An Coimisiún um
Rialáil Cumarsáide
Commission for
Communications Regulation

Redacted version of expert report of Professor J. Peter Clinch titled "Economic Impact of a Delay in the MBSA2 Award"

Redacted version dealing with the expected economic benefit to Ireland from the widespread deployment of 5G

Information Notice

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1 Introduction

1.1 In the Multi Band Spectrum Award ("MBSA2") High Court proceedings[1], ComReg obtained reports from economic experts Dr. Dan Maldoom[2] and Professor J. Peter Clinch[3] with regard to the economic impact of a delay in the award of MBSA2 rights. Of necessity these reports had to consider the likely economic benefits from the widespread deployment of 5G.

1.2 This document sets out a redacted version of Professor J. Peter Clinch's report dealing with the expected economic benefit to Ireland from the widespread deployment of 5G.

[1] High Court Record Number: 2021/9 MCA

[2] Doctor Dan Maldoom is a founding Partner of DotEcon Limited and expert economic advisor to ComReg.

[3] Professor J. Peter Clinch is Chairman and Director of EnvEcon Decision Support Ltd., Dublin, Ireland and is Full Professor of Public Policy at University College Dublin where he formerly served as Vice-President for Innovation, Enterprise Development and Corporate Partnerships.

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EXPERT REPORT OF PROFESSOR J. PETER CLINCH

Economic Impact of a Delay in the MBSA 2 Award

20 June 2022

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1 Introduction

1.1 Qualifications and experience

1. I am Director and co-founder of EnvEcon Ltd. I am also Full Professor of Public Policy at University College Dublin where I formerly served as Vice-President for Innovation, Enterprise Development and Corporate Partnerships. I am a former Chair of the National Competitiveness Council of Ireland and of Ireland's National Productivity Board and I have served as a Member of the National Advisory Council on Climate Change. I am an Affiliate Faculty Member of the Microeconomics of Competitiveness program at Harvard Business School. I have held visiting positions and/or have been an invited speaker, at, *inter alia*, the University of California, Berkeley and San Diego, Said Business School at Oxford University, Cambridge University, the University of Southern California, Harvard Business School, and the John F. Kennedy School of Government at Harvard University. In 2017, I was conferred with a Fellowship of the Academy of Social Sciences for distinguished research and policy contributions.

2. I hold BA and MA degrees in economics, a PhD, and a Diploma in environmental impact assessment from University College Dublin, with further business qualifications from Harvard and Insead. I have thirty years' experience of research and economic analysis during which time I have advised international organisations, governments, and government agencies, with a particular focus on competitiveness, productivity, innovation, and sustainability. I have authored, or co-authored, over 100 academic publications and more than 100 other papers and policy reports. Details of my qualification and experience may be seen in my CV, which is submitted as an attachment to my affidavit.

1.2 Background to the report and my instructions

3 Three Ireland (Hutchison) Limited and Three Ireland Services (Hutchison) Limited (hereafter, "Three") have challenged the Commission for Communications Regulation ("ComReg") decision[1] (the "Decision"), which sets out the process by which ComReg proposes to award a number of long-term rights of use of radio spectrum (the "Award Process").

4 The licence duration will be approximately 20 years for rights in the 700 MHz, 2.3 GHz and 2.6 GHz bands, with differing duration for rights in the 2.1 GHz band to facilitate a common expiry date for all the bands in the Award[2].

5 The substantive hearing in the High Court was completed in 2021 and judgment is awaited. However, there is currently no stay on the Decision to implement the Award Process.

6 In the interim, ComReg has made certain rights of use of spectrum available pursuant to temporary licences, granted in light of changes in traffic patterns as a result of COVID-19.

[1] ComReg (2020) and, specifically, the decision D11/20 therein.
[2] *Ibid*.

Those temporary licences will come to an end in October.

7 Separately, certain other rights in the 2.1 GHz band of use will come to an end in October.

8 ComReg intends to proceed with the Award Process (also known as the "MBSA2 Award") in order to make the relevant spectrum available on a long-term basis.

9 I have been asked to prepare this report in the context of an application by Three for a stay to be placed on the implementation of the MBSA2 Award.

10 The scope of my instructions is to provide an independent report for the Court containing my view regarding the economic impact of a delay in the MBSA2 Award and to assess Sections 2-4 of the report, authored by Mr Dan Maldoom of DotEcon ("Issues arising from delay of the MBSA2 award 20 June 2022") and commissioned by ComReg (henceforth, the DotEcon report), on the economic impact of a delay in the MBSA2 Award process. I have also been asked to examine the Exhibit RM1 of Richard Marsden (henceforth, the Marsden report) and to give my expert opinion of its conclusion in paragraph 6 d) regarding the broader costs to the Irish economy associated with auction delay.

11 I have based my report on my own expert judgement, research and evidence on the topic, a number of other reports and papers as referenced in my report, information provided to me in my instructions, and an assessment of the relevant sections of the DotEcon and Marsden reports. A list of documents I have reviewed is included at the end of my report.

12 My expertise is in economic impact assessment and so my expert assessment is limited to the economic impact of a delay in the MBSA2 Award process. I have not been instructed to make, nor will I make, any comments on other aspects of the two reports referred to in the preceding paragraph or on any other matters related to the application before the Court. To the extent that I set out certain matters outside of my area of expertise, such as the contents of the Decision or the regulatory framework within which ComReg operates, that is simply to set out my understanding of such matters, which understanding is part of the context in which I formed my opinions.

13 The limitations of my report include: the length of time available for completion, the limited availability of data and studies specific to Ireland on the issues of concern in the report, and the requirement to make certain assumptions regarding the impact of a delay in the award process, in terms of the timing of the process and any measures envisaged by ComReg in response to that delay. As noted in the report, my assumptions in this regard are taken from the DotEcon report.

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3. Economic impact of 5G

39 As background to the conclusions of my report relating to the economic impact of the delay in the issuing of long-term licences, this section sets out a short summary of the economic impact of efficient investment and innovation in new and enhanced infrastructures. The information in this section becomes relevant in my commentary on the DotEcon report's conclusions.

3.1 Macroeconomic impacts

40 There is extensive evidence that adoption of broadband, digitisation, and ICT contribute positively to GDP and economic growth. The contribution of high-impact digital technologies resulting from 5G, such as artificial intelligence, high-performance computing, advanced robotics, and virtual and augmented reality, could lead to cumulative additional GDP of €2.2tn in the European Union by 2030, or a 14.1 per cent growth compared to 2017.[6] Additionally, a study found that in the 27 EU Member States, a 1 per cent increase in ultra-fast broadband adoption leads to an increase in about 0.002-0.005 per cent of GDP.[7] By 2030, the adoption of 5G in particular, would in aggregate add US$1.3tn to global GDP, with a yearly average 0.5 per cent of GDP enabled by 5G.[8]

[6] European Commission (2020).
[7] Briglauer and Gugler (2019).
[8] PWC (2021).

41 5G has applications in, amongst others, the healthcare, automotive, transport, and utilities sectors, in the form of smart energy grids, smart cars, fleet management, advanced medical procedures, smart homes, smart workplaces, etc. The highest levels of impact are in the sectors where investment initially takes place - radio, television and communication equipment, construction and, post and telecommunications[9].

42 In order to form a wide view of the benefits arising from an investment, the first order, as well as the second order, benefits must be considered. First order benefits from an investment arise from the more direct benefits to the producers of the goods and services. These can be classified as strategic benefits derived from greater access to information about the supply chain, operational benefits and enhanced productivity from increased access to information about operations, direct user benefits for consumers from access to improved goods or services, enhanced access to data that might help administrators and other third parties enhance the provision of services, and increased innovation as a result of 5G's capabilities to enable new business models to develop new goods and services.

43 Second-order benefits arise from the 'knock-on' impacts from the use of goods and services and are generally more indirect benefits to society[10] such as enhanced productivity (economic), reduced pollution (environmental), and enhanced security (legal/regulatory). For example, the incorporation of 5G capabilities in vehicles (by private sector manufacturers) would enable public-sector managers to better monitor vehicular flow and better manage traffic. Second order impacts of better traffic management for society will be reduced travel time, less consumption of hydrocarbons, and reduced pollution.

44 A study by the European Commission estimates that, in EU27 Member States and the UK, the total cost of 5G deployment will be approximately €56bn in 2020 and will lead to 'trickle-down' or multiplier effects with a value €141bn. These effects are predicted to create 2.3m jobs in EU28 Member States.[11] Specific to Ireland, the study found that a €490m investment in 5G in 2020 will lead to an output of €1,210m and will be responsible for 10,700 jobs.[12]

3.2 Impact on Productivity

45 Historically, innovations and advancement in the telecommunications sector have had positive impacts on productivity. A study of Irish firms from 2006 to 2012 found a positive and significant impact of the introduction of digital subscriber line (DSL) broadband services on the total factor productivity in Information & Communication and Administrative and Support Services. In these two sectors, the effects measured were large, equivalent to about a third of the typical variation in productivity. The effect of broadband on productivity in other sectors was smaller, thereby suggesting that the impact is dependent

[9] European Commission (2020).
[10] European Commission (2017).
[11] *Ibid*.
[12] *Ibid*.

upon sectoral and firm characteristics.[13] By increasing speed and coverage, 5G is also estimated to remove frictions and improve efficiency and productivity.

3.3 Social and environmental benefits

46 The quantity of data transferred over mobile networks is constantly increasing as more data-heavy applications are available on devices and a there is a higher penetration of smartphones in developing markets. As traffic increases, the energy consumption and costs also increase. It is estimated that over the next 10 years, there could be a 20-fold increase in data traffic over current levels.[14] In light of this, accelerating the adoption of more energy efficient 5G technologies and associated operational practices can help mitigate the carbon emissions from energy consumption. A report found that faster 5G roll out could reduce cumulative carbon emissions by 0.5bn tonnes of CO2 by 2030.[15] The analysis also estimates that rapidly rolling out 5G networks could reduce the cumulative CO2 footprint of mobile networks globally by over a third, compared with a slower roll-out. 5G can achieve this through direct curtailment of energy consumption in mobile access networks through the better energy performance of 5G network equipment and operational practices relative to 4G, reduced energy consumption by devices, improved productivity, and process efficiencies and through improving resource allocation[16] through 5G applications such as smart cities, smart grids, and smart meters[17]

47 The cumulative estimated carbon emissions from mobile networks in Ireland from 2020 to 2030 have been estimated as 2.6m tonnes in a fast roll-out of 5G, 3.2m tonnes in a medium roll-out of 5G, 4.3m tonnes in a slow roll-out of 5G and 5.4m tonnes in a scenario where there is no roll-out of 5G.[18]

48 According to a report by The Carbon Trust, on behalf of GSMA, the enabling impact (any mechanism which, through its use, facilitates the avoidance of carbon emissions) of mobile communication technologies in 2018, was estimated to be around 2,135m tonnes of CO_2e, while the total annual emissions of the sector were approximately 20 Mt CO_2e, which was about 0.4 per cent of global emissions.[19] .

[13] Haller, and Lyons (2015).
[14] STL Partners (2019).
[15] *Ibid*.
[16] Huseien, and Shah (2021).
[17] STL Partners (2019).
[18] Ibid.
[19] GSMA (2019).

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5. Regulatory framework for assessing the impact of a delay

56. To assess the economic impact of a delay, I have revisited the regulatory framework under which ComReg operates. This provides a useful set of headings for assessing the impact of any delay. Appendix 2, paragraph A 2.17, of the Decision[20], makes clear that, in pursuit of its objectives under Regulation 16(1) of the Framework Regulations and Section 12 of the 2002 Act, ComReg's Regulatory Principles include, *inter alia*:

- promoting regulatory predictability by ensuring a consistent regulatory approach over appropriate review periods;
- safeguarding competition to the benefit of consumers and promoting, where appropriate, infrastructure-based competition;
- promoting efficient investment and innovation in new and enhanced infrastructures, including by ensuring that any access obligation takes appropriate account of the risk incurred by the investing undertakings and by permitting various cooperative arrangements between investors and parties seeking access to diversify the risk of investment, while ensuring that competition in the market and the principle of non-discrimination are preserved;
- taking due account of the variety of conditions relating to competition and consumers that exist in the various geographic areas within the State.

57. Therefore, the main issue, I believe, is whether the consequences of a stay, and the associated delay in the award process, such that ComReg is unable to make the relevant spectrum available on a long-term basis, will have a negative impact on the public interest by compromising the regulatory principles as set out above and have a negative economic impact.

[20] ComReg (2020).

6. Assessment of Economic Impact of a Delay in the Award Process

58. Utilising the headings listed above, I have set out what I believe are the economic implications of a delay.

6.1 Efficient investment and innovation in new and enhanced infrastructures

6.1.1 European Union ambitions and Ireland's obligations

59. According to Europe's 5G Strategy in the Digital Decade, 5G will play a key role in reaching one of the "cardinal points targeted by the digital compass: secure and performant-sustainable digital infrastructure".[21] The Strategy states that, while most EU countries have launched commercial 5G services, the spectrum assignment and network deployment is slower than in leading countries such as South Korea and the US. Therefore, the Strategy stresses the importance of Europe's leadership in 5G.

60. The COVID-19 pandemic has already delayed 5G rollout. EU Member States were expected to make the low-band spectrum available for use by 30 June 2020[22] and mid and high-band spectrums by 31 December 2020[23]. However, according to a Special Report by the European Commission, Member States had assigned less than 53 per cent of the total available pioneer bands by end 2021.[24] Swift action with regard to spectrum allocation is required in order to reach the EU's 2025 and 2030 5G deployment objectives.

6.1.2 National competitiveness

61. Capital investment is a critical input into national competitiveness. Ireland, as a small open economy, relies upon being competitive in international trade. If critical infrastructure is delayed, the Irish private and public sectors fall behind our competitors in productivity performance. There is substantial evidence that the speed of deployment of new wireless technologies, and the resulting ability to outpace other countries, affects economic development.[25] Countries such as China, United States, Japan, and South Korea have already invested large sums in infrastructure to facilitate the speedy deployment of 5G.

[21] European Commission (2020).
[22] European Parliament and European Council (2017).
[23] European Parliament and European Council (2018).
[24] European Court of Auditors (2022).
[25] Analytics, R. (2018); Deloitte (2018).

62. National competitiveness, particularly for the world's major economies, will increasingly be determined by the level of, what has been termed, the 'Fourth Industrial Revolution' and the related technological adoption and innovation, which, in turn, will depend on the quality of national 5G wireless networks to support a stronger, more innovative, and more competitive business landscape, which in turn would support sustainable and high-paying jobs.

6.1.3 Quality of the network and societal welfare

63. A switch to hybrid working, new technological innovations and their applications, and expansion of the digital economy, continue to drive the demand for the radio spectrum in the 2.1 GHz and 700 MHz Duplex bands.[26] In the case that mobile traffic demand exceeds mobile network capacity, and spectrum availability is constrained, mobile operators generally face two choices - they can either densify their network to meet traffic demand and/or accept a degree of quality degradation in the performance experienced by users. Densifying the network generally means higher rollout costs and, thus, may have an impact of producer surplus. In the case that these higher prices are passed on to the consumers, it may lead to a decrease in consumer surplus. There is also a possibility that it can lead to interference and, thus, a poorer quality of service. The second option, quality degradation, means that consumer surplus would decrease.[27]

6.2 Regulatory Predictability

6.2.1 Regulatory Processes, policy coordination failure, and investment

64 The longer the statutory and regulatory processes, the less attractive are investment opportunities. Policy coordination failures also disincentivise investment. Policy coordination failure can be defined as a lack of coherence within public institutions, and between the public and private institutions, which can result in a lack of effective temporal coordination.[28] Whether delays are caused by policy failures, or, simply, the implementation of required statutory or regulatory processes, they can lead to delayed or lost investment. An increase in domestic policy uncertainty in a host country, everything else being equal, reduces FDI inflows and has been shown to affect stock market volatility.[29]

[26] ComReg (2020).
[27] GSMA (2022).
[28] Weber and Rohracher (2012).
[29] Choi and Furceri (2021).

Policy coordination failures have been cited as one of the reasons for possible 5-G rollout failure.[30]

6.2.2 Short-term licences, irreversibility and investment

65 There are two important characteristics of investments in network infrastructure that need to be considered – sunk costs and the timing of investment. Temporary short-term licences would mean that the operators will face expenditures that are partly irreversible, i.e. sunk costs which cannot be recovered. Secondly, investments can be delayed, so that the firm has the opportunity to wait for new information to arrive about prices, costs, and other market conditions before it commits resources.[31] The seminal research by Dixit and Pindyck (1994) further explores this through 'option theory' – when an investment decision is made, a company gives up the opportunity of waiting for new information to arrive. This lost option value is incorporated in the investment cost. Thus, in some cases, an operator may choose to delay investment (in the case of Ireland, until the MBSA2 award results) even if the investment is expected to offer positive returns. This allows them to 'wait and see' until there is greater clarity on future market and regulatory developments. Any regulatory measures that create a less predictable investment environment increase the option value of postponing capital expenditure.

6.2.3 Uncertainty and underinvestment

66 When investors incur fixed, and irreversible, setup costs, uncertainty about the local conditions - especially policy and regulatory uncertainty - can have a dampening effect that reduces investment response to new investment opportunities.[32] Research shows that investor confidence and FDI flows increase with regulatory transparency and predictability.[33]

67 Businesses operating in the telecommunications sector - not just service providers but also all other businesses operating across the value chain - may face uncertainty regarding the timing, content, and potential impact of policy decisions. A study found a strong, negative relationship between policy uncertainty and capital investments, and that it takes two to three years for investments to recover from the initial effects of policy uncertainty.[34]

68 Firms typically use Discounted Cash Flow Analysis to estimate the value of an investment, based on its expected future cash flows. The present value of future cash flows is calculated by discounting the future cash flows by a discount rate. The appropriate discount rate is chosen based on a number of factors. One of the important factors that affects the discount rate is uncertainty. The higher the risk, the higher the discount rate necessary to adjust for

[30] Blind and Niebel (2022).
[31] Dixit and Pindyck (1994).
[32] Bernanke (1983); Bloom (2009); Dixit (1989).
[33] Hebous et al (2020).
[34] Gulen and Ion (2016).

the likelihood that the project revenue might not be realised and the lower the present value of the projected stream.[35] There are substantial fixed, or up-front, costs of investing in telecommunications networks. Any factor that increases the discount rate will decrease the attractiveness of the investment proposition. If the value calculated through DCF is higher than the current cost of the investment, the opportunity is typically not considered. In this way, uncertainty arising from the temporary licences, or legal delays, may affect the investment decisions of operators and other related firms.

6.3 Safeguarding of competition to the benefit of consumers

69 Under the extraordinary situation presented by COVID-19, temporary licences were granted to Meteor, Three and Vodafone without a competitive selection process.[36] The roll-out of 5G involves highly-risky initial investment costs and increased complexity. Any issuance of new short-term licences may have the unintended effect of limiting competition by increasing barriers to entry for new entrants.

70 Decreased competition, that results from new entrants being deterred from entering the temporary allocation, might have detrimental effects on consumers through higher prices and less coverage. This could exacerbate the already low adoption rates. A survey by Deloitte found that 57 per cent of the surveying consumers in Ireland did not know about 5G and the benefits it brings.[37]

6.4 Taking due account of the variety of conditions relating to competition and consumers that exist in the various geographic areas within the state

71 According to the recently launched framework called "Harnessing Digital – The Digital Ireland Framework", the Irish government has committed to enhancing digital infrastructure by making connectivity available to everyone, including bringing 5G to all populated areas by 2030. Access to mobile broadband and digital technologies has generally lagged behind in rural areas as compared to urban areas. 5G, through its inherent enabling of multi-tenanting for mixed uses and users could play a considerable role in providing an economically sustainable ICT-enabling infrastructure for the rural environment.[38] A study finds that in 2025, 5G can provide annual economic (€2.2bn), social (€8.3bn) and environmental (€38.3bn) benefits of up to €10.5 bn in non-urban areas in the EU, on the grounds that the targeted coverage is realised.[39]

72 By enabling virtual learning, digital education, remote work, precision agriculture, and public transport/mobility, 5G can be instrumental in reducing the rural-urban divide. This could also have knock-on effects on the environment, such that 5G will make numerous

[35] Damodaran (2012).
[36] Comreg (2020).
[37] Deloitte (2021).
[38] European Commission (2017).
[39] *Ibid*.

services available remotely, which would reduce the amount of time people living in rural areas spend to go to urban areas, thereby reducing transport-related carbon emissions. Providing 'Universal Access', which has been a challenge facing numerous countries, can be aided significantly by the roll-out of 5G.

6.5 Conclusion on opportunity cost of delayed investment

73 A study by Accenture found that 5G will add up to €1.0tn to European GDP between 2021 and 2025. Furthermore, the study finds that multiplier effects will be felt in every industry such that, for every euro resulting from the direct effect of 5G in Information Communication Technologies (ICT), an additional €1.00 will result elsewhere in the economy.[40] 5G promises significant economic benefits for Ireland, both in terms of GDP and job growth. As stated earlier, a €490m investment in 5G in 2020 is estimated to lead to an output in Ireland of €1,210m and to be responsible for 10,700 jobs.[41]

74 A study that examined the economies in the Eurozone area between 1996 and 2016, with a special focus on the period of the economic crisis, found that investments in ICT under economic crisis conditions seem to have a greater impact on development than in previous years, revealing the fundamental role of ICT in economic renaissance.[42] In light of the economic crisis presented by the aftermath of the COVID-19 pandemic, and to secure the economic advantages of fast and efficient networks, it is crucial that the ICT sector is provided with all the necessary infrastructure.

75 Apart from the direct impacts, the indirect and induced impacts will also be realised, however, this is dependent on the smooth and timely rollout of 5G infrastructure. Referring to the evidence stated above, 5G will have significant socio-economic benefits and the delay in the roll-out can create an opportunity cost in terms of foregone economic, social and environmental benefits. A study conducted by BCG found that in the United States, every six-month delay in 5G deployment could, on average, mean a loss of $25bn in potential 5G benefits from 2020 through 2030.[43] Additionally, delays in 5G investments also pose serious risks and costs for equipment vendors whose sales for the period of the delay may be jeopardized, and the entire supply and value chain can be affected.[44]

[40] Accenture Strategy (2021).
[41] *Ibid*.
[42] Laitsou et al (2020).
[43] BCG (2021).
[44] PwC (2020).

7. Commentary on the DotEcon report's assessment of the impact of a delay

76 The prior sections provide the rationale for my assessment of the economic impact of a delay in investment in network infrastructure. In this section, I utilise that information to give my commentary on the DotEcon report's assessment of the impact of a delay in the MBSA2 award.

7.1 DotEcon report's conclusions on risk, uncertainty and investment

77 The DotEcon report points to a variety of risks for the MNOs associated with interim licensing. The report concludes that any associated investment in network infrastructure is potentially risky, as long-term access to spectrum is not guaranteed. This contrasts with the long-term rights of use that the MBSA2 award process would allocate; these would last for approximately 20 years. The report states that temporary licensing of spectrum as a stop-gap measure does not provide the same level of certainty to operators as the 20-year licences that would have been otherwise awarded, and cannot be expected to support a similar level of major network investment, including that needed to introduce new 5G mobile services particularly in rural areas.

78 In my view, this conclusion is reasonable. The shorter the licensing terms, the greater is the risk. Moreover, if the Award is delayed, uncertainty increases. Firms typically use Discounted Cash Flow Analysis to estimate the value of an investment, based on its expected future cash flows. The present value of future cash flows is calculated by discounting future cash flows by a discount rate. One of the factors that affects the discount rate is uncertainty. The higher the uncertainty, the higher the discount rate necessary to adjust for the likelihood that the project revenue might not be realised and the lower the present value of the projected stream. If the value calculated through DCF is higher than the current cost of the investment, the opportunity is typically not considered. In this way, uncertainty arising from the temporary licences or legal delays will affect the investment decisions of operators.

7.2 DotEcon report's conclusions on irreversibility of the investment

79 The DotEcon report asserts that, although modern networks are increasing agile, allowing reconfiguration through software, many aspects of the associated network investments are sunk and not recoverable if an operator loses access to spectrum, or finds that access to spectrum in one band is replaced by another. Equipment is required at cell sites. Network layout and some antennas are specific to the spectrum bands used. Therefore, a substantial part of the associated network investment will be at risk of becoming stranded unless the operator has long-term access.

80 The DotEcon report concludes that, overall, the irreversible nature of these investments in both network and service development makes investment incentives sensitive to risk. The

report states that economic theory shows that investment incentives may be acutely sensitive to risk when investment is irreversible. Operators will have strong incentives to defer associated investments in large scale 5G transition until the supporting spectrum is available through long-term usage rights.

81 In my view, the DotEcon conclusion regarding the irreversible nature of the investment is reasonable. The conclusion that economic theory shows that such investments are acutely sensitive to risk is sound. Temporary short-term licences would mean that the operators will face expenditures that are partly irreversible, i.e. sunk costs which cannot be recovered. It is reasonable to assume that there will be a higher option value of wait and see approach so that the firm has the opportunity to wait for new information to arrive about prices, costs, and other market conditions before it commits resources.

82 The DotEcon report concludes that limited 5G deployment in urban areas is unlikely to support high-value 5G applications, such as transport applications and smart agriculture, that require extensive network coverage and, to be effective, require 5G beyond urban centres.

83 This is a logical conclusion and an opinion with which I agree. While I do not claim to be an expert on the suitability of the spectrum for particular services, I understand that the 700 MHz band in the MBSA2 award is particularly suitable for rural 5G and there is a significant problem with rural broadband coverage which is an inhibitor to economic and social development in rural areas. According to a report by the National Economic and Social Council, people in rural areas tend to have weaker online engagement, linked to poorer connectivity in these areas.[45] In light of the recent Covid-19 pandemic and the gradual move to working-from-home, the need for higher connectivity is increasing. A survey conducted by ComReg in 2019 found that 25 per cent of those surveyed in rural areas had daily problems with the quality of mobile-phone coverage.[46] Furthermore, farmers are also at a particular disadvantage due to their rural locations. An IFA survey of 798 farmers found that the availability quality of internet connection was the foremost barrier, cited by 55 per cent of those surveyed, to further adoption of technology on their farms.[47]

7.3 DotEcon report's conclusions on the impact of a delay

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[45] National Economic and Social Council (2021).
[46] ComReg (2019).
[47] IFA (2019).

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93 Mobile services are critical for providing coverage to firms and consumers in rural areas. The Irish government has committed to enhance digital infrastructure by making connectivity available to everyone, including bringing 5G to all populated areas by 2030. Access to mobile broadband and digital technologies has generally lagged behind in rural areas as compared to urban areas. 5G, through its inherent enabling of multi-tenanting for mixed uses and users could play a considerable role in providing an economically sustainable ICT-enabling infrastructure for the rural environment.[54] A European Commission study predicts that, in 2025, 5G could provide annual economic (€2.2bn), social (€8.3bn) and environmental (€38.3bn) benefits of up to €10.5 bn in non-urban areas in the EU, on the grounds that the targeted coverage is realised.[55]

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7.4 DotEcon report's conclusions on the costs of a delay

96 The DotEcon report includes a table reporting studies on the general economic benefits of 5G mobile. This is re-produced here as Table 1. The authors of the report express the estimated benefit relative to the affected population of the country considered. The report annuitises the benefits to express them in a per-annum, per-capita form assuming a real

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[54] European Commission (2017).
[55] Ibid.

discount rate of 4% (the discount rate utilised for public sector projects) and 2% growth in the benefits over time, reflecting long-run economic growth.

97 In my view, the 4% discount rate is appropriate and the use of a 2% assumed growth rate is reasonable. However, extrapolating EU or global results to Ireland, simply by dividing by the affected population, may not give entirely accurate results. Factors such as population demographics, population distribution, demand characteristics, the nature of the enterprise base including R&D intensity and sectoral distribution, the regulatory environment, competition dynamics of the MNOs and the resulting prices, and uptake levels, will affect the applicability of foreign data to an Irish setting.

Table 1. The DotEcon report's calculation of the benefits of 5G mobile

Study	Estimated benefit	Benefit per capita	Extrapolated to Ireland
BCG/CTIA (2021)	$1.4-$1.7 trillion contribution to US GDP, over the next ten years	$4220-$5130 (€4050-€4920)	€20.2-€24.2 billion GDP contribution over ten years *€2.2-€2.7 billion contribution in the first year*
McKinsey (2020)	€2.2 trillion contribution to GDP of the EU+UK from 2017-2030	€4270	€21.3 billion GDP contribution over 13 years *€1.8 billion contribution in the first year*
Centre for Policy Studies (2020)	Up to £52.6 billion increase in UK economic output between 2021 and 2027	£783 (€916)	€4.56 billion contribution over six years *€798 million contribution in the first year*
Huawei (2020)	€6 billion *more* cumulative benefit to Irish GDP with high 5G investment, compared to low investment scenario, by 2025	€1224	€6.1 billion increase over low investment scenario, over seven years *€920 million contribution in the first year*
GSMA (2022)	$121 billion contribution to European GDP from 5G mid-band spectrum **in 2030** (N.B. this is a single year)	$221 (€212) (N.B. this is in 2030)	*€1.06 billion contribution* from mid-band spectrum in 2030

98 In terms of the studies cited in the table, the majority are from consulting firms, some of which are less than clear regarding the methodology utilised. Thus, it can be difficult to corroborate the figures. The McKinsey (2020) report states that new digital technologies (AI, big data analytics, quantum and high-performance computing, IoT, next gen internet and infrastructure, cloud computing, digital platforms, and distributed ledger technology), can make a €2.2 trillion contribution to the GDP of the EU and UK from 2017-2030. However, the estimated contribution to GDP does not appear to disaggregate the effects

of 5G from other drivers of developments of those technologies and, thus, figures extrapolated from it appears to be an overestimate in my opinion. The figure of £52.6 billion taken from the Centre for Policy Studies report[56] is for their high-modelling scenario (as opposed to low and central) for the criteria that the UK Government exceeds the coverage target (51 per cent coverage by 2027) by a quarter and achieving 64 per cent coverage. In the central modelling scenario where the UK Government reaches the 51 per cent target by 2027, there will be an estimated £34.1 bn increase to economic output.

99 According to the Huawei report cited, in 2025, the low 5G investment scenario will have an estimated impact of €411.8bn, whereas that for a high-investment scenario is €417.9bn. Thus, the opportunity cost of low 5G adoption has been estimated as €6.1bn. However, the methodology used for these figures involves some important assumptions. The first is that a coefficient is taken from a global context to reflect what proportion of economic growth is contributed by 5G adoption. The report then utilises the OECD's forecast for Ireland's long-term growth which already assumes an implicit contribution from technologies such as 5G. The report then multiplies the 5G coefficient by the growth scenario to calculate the proportion of economic growth contributed by 5G adoption. Extrapolating a global estimate to Ireland may not accurately determine the contribution of 5G investment to GDP growth due to differences in the enterprise regional and demographic differences.

100 The DotEcon report concludes that delay costs to the Irish economy could be in the order of €1 bn per annum. This is consistent with international studies. In my opinion, despite the limited data and research available, the difficulty of forecasting future events, and the need for the studies considered to extrapolate international data to an Irish context, it is not unreasonable to assume that the delay costs to the Irish economy would be very substantial, particularly given the Irish context of a high economic reliance on FDI, the need to boost productivity via innovation-intensity in Irish firms, and the low rural population density which, as the report states, makes sub-1 GHz spectrum especially important and so boosts the importance of releasing 700 MHz spectrum. 5G will have significant socio-economic benefits and the delay in the roll-out can create an opportunity cost in terms of foregone economic, social and environmental benefits. Additionally, delays in 5G investments could pose serious risks and costs for equipment vendors whose sales for the period of the delay may be jeopardised, and the entire supply and value chain can be affected.[57]

101 The DotEcon report on the economic impact of a delay in the MBSA2 award concludes by referring to the indirect benefits of 5G that also should be considered such as the significant opportunities in healthcare, for remote health monitoring, ingestible or wearable sensors and robot-assisted surgery. The report also points to sustainability benefits across water management, air quality, energy efficiency, smart buildings and traffic management.

102 This is a reasonable conclusion in my view. I would note, particularly, the sustainability argument. In a European context, Ireland is one of the more challenged countries in terms of meeting its international obligations to reduce greenhouse gas emissions. The research

[56] Jackman and King (2021).
[57] PwC (2020).

suggests that a faster rollout of 5G can aid countries in making progress towards its national climate targets. Ireland faces considerable challenges in transportation, buildings and agriculture in terms of reducing emissions. Accelerating the adoption of more energy efficient 5G technologies and associated operational practices can help mitigate the carbon emissions from the energy consumption. Faster 5G roll out could reduce the cumulative CO2 footprint of mobile networks globally by over a third, compared with a slower roll-out.

[redacted]

[redacted]

[redacted]

9. Documents Referenced in this report

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