p.5; DITRDC, 2021b, p.5).

The demonstration of benefits is leveraged as a means of increasing investment. For example, the consultation summary explains,"The Initiative will support investment in 5G trials by demonstrating the value of 5G to business" (DITRDC, 2020b, p.4). The intent of supporting private sector investment is also explicit in the Initiative's stated objectives– "supporting private sector investment in 5G trials"– and its intended outcomes – "encouraging the more rapid deployment of 5G in Australia, in turn supporting increased investment in telecommunications infrastructure and jobs" (DITRDC, n.d.-r; DITRDC, 2020a, 2020, p.3; DITRDC, 2021a, p.5; DITRDC, 2021b, p.5). Moreover, the discussion paper maintains that "the Initiative is aiming to grow investment opportunities in the sectors that benefit from 5G and realise the benefits of 5G as early as possible" (DITRDC, 2020b, p.4).

Commercial Incentive

A recurring theme within the data set is that the Initiative will create commercial incentives for businesses to adopt 5G solutions (Fletcher, 2022b; Fletcher, 2020a; Fletcher, 2021c; DITRDC, 2020b). Source documents expressed the idea with variations of the following phrase: "Funding recipients will pilot ways of using 5G in their businesses that will help create the commercial incentive for other businesses to adopt 5G solutions and for carriers to accelerate their 5G rollouts" (DITRDC, 2020b, p.4). The first variation involved creating commercial incentives versus demonstrating commercial incentives, and the second variation was whether the phrase discussed accelerating rollout.

Solutions

The goal of the Initiative is less to generate solutions so much as to demonstrate these solutions and encourage businesses to adopt 5G technology, which is reflected in the eligibility and assessment criteria. For example, an eligibility criterion for the project is that it must "identify solutions that demonstrate 5G's capabilities" (DITRDC, 2021a, p.7; DITRDC, 2021b, p.8). Moreover, the only time 'solutions' appears in the competition guidelines is in the third assessment criterion for the second round of funding, 'Benefits of your project,' which states that applicants must demonstrate "the larger scale benefits of your project, such as…wider-scale adoption of the solutions trialled in your project" (DITRDC, 2021b, p.10). The emphasis on encouraging the adoption of solutions is also reinforced by the repeated assertion that the trials funded by the Initiative will demonstrate or create commercial incentives for businesses to adopt 5G solutions.

While the discussion paper explains that the "Initiative will support a mixture of smaller and larger scale projects " (DITRDC, 2020b, p.5), the government never explained which type of solutions it seeks. However, the examples of 5G technology solutions used by the government strongly indicate that the Initiative is targeting industrial solutions. For example, the government discussed "smart manufacturing solutions," "fright and logistics management solutions," and "solutions in areas such as production and processing" (Fletcher, 2022b; DITRDC, 2020b, p.5; DITRDC, 2022c). This conclusion is supported by the government's assertion that the development of 5G solutions will have an economic and commercial effect (DITRDC, 2022c). Moreover, it is businesses and industries that are often positioned as both the beneficiaries and facilitators of new 5G solutions. For example, the discussion paper states, "The Initiative aims to support businesses to try new and innovative technology solutions…and offers businesses the

opportunity to identify problems and technological solutions that take advantage of 5G's capabilities" (DITRDC, 2020b, p.4).

Benefits

The thematic analysis identified three types of benefits embedded in government discourse and the design of the Initiative: employment, productivity, and economy. The role of productivity, job creation, and economic benefits is expected given that the Initiative is part of the government's economic recovery plan as well as other economic programs such as the Digital Job Maker's Business Plan (Morrison & Frydenberg, 2020; Fletcher & Coulton, 2020; Fletcher, 2021b; DITRDC, 2021j).

Job creation is one of the benefits discussed by the government in relation to the Initiative. The third assessment criterion of the second round of funding, 'Benefits of your project,' establishes that the government categorizes job creation as a benefit. The description of the criterion states applicants must demonstrate "how the project will generate productivity gains for your business, such as new job opportunities… and the larger scale benefits of your project, such as… job opportunities beyond the life of the project" (DITRDC, 2021b, p.10). Moreover, job creation is one of the performance measures listed in the appendix of the Competition Guidelines - Round 2 (DITRDC, 2021b, p.23). Emphasis on job creation is also reflected in the intended program outcomes: "Boosting productivity and creating jobs with 5G technology" and "encouraging the more rapid deployment of 5G in Australia, in turn supporting increased investment in telecommunications infrastructure and jobs" (DITRDC, 2020a, p.4, p.6; DITRDC, 2021a, p.5; DITRDC, 2021b, p.5). Moreover, in the coded data set, the government regularly cites the ability of 5G to create jobs (DITRDC, 2020c; DITRDC, n.d.-r; Morrison & Frydenberg,

2020; Fletcher, 2022b; Fletcher & Coulton, 2020; Fletcher, 2021a; Fletcher, 2021b; Fletcher, 2021c; DITRDC, 2020a, p.4, p.6; DITRDC, 2021a, p.5; DITRDC, 2021b, p.5.).

References to productivity and 'productivity benefits' were also prevalent throughout the dataset. The Reserve Bank of Australia defines productivity as "how much output can be produced with a given set of inputs. Productivity increases when more output is produced with the same amount of inputs or when the same amount of output is produced with less inputs" (Reserve Bank of Australia, p.1). The phrase 'productivity benefits' accounts for 19 out of the 61 times the word benefit appears in the data set (DITRDC, n.d.-r; Fletcher, 2022b; Fletcher, 2021a; DITRDC, 2020a; DITRDC, 2020b; DITRDC, 2021a; DITRDC, 2021b). Emphasis on productivity is also reflected in two of the intended program outcomes: "boosting productivity and creating jobs with 5G technology" and "bringing forward the potential economic and productivity benefits to the Australian economy;" three of the intended outcomes of the grant opportunity: "supporting the testing of 5G applications that bring productivity benefits to businesses and organizations in Australia" and "demonstrating productivity benefits as widely as possible" (DITRDC, n.d.-r; DITRDC, 2020a, p.4; DITRDC, 2021a, p.5; DITRDC, 2021b, p.5).

The importance of productivity benefits is also reflected in the assessment and evaluation criteria. For example, the first criterion for the second round of funding, 'Project alignment with program objectives and outcomes for the use of 5G' requires applicants to demonstrate how their "project demonstrates economic, productivity or other benefits derived from the application of 5G" (DITRDC, 2021a, p.9).

References to economic benefits (DITRDC, n.d.-r; Fletcher, 2020a; Fletcher, 2021a; Fletcher, 2021b; DITRDC, 2020b, p.8, p.11; DITRDC, 2022c; DITRDC, 2020f, p.222) often

arise alongside productivity. For example, one of the intended program outcomes is "Bringing forward the potential economic and productivity benefits of 5G to the Australian economy by demonstrating 5G applications" (DITRDC, n.d.-r; DITRDC, 2020a, p.4; DITRDC, 2021a, p.5; DITRDC, 2021b, p.5). Several media releases and internal government documents highlight 5G and the Initiative's expected contribution to economic and industry growth (DITRDC, n.d.-r; Morrison & Frydenberg, 2020; DITRDC, 2022c; DITRDC, 2021g, p.139; DITRDC, 2020f, p.222; DITRDC, 2022a, p.25). The media releases, in particular, discuss how 5G will have a long-term economic impact and effect (Fletcher, 2022b; Fletcher & Coulton, 2020; Fletcher, 2020a; DITRDC, 2020b, p.6). As with job creation and productivity benefits, the role of economic benefits is represented in the assessment and evaluation criteria. For example, the first criterion for the second round of funding, 'Project alignment with program objectives and outcomes for the use of 5G' requires applicants to demonstrate how their "project demonstrates economic, productivity or other benefits derived from the application of 5G" (DITRDC, 2021a, p.9).

The positive impact of the Initiative on GDP arose four times in the data set. The government cited the following two statistics. First, the rollout of 5G will add $1,300 to $2,000 in GDP per person after the first decade (Fletcher, 2022b; Fletcher, 2020a; DITRDC, 2020b). Second, the digital infrastructure package, under which the Initiative is funded, is "estimated to increase [GDP] $6.4 billion a year by 2024" (Morrison & Frydenberg, 2020). Notably, both statistics attribute the increase of GDP to larger programs and initiatives rather than the Initiative itself.

A Leading Digital Economy and Society

In the coded documents, the government thrice makes reference to making Australia "a leading digital economy and society by 2023" (Morrison & Frydenberg, 2020; DITRDC, 2021k; DITRDC, 2021j). Twice the government asserts that the "Initiative directly supports the Government's Digital Economy Strategy and will contribute to Australia's goal of becoming a leading digital economy and society by 2030" (DITRDC, 2021k; DITRDC, 2021j). The third reference to making Australia a leading digital economy and society is in a media release on Australia's Digital Business Plan. It explains that "The Digital Business Plan is part of the Government's economic recovery plan to grow the economy and create jobs and supports our goal for Australia to be a leading digital economy and society by 2030," with the Initiative listed as one of the Plan's components (Morrison & Frydenberg, 2020). In none of the cases did the government specify what it means by a leading digital economy and society, nor how 5G will contribute to this.

Improving Economic Competitiveness

The only references to Australia's competitiveness are found in two ministerial budget statements, which both assert that "[5G] technology can support novel industrial applications that can improve innovation, productivity, and Australia's international competitiveness (DITRDC, 2021g, p.138; DITRDC, 2020f p.221). One of the statements specifies that the Initiative "will focus on developing 5G applications in sectors where Australia has a competitive advantage, or where the productivity benefits are likely to be significant can help sectors where Australia already has a competitive advantage" (DITRDC, 2021g, p.138). The telecommunications industry or 5G rollout is never discussed in the context of international leadership and competitiveness.

Within the dataset, Australia never compares itself to other countries. The sole instance other countries are mentioned is in the discussion paper where the government explained that "Other countries have already made significant investments in supporting the growth of 5G use cases across a range of sectors" (DITRDC, 2020b, p.7). Specifically, it cited the examples of the UK 5G Trials and Testbeds programme and Singapore's 5G Grant program.

The Role of the Telecommunications Industry

The most obvious way that the telecommunications industry arises in the data set and relates to the Initiative is that it is represented in one of the official intended program outcomes: "encouraging the more rapid deployment of 5G in Australia, in turn supporting increased investment in telecommunications and infrastructure and jobs" (DITRDC, 2020a, p.4; DITRDC, n.d.-r; DITRDC, 2021a, p.5; DITRDC, 2021b, p.5).[8] Moreover, in source documents, especially media releases about larger government strategies, the Initiative falls under headings or subheadings relating to telecommunications or 5G rollout. Alternatively, it is grouped together with other initiatives dedicated to 5G networks (Morrison & Frydenberg, 2020; DITRDC, 2020g; Fletcher & Coulton, 2020) or telecommunications more broadly (DITRDC, 2021c, p.8). The Initiative's relationship to the telecommunication industry is also reflected in departmental budget documents, where the Initiative is listed under budgeted expenses for Outcome 5 under Program 5.1 (DITRDC, 2021d, p.44; DITRDC, 2021f, p.73; DITRDC, 2021e, p.55; DITRDC, 2020e, p.70). Finally, the Initiative is discussed in the 'Government Response to the Inquiry into

[8] Outcome 5: Promote an innovative and competitive communications sector, through policy development, advice and program delivery, so all Australians can realize the full potential of digital technologies and communication services; Program 5.1: Digital Technologies and Communications Services)

the Deployment, Adoption and Application of 5G in Australia' as a means of raising awareness about the benefits and applications of 5G technology (Australian Government, 2020).

However, the telecommunications industry is largely absent from the discourse on desired applicants and projects of the Initiative. Telecommunications is never used in examples of the commercial and industrial benefits and applications of 5G that the Initiative aims to support. The only instance the telecommunications industry is discussed in the context of desired applicants is when the discussion paper states, "Applications including businesses that are not traditionally involved in telecommunications projects, and from small to medium enterprises, are encouraged…Although the deployment of large-scale mobile networks by telecommunications carriers will form an important part of the 5G ecosystem, the Government's policy objectives also seek to support smaller scale applications that may provide fertile ground for more novel applications of 5G technology" (DITRDC, 2020b, p.12). Therefore, while the Initiative is clearly positioned within government policy and discourse on 5G rollout and the telecommunications industry, it is focused on industries and sectors not traditionally associated with 5G technology.

Location

The government explicitly expressed its wish to "encourage applications from across different locations or geographic regions," stating, "It will be important to demonstrate 5G's ability to be used in different regions as well as different industries" (DITRDC, 2020b, p.7). Indeed, one of the official program objectives is "supporting various projects that demonstrate 5G's capability and benefits across a range of industry sectors and locations" (DITRDC, 2021a, p.5; DITRDC, 2021b, p.5). The sentiment is similarly reflected in one of the official intended outcomes of the program, which is "showcasing 5G applications across different industries and

locations, and demonstrating the productivity benefits as widely as possible" (DITRDC, 2021a, p.5; DITRDC, 2021b, p.5). Furthermore, the government makes a point of highlighting that "The 19 projects are located across Australia, in five different states in a mix of metro and regional areas" and provides a geospatial detailing the location(s) of each project (DITRDC, n.d.-b). The role of rural areas is also highlighted in a ministerial budget statement stating, "The outcomes of the Initiative's first round of grants were announced in August 2021, with 19 successful projects receiving grant funding in 2021–22 throughout Australia, including in regional areas" (DITRDC, 2022a, p.255), and that the "Projects [for the second round] are expected to include those in the agriculture, transport, manufacturing and logistics sectors, where applications of 5G have the potential to support economic development and productivity in regional Australia" (DITRDC, 2021g, p.139; DITRDC, 2020f, p.222; DITRDC, 2022a, p.255).

The Western Parkland City Deal

Interestingly, while there is an emphasis on diverse geographic areas, with the second round of funding comes an obvious focus on location: the Western Parklands. In the second round of funding, $2 million is reserved for projects in the Western Parkland City District as part of support for the Western Sydney City Deal (Fletcher, 2021c; DITRDC, 2021b, p.6; DITRDC, 2022b; DITRDC, 2022c; DITRDC, 2021j). Signed in 2018, the Western Sydney City Deal (City Deal) is an agreement between the Australian, NSW, and the eight local governments comprising the Western Parkland City councils. Under this agreement, which delivers on the Australian

Government's Smart Cities Plan,[9] the three tiers of government have committed to jointly invest over $11 billion to support city-building initiatives working together to deliver the 38 City Deal commitments and create quality outcomes for the Western Parkland City community" (Western Parkland City Authority, n.d.). The six categories of commitments are connectivity, jobs for the future, skills and education, livability and environment, planning and housing, and implementation and governance (Australian Government, 2018, p.8-9). Under the connectivity commitment, "The NSW and local government will develop a 5G strategy for the Western Parkland City, which will include partnering with a telecommunications carrier to deliver a trial of 5G technology" (Australian government, 2018, p.11). However, the creation of a 5G strategy is only a small part of the City Deal, and the City Deal surpasses the Initiative in scope, resources, and time.

Analysis of the Government's Execution of the Initiative

Analysis of Project Recipients[10]

[9] The Australian Government's Joint Committee of Public Accounts and Audit (2007) defines smart cities as "those which leverage innovative technologies to 'enhance [the] quality and performance of urban services, to reduce costs and resource consumption, and to engage more effectively and actively with its citizens" and explains that "The Australian Government recognises the potential of technological innovation to make our cities more liveable, prosperous and sustainable and outlines a 'smart cities agenda' in its *Smart Cities Plan*. In the plan it commits to 'embrac[ing] new technology with the potential to revolutionise how cities are planned, function, and how our economy grows.'"

[10] See Annex 1 for a full list project recipients and project partners (59 in total). Organized by project, the table includes data on name, entity type (i.e. government, private, not-for-profit, university), and country of origin. Citations included.

Almost two-thirds of the successful projects involve at least one project partner.[11] All projects feature at least one private sector entity, six projects feature at least one university,[12] three projects feature at least one government body,[13] and two feature a not-for-profit.[14] While the private sector represents the majority of project leads and project partners, the involvement of non-private sector entities–especially universities–is greater than anticipated. However, they mainly assume the role of project partner, with only three successful projects featuring leads that are not private sector entities.[15] Notably, all levels of government– municipal, state and national– are involved in the Initiative as either a project lead or project partner. Moreover, the NSW Government has important connections to two private sector entities: Endeavour Energy[16] and Transdev Ferries.[17]

The telecommunication industry is strongly represented in project recipients and project partners. All three operators that have been issued 5G spectrum-based licenses in Australia –

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[11] In brackets is the number of project partners (not including the primary recipient) for that project. Project 1 (6), Project 2 (2), Project 3 (1), Project 4 (2), Project 6 (3), Project 7 (1), Project 8 (3), Project 10 (1), Project 11 (5), Project 12 (3), Project 15 (9), Project 17 (3), Project 18(1).

[12] Project 4, Swinburne University of Technology; Project 7, La Trobe University; Project 8, Deakin University and La Trobe University; Project 10, University of Technology Sydney; Project 11, University of Adelaide; Project 17, University of Technology Sydney.

[13] Project 4, Brimbank City Council (Municipal government); Project 11, South Australian Government (State government) and Department for Infrastructure and Transport (State government); Project 15, Geoscience Australia, (Federal government agency)

[14] Project 6, Gidarjil Development Corporation (GDC); Project 15, Spatial Information Systems Research (FrontierSI).

[15] Project 4, Brimbank City Council (Municipal government in the Greater Melbourne region); Project 6, GDC (Indigenous owned nonprofit); Project 15, Frontier SI, (Not-for-profit specializing in R&D space and spatial technology).

[16] Endeavour Energy, an electricity company and one of the project partners in Project 11, was originally state-owned and operated. However, the NSW Government leased 50.4 percent to a private consortium, retaining the remaining 49.6 percent and regulatory oversight (NSW Government Treasury, n.d.; Endeavour Energy, n.d.).

[17] Transdev ferries, the lead organization of Project 18, operates the ferry services in Sydney under a franchise agreement with the NSW government. In addition to ferry services, Transdev Sydney Ferries operates light rail and bus services across Sydney in partnership with Transport for NSW (Transdev, n.d.).

Telstra, Optus, and TPG Telecom – are involved in one or more successful projects (Saunders, 2023, p.12). Optus is involved in three projects, TPG Telecom is involved in one, and while Telstra was not officially awarded funding or a project collaborator, Telstra Purple, a subsidiary of Telstra, has acquired Aquara Technologies, the lead of Project 2 (CB Insights, n.d.).[18]

Regarding non-Australian stakeholders, Australia has "key partnerships with Nokia, Ericsson, and Amazon for 5G Infrastructure" (Saunders, 2023, p.11). All three companies are represented in the first round of projects.[19] Notably, Nokia is the only funding recipient to receive funding twice. Ericsson and Nokia's involvement in the Initiative are interesting, given that the companies dominate the international 5G telecommunications market alongside Huawei, ZTE, and Samsung (Ahmed et al., 2021). Surprisingly, none of the successful projects, including those involving actors in the telecommunication sector, focus on telecommunications technology, infrastructure, or services.

Analysis of Project Locations

The successful projects are located across Australia, with some projects taking place in more than one location. The DITRDC information page for each project details the project's location(s): city, state or territory, whether the location is metro or regional,[20] and the percentage

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[18] Optus: Project 4 (Collaborator), Project 12 (Lead), Project 15 (Collaborator); TPG Telecom: Project 17 (Lead); Aquara Technologies: Project 2 (Lead)

[19] Ericsson: Project 15 (Collaborator); Amazon: Project 12 (Collaborator), Project 17 (Collaborator); Nokia: Project 10 (Lead), Project 11 (Lead), Project 17 (Collaborator).

[20] The Regional Australian Institute (RAI) defines 'regional Australia' as "everything beyond the major capital cities of Sydney, Melbourne, Brisbane, Perth, Adelaide and Canberra – from remote Aboriginal and Torres Strait Islander communities, to inland and coastal towns and bustling regional hubs" (Institute). This definition was adopted by the Parliament of Australia, who specifies it as "all the towns, cities, and areas outside Australia's largest capital cities; Sydney, Melbourne, Brisbane, Adelaide, Perth and Canberra" (Parliament of Australia, 2018).

of the project that will take place there. Of the nineteen projects awarded, thirteen are located in metro areas, three are in regional areas, and three are in a mix of metro and rural areas.

In terms of sub-national jurisdictional distribution, the successful projects are spread out across five states: New South Wales (NSW), Queensland (QLD), South Australia (SA), Victoria (VIC), and Western Australia (WA). Western Australia and South Australia are the least represented of these states, with only one project each. NSW is the most represented, with six projects located solely within the state. VIC and QLD each have three projects located solely within the state. Meanwhile, five of the projects involve more than one state. No projects explicitly link to the Western Parklands Project.

Analysis of Project Topics[21]

Key Economic Sectors

The Australian government organizes the successful projects into the following categories: Agriculture, Mining, Manufacturing, Utilities, Transport, Indigenous Environmental Management, Education and Training, Construction, Infrastructure, Logistics, and Emergency Services.[22] These categories overlap with the industries identified as garnering the most attention in government discourse[23] and mirror the composition of Australia's economy. According to the Reserve Bank of Australia (2023)'s *Composition of the Australian Economy Snapshot*, Mining (14.6%) makes up the largest industry share of output in key sectors, followed by Health &

[21] See Appendix 3

[22] The amount of projects classified in these categories: Agriculture (2), Mining (1), Manufacturing (2), Utilities (3), Transport (3), Indigenous Environmental Management (1), Education and Training (1), Construction (1), Infrastructure (1), Logistics (2), and Emergency Services (2)

[23] Top sectors identified in Analysis I: agriculture, manufacturing, transport, construction, mining, health, and education and training.

Education (13.0%), Finance (7.6%), Construction (7.3%), and Manufacturing (5.8%). These sectors are also represented in Australia's key exports: gold, minerals, and petrol (58%), services (19.4%), manufacturing (11%), agriculture, forestry and fisheries (9.8%), and other goods (2.6%) (Department of Foreign Affairs and Trade [DFAT], 2021, p.20). In addition to its contribution to industry share output and Australian exports, mining is essential to Australia's economic competitiveness, as Australia is the fourth largest mining country in the world (International Trade Administration, 2022). Interestingly, Australia's 4th largest commodity import in 2019-2020 was 'telecom equipment & parts' (DFAT, 2021, p.40).

Indigenous Rights and Empowerment

Of the 19 successful projects, Project 6 proves an interesting outlier because it is the only project that focuses on using 5G technology to realize social benefits. Project 6, 'Exploring Land & Sea Country Using 5G-enabled Drones and HD Video,' is led by Gidarjil Development Corporation (GDC). GDC is "an indigenous owned enterprise, based in Bundaberg, Queensland. The Corporation was established in 2000 by representatives of the Gurang and Gooreng Gooreng peoples to give leadership and momentum to the economic, social and cultural development of indigenous people" (Lewis, 2021). A press release published by one of the project partners explains, "The key objective of the grant funding was to enable Gidarjil to reconnect community Elders, who are unable to travel, with areas of cultural significance across traditional land and sea country" (Lewis, 2022). While Indigenous Rights and empowerment is recognized as an important issue on an international level, the project does not seem to fall under a larger effort by the Australian Government to further Indigenous Rights.

Indeed, in 2007, Australia infamously voted against the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). Despite endorsing UNDRIP in 2009, Australia continues to be criticized for failing "to recognise and implement its standards and protections domestically in a formal and comprehensive, as opposed to piecemeal, manner" (Senate Legal and Constitutional Affairs References Committee, 2022, p.6). Therefore, the actions of the government have not demonstrated a historical trend or inclination toward tackling Indigenous Rights and empowerment.

Public Infrastructure

Almost a third of the funded projects involve public infrastructure despite the government listing only one project under the 'Infrastructure' category. For the purposes of this thesis, public infrastructure is understood as:

> an investment where the government has the primary role in, and responsibility for, deciding on whether and how the infrastructure is provided in the interests of the broader community and on the source of the revenue streams to pay for the infrastructure over its life. Thus, public infrastructure extends beyond infrastructure that is owned or directly funded by the public sector. For example, this definition would capture infrastructure assets and services owned and operated by the private sector, but where the government has created the overarching policy and regulatory framework, or possibly retains a contingent liability for the infrastructure assets and continued service provision" (Heath & Read, 2014, p.98)

Of the nineteen funded projects in Round 1, six projects are using 5G technology to improve, maintain or support public infrastructure – specifically, economic infrastructure.[24] Four

[24] "Economic infrastructure (such as utilities, transport and communications networks) provides essential services to individuals, households and businesses, and influences the efficiency of an economy," while "Social infrastructure (such as education, health and community facilities) provides important services for the day-to-day activities of individuals and supports economic and social objectives" (Heath et al., 2014, p.98).

projects involve transportation infrastructure,[25] and three involve public utilities infrastructure.[26] The type of economic infrastructure notably missing is communications infrastructure. Despite involving multiple companies that are key actors in the telecommunication and 5G infrastructure sector in Australia,[27] no project focuses on 5G rollout or 5G infrastructure.

Public Goods and Quasi-Public Goods

Public goods are commodities that are non-excludable and non-rival. In other words, people cannot be excluded from the benefits or access to that good and the consumption of this good and its benefits does not impact or limit the ability of others to enjoy or consume this public good. In reality, it is rare to find examples of pure public goods. Instead, we often see quasi-public goods, commodities that exhibit only one of the characteristics of a public good. Out of the 19 successful projects, three facilitate the provision of a public good, and one facilitates the provision of a quasi-public good.

Public Goods. Project 14 and Project 16 both use 5G technology to improve public safety, an example of a non-tangible public good (Spiegel, 2008). Project 14, "5G Remote controlled Firefighting Tank," is led by Rheinmetall Defence Australia and seeks to develop firefighting tanks that can be controlled remotely using 5G technology (Nine, 2021; DITRDC, n.d.-o). Australia is prone to bushfires, making firefighting technology important to public safety. Indeed, the Initiative was launched in the wake of the Black Summer, when bushfires

[25] Project 4 is using 5G to improve city maintenance of roads; Project 7 is using 5G to improve the accessibility of public transportation for elderly and disabled folks; Project 18 is using 5G to improve the operation of ferry services in Sydney; and Project 11 is using 5G to improve rail safety and increase airport situational awareness.

[26] Project 11 is using 5G technology to improve electrical grid safety and maintenance; Project 12 is using 5G technology to improve the maintenance and reliability of Endeavour Energy's infrastructure grid; and Project 19 is using 5G technology to improve the quality and productivity of inspections of water pipes.

[27] Optus, Nokia, TPG, Ericsson, and AWS.

raged across the country. The fires caused devastating and, in some cases, irreparable damage to individuals, property, wildlife, and the ozone layer (Humphries, 2022; Clarke et al., 2022; Haque et al., 2021). Therefore, firefighting technologies serve a clear public good, limiting the damage and consequences of fires for not only Australians, but the planet itself.

Another project contributing to public safety is Project 16, "5G-enabled UAV for lifesaving pathology supply and coastal monitoring." The project, led by SwoopAero, aims to trial and deploy 5G technology that helps with coastal search and rescue operations and which can help transport medical supplies and equipment like vaccines to hospitals and medical centres (Saunders, 2023; DITRDC, n.d.-q). Coastal monitoring facilitates public safety because "To keep coastal communities, economies, and ecosystems healthy requires keeping track of ocean and coastal areas" (National Ocean Service, n.d.). For example, coastal monitoring can help track rising sea levels, improve responses to oil spills, and protect public health by monitoring water quality, which are services that benefit not only all Australians, but the Earth (National Ocean Service, n.d.).[28]

Another project that facilitates the provision of a public good is Project 19, "Improving wastewater pipe inspections using Artificial Intelligence and 5G." The project, led by VAPAR Innovation, seeks to improve water pipe inspections, which are currently done manually (Martin, 2022). The "technology will help make condition assessment faster and cheaper, benefiting public infrastructure and the cost of water for all Australians" (DITRDC, n.d.-u). While the water it transports may be rival and excludable, the quality and safety of the infrastructure itself represent a public good.

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[28] Whether vaccines, under the right circumstances, can be considered a public good remains a contentious debate (Peacock, 2022).

Quasi-Public Goods. Quasi-public goods are commodities that exhibit one of the characteristics of a public good – it is non-rival or non-excludable. Public infrastructure "often demonstrates assets and services that exhibit public good and/or monopoly characteristics" (Heath et al., 2014, p.98). Therefore, it is not uncommon for public infrastructure to be characterized as a quasi-public good. A popular example of infrastructure as a quasi-public good is roads (Li-Kim-Mui, 2013). Assuming the absence of tolls, roads are accessible to everyone (non-excludable); however, roads are not always non-rival because, in instances of road congestion, there is not enough room on the road for every vehicle (Li-Kim-Mui, 2013).

Therefore, Project 4, "Mobile 5G IoT Solutions for Data Driven Road Asset Maintenance in Brimbank," is a project involving a quasi-public good. Led by the Brimbank City Council, the project aims to improve the city's capacity to fix and maintain roads, helping to reduce congestion and reduce costs (Martin, 2022; DITRDC, n.d.-e). By trying to create roads at peak efficiency (i.e. eliminating congestion), the project seeks to impose public good characteristics onto the quasi-public good.

Discussion

Market Failure Approach

The government's discourse and the design of the Initiative strongly align with the market failure approach. The first parallel is the central role played by the private sector. Businesses were explicitly encouraged to apply, while non-private sector actors were rarely addressed as potential applicants. Moreover, the eligibility criteria were restrictive, and the assessment criteria were tailored towards businesses, using language that would make it difficult for non-businesses to qualify. The centrality of the private sector is further visible in the 5G

benefits and applications highlighted by the government and within the design of the Initiative. Businesses were framed as the primary beneficiaries of the Initiative, with all benefits being economic, and the government exclusively used industrial and commercial 5G applications as examples when discussing the type of 5G technology the Initiative aims to support.

Another significant parallel between the government's behaviour and the market failure approach is the government's use of the Initiative to encourage the commercialization and widespread adoption of 5G technology by the private sector. Doing so indicates that the government is aiming to intervene in the later stages of technological innovation, accounting for the lack of R&D funding within the Initiative. Government manipulation of the market is also reflected by discourse on the commercial incentive and private sector investment.

The analysis of the successful projects reveals a strong correlation between the government's execution of the Initiative and the market failure approach. First, the majority of project recipients and project partners are private sector entities, although the representation of non-private sector entities is stronger than expected. Second, many of the successful projects focus on industries like mining, which are closely tied to Australia's economy, and aim to generate benefits within the sector, including for businesses.

The most striking parallel between the government's execution of the Initiative and the market failure approach is the role of public and quasi-public goods. Of the nineteen successful projects, three facilitate the provision of public goods, and one facilitates the provision of a quasi-public good. While this represents a minority of the total projects, the rarity of pure public goods makes the finding particularly compelling.

Mission-Oriented Innovation System (MIS) Approach

The government discourse and design of the Initiative deviate from the expectations associated with the MIS approach in significant ways. The most important deviation is that there is no evidence that the government was using the Initiative to address a grand challenge. While there was some discussion around 'finding solutions,' these discussions were vague, and the solutions were framed as having industrial applications or benefiting businesses. Similarly, the benefits the government outlined were economic benefits, despite the potential to frame these benefits as contributing to a greater good.

Another significant deviation from the MIS approach is the minimal emphasis on cross-stakeholder collaboration and cooperation. Non-private sector entities were notably absent from discussions on who is encouraged to apply and who will benefit from the Initiative, despite the eligibility of sub-national governments and NGOs. Non-private sector entities were largely delegated to supporting roles, and the only instance they played a prominent role was in the government's solicitation of input from all stakeholders on the design of the Initiative. The one parallel between the behaviour associated with the MIS approach and that demonstrated by the government is the Initiative's emphasis on attracting and benefiting a wide range of industries and sectors.

The analysis of the successful projects demonstrates a stronger correlation to the MIS approach than that uncovered by the thematic analysis of government discourse and the design of the Initiative. First, collaboration and the role of non-private sector entities were more significant than expected, with multiple projects involving partnerships, including those comprised of diverse types of entities. Second, the successful projects reflect a range of industries; however, this range is present primarily across projects rather than within projects. Third, only one out of

the nineteen projects can be interpreted as addressing a grand challenge. The Gidarjil Development Corporation (GDC) project does contribute to Indigenous empowerment and rights, yet there is no apparent link to an overarching Australian effort to improve Indigenous rights.

The Catching-Up Context

The thematic analysis uncovered two themes relating to international leadership and competitiveness: Australia's goal of becoming a leading digital economy and the Initiative's targeting of sectors where Australia already has a competitive advantage. The telecommunication industry was notably absent from all discussions of international competitiveness and leadership despite the political and economic incentive for Australia to catch-up in the telecommunications sector, given tensions with Huawei. The telecommunications industry and 5G rollout played a minor role in the Initiative's design and discourse, acting as an umbrella category of government priorities under which the Initiative falls or as an indirect beneficiary of the Initiative. Instead, government discourse and the design of the Initiative favoured applicants and applications within sectors like agriculture, mining, and construction.

The thematic analysis also highlights two themes corresponding with the NSI approach, often associated with the catching-up context. First, the government asserts that the Initiative will help create or strengthen the Australian ecosystem; however, discussions surrounding the Australian ecosystem were largely superficial as the government never elaborated on how the Initiative will contribute to the creation of this ecosystem. Second, in Round 2, the government allocated funds for projects supporting the Western Parklands Project, which aims to facilitate

the creation of smart cities and innovation clusters; however, the Western Parkland project is independent of the Initiative and relevant only to the second round of funding.

The analysis of the successful projects reflects the findings of the first thematic analysis. Many of the successful projects focus on industries of important economic value to Australia and its economic competitiveness. The role of the telecommunications industry is also ambiguous. None of the funded projects focus on the telecommunications sector, despite actors within the industry being strongly represented in the awarded projects, including international competitors like Nokia and Ericsson. The findings were largely inconclusive regarding government behaviours associated with the NSI approach. While many stakeholders are involved, it is difficult to confirm whether this represents the creation of an ecosystem. No projects explicitly link to the Western Parklands Project, but this is expected given that the analysis does not cover the second round of funding.

Gaps in the Theoretical Framework

The theoretical framework fails to account for two themes identified within the thematic analyses. The first theme is the presence of inter-governmental collaboration. The role of inter-governmental collaboration within the Initiative is first apparent within the eligibility criteria, which allows sub-national governments to apply as long as they have an eligible project partner. However, the theme is particularly evident in the composition of the successful project recipients and partners, where all levels of government were represented. While the topic of cooperation between different types of actors – government, NGO, businesses, and academia–is thoroughly addressed in the literature, the field has yet to study the conditions under which multiple levels of government cooperate to support the innovation of a particular technology.

The second theme is the role of public infrastructure – particularly as a motive for government intervention in technological innovation. The analysis of the successful projects reveals that a striking amount of projects focus on public infrastructure. The market failure approach can account for public infrastructure that constitutes a public or quasi-public good. However, it cannot account for public infrastructure as a motive when the infrastructure fails to meet the conditions of non-excludability or non-rivalry, as was the case for many of the infrastructure projects funded by the Initiative. Consequently, the established theoretical framework and the literature on which it is built cannot account for public infrastructure as a motive for government intervention in technological innovation.

Conclusion

My research demonstrates that the Australian Government invested in the innovation of 5G technology through the 5G Australian Innovation Initiative to (i) strengthen key sectors of the national economy, (ii) improve public infrastructure, and (iii) facilitate the provision of public goods, especially public safety. My research also hints that, while not the direct aim of the Initiative, the Initiative may be part of a larger Australian strategy towards the telecommunication sector and 5G infrastructure.

My analysis also highlighted one of the most important differences of 5G technology from previous generations: its applications and impact extend well beyond the realm of telecommunications. The seemingly endless potential of 5G, and its associated benefits and risks, make 5G one of the most topical areas of study in the 21st century. However, it also makes studying the motives of government intervention in the innovation of technology a daunting task.

My theoretical framework proved an efficient and novel way to tackle this challenge, albeit on a small scale. While my analysis focused on the motives behind a single action of government intervention in the innovation of 5G technology (i.e. the Australian 5G Innovation Initiative), a comprehensive study of Australia's intervention actions, including standardization measures, relevant legislation, and tax policies, can be used to form a bigger picture of the country's overall motives. My theoretical framework can be applied at the subnational level and used to study government motives towards other types of technologies. Finally, my analysis and research findings offer future avenues of investigation within the literature on government intervention in technological innovation. First, it is worth exploring the relationship between technological innovation and intergovernmental collaboration, including the role of municipal governments. Second, my research highlights how public infrastructure as a motive for technological innovation may fall through the cracks of innovation literature in situations where it is not a public good or does not contribute to larger goals.

ANNEX 1			
COMPANY	**COUNTRY**	**TYPE**	**SOURCES**
Project 1: 5G Enhanced Mobile Broadband for Agricultural Applications with Zetifi			
Agensio (i.e. Zetifi)	AU	Private	(CB Insights, n.d.-ah; Zetifi, 2021; DITRDC, n.d.-a)
Case IH	US	Private	(CB Insights, n.d.-f; Case IH, n.d.; Zetifi, 2021)
SwarmFarm Robotics	AU	Private	(CB Insights, n.d.-ab; Zetifi, 2021)
Elders	AU	Private	(CB Insights, n.d.-i; Zetifi, 2021)
Nutrien Ag	US	Private	(CB Insights, n.d.-r; Zetifi, 2021)
Delta Agribusiness	AU	Private	(CB Insights, n.d.-h; Zetifi, 2021)
AuctionsPlus	AU	Private	(CB Insights, n.d.-c; Zetifi, 2021)
Project 2: Aqura 5G Underground Experience Initiative (A5UX)			
Aquara Technologies	AU	Private	(CB Insights, n.d.-b; DITRDC, n.d.-c; Aquara, n.d.; Aquara, 2021)
Northern Star Resources	AU	Private	(CB Insights, n.d.-q; Aquara, n.d.)
OZ Minerals	AU	Private	(CB Insights, n.d.-t; Aquara, n.d.)
Project 3: Smart Food Safety Verification for Australian Meat Processing Exporters			
Australian Meat Processor Corporation	AU	Private	(AMPC, n.d.; DITRDC, n.d.-d; AMPC, 2021)
Bondi Labs	AU	Private	(CB Insights, n.d.-e; AMPC, 2021)
Project 4: Mobile 5G IoT Solution for Data Driven Road Asset Maintenance in Brimbank			
Brimbank City Council	AU	Government	(DITRDC, n.d.-e; Brimbank City Council, 2022a; Brimbank City Council, 2022b; Lynch, 2022
Swinburne University of Technology	AU	University	(Brimbank City Council, 2022a; Brimbank City Council, 2022b; Lynch, 2022)
Optus Networks	AU	Private	(CB Insights, n.d.-s; Brimbank City Council, 2022a; Brimbank City Council, 2022b; Lynch, 2022)
Project 5: Remote operation of an autonomous vehicle			
Conigital	GB	Private	(CB Insights, n.d.-g; Conigital, n.d.; DITRDC, n.d.-f)
Project 6: Exploring Land & Sea Country Using 5G-enabled Drones and HD Video			
Gidarjil Development	AU	Not-for-profit	(Lewis, 2021; Lewis, 2022; Bundaberg Regional Council, n.d.; DITRDC, n.d.-g; CB Insights, n.d.-m)
MobileCorp	AU	Private	(MobileCorp, 2021; MobileCorp, 2022; MobileCorp, n.d.)
SeeunderSea	AU	Private	(MobileCorp, 2021; MobileCorp, 2022)
Drone Training Solutions	AU	Private	(MobileCorp, 2021; MobileCorp, 2022)
Project 7: Enhanced Mobility for Disabled and Elderly using Automated Vehicles			
HMI Technologies	AU	Private	(DITRDC, n.d.-h; CB Insights, n.d.-o; Staff writers, 2022)
La Trobe University	AU	University	(Staff writers, 2022)
Project 8: Interchange: VR and AI soft skills training streamed at low latencies			
Liminal VR	AU	Private	(DITDRC, n.d.-i; Liminal VR, n.d.)
Deakin University	AU	University	(Liminal VR, n.d.)
La Trobe University	AU	University	(Liminal VR, n.d.)
Pluto VR Inc.	AU	Private	(Liminal VR, n.d.; CB Insights, n.d.-v)
Project 9: Real-time streaming of construction site 3D scans over retail 5G networks			
Maxart	AU	Private	(DITRDC, n.d.-j; Maxart, n.d.)
Project 10: 5G Connected Cobots (Collaborative Robots)			
Nokia Solutions and Networks Australia	FI	Private	(DITRDC, n.d.-k; CB Insights, n.d-p; Nokia, 2021)
At UTS Tech Lab	AU	University	(DITRDC, n.d.-k; CB Insights, n.d; Nokia, 2021)
Project 11: South Australia National 5G Industrial Incubation Lab			
Nokia Solutions and Networks Australia	FI	Private	(ITS Australia, 2021; DITRDC, n.d.-l; CB Insights, n.d.-p)

Annex 2			
Location	State or Territory	Metro or Regional	% of project
Project 1: 5G Enhanced Mobile Broadband for Agricultural Applications with Zetifi			
Wagga Wagga	NSW	Regional	95%
Birchip	VIC	Regional	5%
Project 2: Aqura 5G Underground Experience Initiative (A5UX)			
Osborne Park	WA	Metro	10%
Osborne Park	WA	Metro	40%
Kalgoorlie	WA	Regional	50%
Project 3: Smart Food Safety Verification for Australian Meat Processing Exporters			
Tanjil South	VIC	Regional	30%
South Melbourne	VIC	Metro*	40%
East Deep Creek	QLD	Regional*	30%
Project 4: Mobile 5G IoT Solution for Data Driven Road Asset Maintenance in Brimbank			
Keilor Park	VIC	Metro*	25%
Sunshine	VIC	Metro*	30%
Sunshine	VIC	Metro*	15%
Hawthorn	VIC	Metro*	30%
Project 5: Remote operation of an autonomous vehicle			
Melbourne	VIC	Metro	5%
Cudal	NSW	Regional	60%
Sydney	NSW	Metro	30%
Chippendale	NSW	Metro	5%
Project 6: Exploring Land & Sea Country Using 5G-enabled Drones and HD Video			
Bargara	QLD	Regional	50%
Mon Repos	QLD	Regional	17%
Palm Cove	QLD	Regional	33%
Project 7: Enhanced Mobility for Disabled and Elderly using Automated Vehicles			
Silverwater	NSW	Metro	20%
Lucas Heights	NSW	Metro	80%
Project 8: Interchange: VR and AI soft skills training streamed at low latencies			
Bundoora	VIC	Metro	12%
Moorabin	VIC	Metro	76%
Burwoord	VIC	Metro	12%
Project 9: Real-time streaming of construction site 3D scans over retail 5G networks			
Port of Brisbane	QLD	Metro	40%
Fortitude Valley	QLD	Metro	60%
Project 10: 5G Connected Cobots (Collaborative Robots)			
Botany	NSW	Metro	100%
Project 11: South Australia National 5G Industrial Incubation Lab			
Adelaide	SA	Metro	80%
Adelaide	SA	Metro	10%
Adelaide	SA	Metro	10%
Project 12: Project Endeavour: Enhancing Electricity Grid Reliability & Safety with 5G			
Huntingwood	NSW	Metro	100%
Project 13: Qube Next-Gen Moorebank Logistics Park 5G Autonomous Cargo Vehicles Qube			
Moorebank	NSW	Metro	100%

ANNEX 3

Official Project Descriptions

Project 1: 5G Enhanced Mobile Broadband for Agricultural Applications with Zetifi

"This project will enable rigorous testing of an innovative, ruggedised long-range 5G gateway in agricultural applications across various regional, rural and remote locations & showcase the productivity benefits that high bandwidth, low latency connectivity can deliver to primary producers and the wider agriculture sector" (DITRDC, n.d.-a). Project sector: Agriculture.

Project 2: Aqura 5G Underground Experience Initiative (A5UX)

"The Aqura 5G Underground Experience (A5UX) Initiative is focused on creation of a Private 5G LTE Network technical architecture and commercial model to be delivered in an operating underground mine. The project will seek to test 5G as a viable underground network wireless broadband technology, validate a commercial business case to enable other underground operations to acquire the technology and validate the 5G LTE underground network via a number of technology use cases" (DITRDC, n.d.-c). Category: Mining.

Project 3: Smart Food Safety Verification for Australian Meat Processing Exporters

"We will implement a 5G enabled platform to address improvements in the quality assurance process of meat production. Specifically we will: Implement a streaming of high-definition video data from meat processing plants for use by On Plant Vets (OPV) and Food Safety Meat Assessors (FSMA); Augment human decision- making abilities based on video stream data ia edge computing artificial intelligent machine (AI) machine vision analysis of meat production.The project will address the regulatory costs of meat production as well as eliminate human inspection errors e.g. box mislabelling, which are known to have a significant impact on our export competitiveness" (DITRDC, n.d.-d). Category: Manufacturing

Project 4: Mobile 5G IoT Solution for Data Driven Road Asset Maintenance in Brimbank

"This project will demonstrate a mobile 5G-based IoT solution that: reduces the cost of assets auditing by more than 50 % by automating asset condition monitoring and auditing; reduces time (to within a week) to identify and document all Brimbank's road and roadside assets requiring maintenance; provides timely information in real time to maintenance crews via an online Points of Maintenance (PoM) map i.e map with locations of assets that require maintenance, and assesses 5g's ability to support mobile, high bandwidth, reliable machine to machine data communications" (DITRDC, n.d.-e). Category: Utilities

Project 5: Remote operation of an autonomous vehicle

"One electric car will be retrofitted with automation and remote operation capability. We will test 5G capabilities in remote controlling a vehicle, switching ownership between the the driverless and remote control systems and exchanging necessary data for V2X communications. These tests will be compared to tests taken over existing infrastructure such as 4G. The project will be a proof of point to our client base that enables them to deploy AVs within their operations sooner. 5G infrastructure will be installed at TfNSW's Cudal testing facility that can be utilised for future testing of a variety of Connected and Automated Vehicle(CAV) and Cooperative Intelligent Transport System's (C-ITS) use cases" (DITRDC, n.d.-f). Category: Transport.

Project 6: Exploring Land & Sea Country Using 5G-enabled Drones and HD Video

"This project will demonstrate full high definition video streaming, remote participant interaction and remote participant control of drones via the internet. It will engage our Elders present and emerging in care for land and sea country by removing physical barriers that have previously made it difficult to attend remote locations. It will reduce risk, increase productivity and create employment opportunities in scientific data collection and caring for land and sea country by indigenous communities. It will combine traditional knowledge and story-telling with innovative technologies and methods. It will allow us to share our traditional, contemporary and future knowledge of land and sea country with the broader community" (DITRDC, n.d.-g). Category: Indigenous Environmental Management

Project 7: Enhanced Mobility for Disabled and Elderly using Automated Vehicles

"This project will demonstrate 5G applications to enable safe, efficient and reliable operation of Automated Shuttle Vehicles (ASVs), in order to provide enhanced mobility for disabled and elderly passengers. ASVs can provide an effective solution to a key missing link in current public transport ecosystems – first and last kilometre travel. This is of particular importance for less mobile travellers, who cannot choose to walk even short segments of their journeys. High-speed, low-latency communications are essential to achieve the full potential of ASVs. This project will demonstrate this through several different applications of 5G, and will compare 4G and 5G operation to demonstrate the superior performance of 5G" (DITRDC, n.d.-h). Category: Transport.

Project 8: Interchange: VR and AI soft skills training streamed at low latencies

"Liminal will develop Interchange, a 5G-enabled virtual reality (VR) soft skills training program which will use artificial intelligence to generate real time, animated responses by high fidelity virtual humans. Animated responses will be determined by real time emotional analysis of verbal statements made by trainees, using IBM's Watson cloud-based cognitive computing system. Interchange will demonstrate the capabilities of commercially available 5G networks to a range of industries across Australia - made possible by huge innovation leaps driven by 5G, edge computing, AI and VR. It will be an Australian-first implementation of the ground-breaking PlutoSphere platform to stream high graphical fidelity real time VR content at low latencies" (DITRDC, n.d.-i). Category: Education and Training.

Project 9: Real-time streaming of construction site 3D scans over retail 5G networks

This project involves the implementation, testing and trials of MAXART's 5G enabled software for real-time streaming of construction site digital twins between workers on site and their office colleagues, using retail 5G mobiles and networks. This technology will harness the potential of 5G technologies to improve how every worker in the construction industry visualises and communicates complex problems on constructions sites, ultimately improving worker productivity and safety whilst creating new jobs within this key Australian industry (DITRDC, n.d.-j). Category: Construction.

Project 10: 5G Connected Cobots (Collaborative Robots)

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"Collaborative robots, or “cobots” are changing the future of industry and our daily life. In this proposal we aim to demonstrate how 5G can be used to offload both sensor data and intensive processing from the cobot to a powerful edge cloud compute platform capable of processing this data and based upon this, instruct the cobot how to interact with its surroundings including nearby humans in real-time. The project will explore the feasibility of this process and aims to develop key learnings applicable to 5G-based remote control of cobots and autonomous entities such as cars, robots, and drones" (DITRDC, n.d.-k). Category: Manufacturing.

Project 11: South Australia National 5G Industrial Incubation Lab

"Nokia and the South Australian Government are proposing a ‘National 5G Industrial Incubation Lab’ to be established in Adelaide to deliver three key user cases covering Rail Safety in Rail corridor via camera and scene analytics using big data, Airport situational awareness for securing public safety using HoloLens and video cameras, as well as power over voltage management in a power network via distributed edge compute via 5G connectivity. These 5G user cases will be supported by our partner eco systems from Adelaide Airport, South Australian Power Network and Department for Infrastructure and Transport. This includes utilisation of local expertise from The Australian institute for Machine learning (University of Adelaide)" (DITRDC, n.d.-l). Category: Infrastructure.

Project 12: Project Endeavour: Enhancing Electricity Grid Reliability & Safety with 5G

"This project Optus in partnership with Endeavour Energy, Unleash live and Amazon Web Services will trial the use of drones and vehicles equipped with 5G connected ultra-high definition (UHD) cameras with computer vision to intelligently monitor Endeavour’s critical electrical infrastructure. If successful, this technology has the potential to reduce the time to diagnose faults, increase safety and reduce carbon emission from vehicles and helicopters" (DITRDC, n.d.-m). Category: Utilities.

Project 13: Qube Next-Gen Moorebank Logistics Park 5G Autonomous Cargo Vehicles Qube

"Qube is developing the Moorebank Logistics Park (MLP). MLP is an intermodal rail terminal and Australia’s largest freight infrastructure project. Central to the value proposition of MLP is the efficient movement of containers from Port Botany to onsite warehouses. The Project will install 5G communications to link automated vehicles to the central fleet management and safety system with the low latency and high reliability of 5G used to create safe, reliable operations. The Project will evaluate the performance and benefits of 5G & the automated transport systems"(DITRDC, n.d.-n). Category: Logistics.

Project 14: 5G Remote Controlled Firefighting Tank

"This Rheinmetall’s Advanced Firefighting Concept (AFC) program is an Australian research initiative to improve firefighter safety by repurposing Military vehicles into vehicles capable of fighting fires in extreme environments. We are developing an autonomous / remote control ‘Firefighting Tank’ (called the Fire Tank) which is a purpose built firefighting vehicle capable of traversing extremely dangerous terrains to support rescue, path clearing and firefighting missions. We believe low-band 5G can be used in our application to support long-range remote control of our vehicles. Our application is focused on investigating the feasibility of this technology and development of a drone based 5G range extension capability" (DITRDC, n.d.-o). Category: Emergency Services.

Project 15: 5G Precise Positioning Testbed - Demonstrating economic benefits of 5G

"Precise positioning of consumer devices to within 10cm is now possible through 5G, however users are unable to access this due to infrastructure and device interoperability barriers. A 5G Precise Positioning Testbed using the Optus network, supported by global telecommunications and positioning leaders Ericsson and GMV, will demonstrate and measure economic benefits of four business applications using 3GPP in the agriculture and consumer sectors, and help inform future 5G investment decisions" (DITRDC, n.d.-p). Category: Logistics.

Project 16: 5G-enabled UAV for lifesaving pathology supply and coastal monitoring

"Swoop Aero is an integrated airborne mobility service provider focused on developing enhanced mobile broadband (5G-enabled telecommunications) infrastructure to enable 2 key innovations: ultra-reliable Unmanned Aircraft Vehicle (UAV) command and control across remote and unserviceable locations with 100% uptime for precise monitoring of location in supply chain, and temperature of cargo, during critical medical supply delivery, advancing upon this, real-time HD/4K video streaming for low-latency machine-driven analysis enabling life-saving coastal monitoring.These advancements will overcome limitations of current 4G technologies (poor data quality, high-latency) which have precluded the use of UAVs in such life-saving applications" (DITRDC, n.d.-q). Category: Emergency Services.

Project 17: 5G enabled livestock counting with real-time data validation

"This project aims to demonstrate how 5G networks can complement AI-image processing, computer vision and edge computing technologies to deliver benefits and efficiencies to the agricultural sector. The project will use 5G to enable multiple high definition video streams to count cattle at a regional livestock exchange, automating the process and removing human error. A supporting 5G edge network will process the counting on-site and relay the data in real time back to farmers on a tablet or mobile device. This project will help bridge the digital divide between urban and regional Australia in terms of access to next generation networks, and allow TPG to better serve enterprise clients in the agricultural sector and in regional Australia" (DITRDC, n.d.-s). Category: Agriculture.

Project 18: Transdev Sydney Ferries 5G Trials for CCTV and HelpPoint

"This project is part of a wider Transdev Sydney Ferries program to fit-out vessels with refreshed, modern information technology. This is the only project in the program leveraging 5G technologies. Transdev Sydney Ferries will measure and compare performance metrics of ferries fitted with both 5G and non-5G technologies. Financing has been secured for the non-5G related projects; this 5G trial project has a discreet scope and benefit related to this application.5G Use Cases in scope the identified subset of ferries:
Help Point (high-availability 99.5%, low latency); CCTV Streaming (multiple streams to multiple locations; CCTV Offload (>300GB per day per vessel offload expected); [Optional] GPS; [Optional] Passenger Wi-Fi" (DITRDC, n.d.-t). Category: Transport.

Project 19: Improving wastewater pipe inspections using Artificial Intelligence and 5G

"Thousands of kilometres of pipes are inspected every year in Australia and around the world to maintain the condition of sewer and stormwater networks. Today this process relies on visual observations of busy operators and defects are often missed.
VAPAR has developed AI (Artificial Intelligence) to automatically detect defects in pipes.Thanks to low latency and massive machine-to-machine communication, 5G will now allow for this analysis to be done in real-time to assist operators to better identify defects.
From a study performed by our global partner Veolia, this technology will make condition assessment faster and cheaper, benefiting public infrastructure and the cost of water for all Australians" (DITRDC, n.d.-u). Category: Utilities.

Project 14: 5G Remote Controlled Firefighting Tank			
Redbank	QLD	Metro	100%
Project 15: 5G Precise Positioning Testbed - Demonstrating economic benefits of 5G			
Macquarie Park	NSW	Metro	40%
Campbellfield	VIC	Metro	20%
Docklands	VIC	Metro	40%
Project 16: 5G-enabled UAV for lifesaving pathology supply and coastal monitoring			
Port Melbourne	VIC	Metro	100%
Project 17: 5G enabled livestock counting with real-time data validation			
Tamworth	NSW	Regional	100%
Project 18: Transdev Sydney Ferries 5G Trials for CCTV and HelpPoint			
Balmain	NSW	Metro	100%
Project 19: Improving wastewater pipe inspections using Artificial Intelligence and 5G			
Alexandria	NSW	Metro	90%
Dandenong South	VIC	Metro	10%

*The classification was not included on the DITRDC webpages, so they were classified based on the definition of 'regional' as “all the towns, cities, and areas outside Australia’s largest capital cities; Sydney, Melbourne, Brisbane, Adelaide, Perth and Canberra” (Parliament of Australia, 2018).

South Australian Government	AU	Government	(ITS Australia, 2021; DITRDC, n.d-l.)
University of Adelaide	AU	University	(ITS Australia, 2021; DITRDC, n.d.-l)
Adelaide Airport	AU	Private	(ITS Australia, 2021; DITRDC, n.d.-l; Adelaide Airport, n.d.)
Department for Infrastructure and Transport	AU	Government	(ITS Australia, 2021; DITRDC, n.d.-l)
South Australian Power Network	AU	Private	(ITS Australia, 2021; DITRDC, n.d.-l; CB Insights, n.d.-aa)
Project 12: Project Endeavour: Enhancing Electricity Grid Reliability & Safety with 5G			
Optus Networks	AU	Private	(DITRDC, n.d-m; CB Insights, n.d.-s; Optus, 2022)
Endeavour Energy	AU	Private	(CB Insights, n.d.-j; Optus, 2022)
Unleash Live	AU	Private	(CB Insights, n.d.-af; Optus, 2022)
Amazon Web Services	US	Private	(CB Insights, n.d.-a; Optus, 2022)
Project 13: Qube Next-Gen Moorebank Logistics Park 5G Autonomous Cargo Vehicles Qube			
Qube Holdings/Logistics	AU	Private	(DITRDC, n.d.-n; CB Insights, n.d.-y)
Project 14: 5G Remote Controlled Firefighting Tank			
Rheinmentall Defence Australia	DE	Private	(DITRDC, n.d.-o; CB Insights, n.d.-z; Nine, 2021)
Project 15: 5G Precise Positioning Testbed - Demonstrating economic benefits of 5G			
Spatial Information Systems Research/FrontierSI	AU	Not-for-profit	(DITRDC, n.d-p.; Frontier SI, n.d.; Australian Business Registry, 2022; Frontier SI, 2022; Cozzens, 2022)
Geoscience Australia	AU	Government	(CB Insights, n.d.-l; Frontier SI, 2022)
Ericsson	SE	Private	(CB Insights, n.d.-k; Frontier SI, 2022; Cozzens, 2022)
GMV	ES	Private	(CB Insights, n.d.-n; Frontier SI, 2022; Cozzens, 2022)
Position Partners	AU	Private	(CB Insights, n.d.-w; Frontier SI, 2022; Cozzens, 2022)
Platform	AU	Private	(CB Insights, n.d.-u; Frontier SI, 2022; Cozzens, 2022)
Quantum-Systems	DE	Private	(CB Insights, n.d.-x; Frontier SI, 2022)
4D Mapper	AU	Private	(Frontier SI, 2022; 4D Mapper, n.d.)
Kondinin Group	AU	Private	(Frontier SI, 2022; AgriFutures grow, n.d.; Cozzens, 2022)
Optus Networks	AU	Private	(CB Insights, n.d.; Frontier SI, 2022; Cozzens, 2022)
Project 16: 5G-enabled UAV for lifesaving pathology supply and coastal monitoring			
Swoop Aero	AU	Private	(DITRDC, n.d.-q; CB Insights, n.d.; Saunders, 2023)
Project 17: 5G enabled livestock counting with real-time data validation			
TPG Telecom Limited	AU	Private	(DITRDC, n.d-s.; CB Insights, n.d.-ad; TPG Telecom, 2021)
Nokia Solutions and Networks Australia	FI	Private	(CB Insights, n.d.-p; TPG Telecom, 2021)
Amazon Web Services	US	Private	(CB Insights, n.d.-a; TPG Telecom, 2021; TPG Telecom, 2021)
University of Technoogy Sydney	AU	University	(TPG Telecom, 2021; CB Insights, n.d.-ae)
Project 18: Transdev Sydney Ferries 5G Trials for CCTV and HelpPoint			
Transdev Sydney Ferries	AU	Private	(DITRDC, n.d.t; Cradlepoint, 2022; Thompson, 2022
Australian Sentinel	AU	Private	(CB Insights, n.d.-d; Cradlepoint, 2022; Thompson, 2022)
Project 19: Improving wastewater pipe inspections using Artificial Intelligence and 5G			
VAPAR Innovation	AU	Private	(DITRDC, n.d.-u; CB Insights, n.d-ag; Martin, 2022)

*ISO country codes: AU = Australia DE = Germany FI = Finland SE = Sweden ES = Spain US = United States