THE CONTRIBUTION OF THE TELECOMMUNICATIONS SECTOR TO THE IRISH ECONOMY

A report for ComReg

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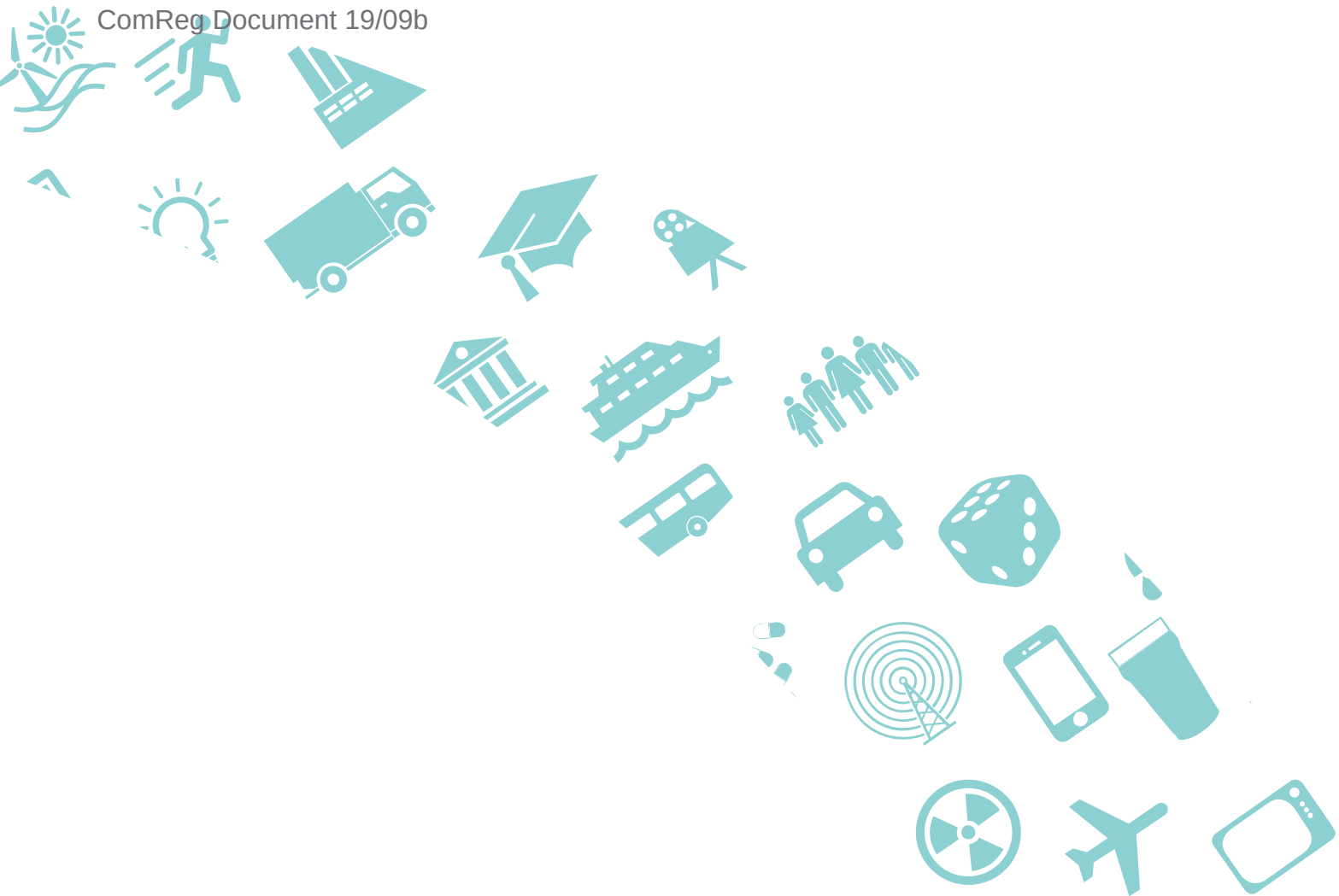
ComReg Document 19/09b



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TELECOMS' DIRECT AND INDIRECT ECONOMIC CONTRIBUTION, 2016
High value added and increased labour productivity

€2bn of value added produced in the telecommunications sector in Ireland

Including the value of inputs to the sector a total of €2.4bn was created in Ireland equivalent to 1.4% of modified Gross National Income

Highly productive sectors

On average across all sectors:

€177k GVA per FTE (relative to GNI* per FTE: €91k)

Telecoms sector includes:

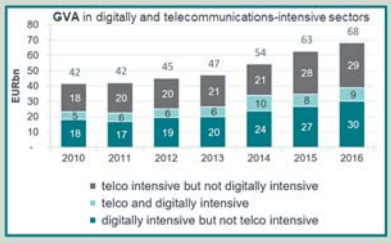
- Mobile communications
- Fixed line telecommunications
- Personal mobile radio
- Fixed wireless
- Mobile and fixed manufacturing
- Telecoms retail services

However, telecoms are used as an input across a much wider set of markets, such as public administration, management consultancy services, advertising, legal activities, other financial activities, postal services, rental services, water collection, etc.

ECONOMIC CONTRIBUTION OF TELECOMS, 2016
Strong sector growth, high investment

The telecommunications sector supports economic activity in a wide range of sectors.

GVA in digitally and telecommunications-intensive sectors has **increased by 8% per** year on average since 2010.



Investments in telecoms capital in the last three years (2013-2016) mean that total ICT capital stock is 37% higher

The increase in the capital stock implies that telecoms-related ICT investment increased TFP by **0.63%**, resulting in an additional **€1.01bn** GNI* in 2016.

EXECUTIVE SUMMARY

Investments in telecommunications such as broadband and mobile services have supported change and innovation across the entire Irish economy. This is because telecommunications are not just a means to communicate, they also support economic activities across the whole economy.

ComReg has commissioned Frontier Economics to estimate the impact that telecommunications have on the Irish economy since 2013 and our findings are set out in this report. This report sits alongside a separate report commissioned by ComReg which considered the economic contribution of *spectrum* to the Irish economy (the "Spectrum Report"[1]). Although both reports use a consistent methodology, there are differences in the sectors covered: telecommunications includes some sectors which do not rely on spectrum. Whereas spectrum is a core input in some sectors which are not related to telecommunications, for example aviation and broadcasting sectors rely spectrum as a core input, though are not telecommunications sectors.

In principle, measuring the economic contribution that telecommunications have on the Irish economy, should consider the economic impact relative to a case where telecommunications services were unavailable. As telecommunications are a technology which suffuses almost all economic activity, it is not easy to imagine how the economy would develop in the absence of telecommunications (though it might be analogous to considering how a long-lasting failure of telecommunications networks would affect the economy).

Given the transformative impact that telecommunications technology has across the wider economy, measuring this impact is complex. We have, therefore, measured impacts in different ways.

1. We assess the economic value added created producing telecommunications goods and services in Ireland.
2. The adoption of telecommunications goods and services in other sectors has meant that firms are able to realise productivity improvements which accrue to the whole economy. Relying on research which examines the relationship between investments in Information and Communication Technologies (ICT)[2] and productivity, we have estimated the impact that investments in telecommunications have had on economy-wide productivity in Ireland.
3. We have also identified those sectors where telecommunications play a particularly important *enabling* role. These can be sectors which are intensive users of telecoms, where it can be assumed that outputs in these sectors would be considerably lower were telecommunications not available. However, telecommunications also have an important *enabling* role in sectors which more generally use digital inputs. For example, telecommunications networks support the development and distribution of digital goods, whether apps, online content, online retail or financial services. As economic output in developed

[1] ComReg document 18/118a.

[2] ICT encompass both telecoms communication technologies and information technology (computing).

countries increasingly relies on digital goods, so telecommunications play a growing role in supporting these sectors.

4. We consider the contribution that telecommunications make to the achievement of wider social benefits.

The economic value produced in the telecommunications sector

The telecommunications sector directly produced €2bn[3] of GVA in 2016[4]. This can be considered as the contribution of the sector to the total value of goods and services produced in Ireland.

This total contribution covers a number of particular telecommunications services, most notably:

- Mobile telecommunications services. These are provided by network operators eir, Vodafone and Three[5] as well as Mobile Virtual Network Operators such as Tesco Mobile, Lycamobile and Virgin Media.
- Fixed line telecommunications services. These include voice and data services from the main fixed line providers: eir and Virgin Media. However, it also includes the contribution from Internet Service providers and telecoms networks infrastructure providers.
- Fixed Wireless Access (FWA) services. These include suppliers of voice and data services to customers at a fixed location, who use wireless spectrum-enabled technologies.
- Private Mobile Radio (PMR). This includes suppliers of radio services where most traffic is between a control point and one or more mobile terminals, or where groups of mobile terminals need to communicate on a "one to all" basis[6].
- Mobile and fixed telecommunications manufacturing. This covers manufacturers of telecommunications equipment. These are often multinational companies, who however have research and design facilities in Ireland.
- Telecommunications retail services. Many telecommunications service providers (typically mobile providers) retail their services through a distribution network, including high street stores.

However, these sub-sectors will all, to some degree, have used, as inputs, other goods and services produced in Ireland. These inputs include the equipment used to provide the services (where this is not captured in the direct estimate set out above) or the vehicles, power, advertising, financial services or legal services

[3] Source: CSO https://www.cso.ie/en/releasesandpublications/ep/p-nie/nie2017/tables/

[4] This is the value added produced in the sector (where the "value added" measures the value of production that takes place within the sector).

[5] Three Ireland Services (Hutchison) Limited

[6] The main uses of PMR (business radio) are for public safety and security, industrial and commercial users such as taxis and couriers, as well as voluntary organisations, all of whom need reliable means of communicating with personnel and, in particular, those on the move. See: https://www.comreg.ie/industry/radio-spectrum/licensing/search-licence-type/business-radio/

which may also be used as inputs. Therefore, our estimate set out above includes also the value added created in supplying those inputs used in the production of telecommunications services.

Taking into account these indirect impacts and taxes[7] on the telecommunications sector, we estimate that the total contribution[8] of the sector to the Irish economy was €2.4bn in 2016. This accounts for 1.4% of Irish GNI*[9].

The sector also contributes significantly to employment in Ireland. For example, we estimate that the sector employs around 10,000 people in Ireland, meaning the value added per employee in the sector amounted to €177k. This compares to the GNI* per employee across the whole economy of €91k.

Telecommunications investments have a significant impact on productivity

As noted above, telecommunications are an important input in economic activity across many sectors of the economy. Investment in telecommunications can lead to economy-wide enhancements in productivity by enabling production and distribution efficiencies; lowering barriers to entry and expansion; or supporting innovation. More generally, as advanced economies tilt towards the production of digital good and services, telecommunications networks obviously play a critical role in supporting production and supply in the digital economy.

In combination, these effects could increase the productive potential of the economy. Indeed, a rich economic literature, developed over the last 15 years, has generated relevant evidence showing that investment in Information and Communication Technology (ICT) leads to productivity gains that exceed those from investing in other types of capital. ICT relates to both telecommunications technologies and Information Technologies (i.e. computing and software).

In this report, we draw on this literature to estimate the impact that investment in telecommunications has on economy-wide productivity in Ireland. In this, we define productivity as 'Total Factor Productivity' (TFP): the output produced in an economy for a given set of inputs used in production (capital and labour).

- We estimate that, as a result of three years of investment in telecommunications capital (2013-15), the total ICT capital stock in Ireland is 37% higher at the end of the period (2015) than it would have been absent the investment[10].
- The literature suggests that a 1% increase in ICT capital stock is linked with a 0.017 percentage point increase in TFP.
- Therefore, we estimate that as a result of investment in telecommunications capital in Ireland between 2013 and 2015, TFP was 0.63 percentage points

[7] In order to understand the full contribution to the economy it is necessary to include product taxes which are levied on products and services which are not included within GVA.

[8] The sum of sector value added, product taxes and indirect impacts.

[9] GNI* relates to estimate modified Gross National Income.

[10] Our estimates take capital stock at the beginning of the period and, given assumptions on depreciation, consider how the capital stock has grown.

higher in 2016 than it would have otherwise been (i.e. TFP was 0.63 higher percentage points than would be the case if the same level of investments had been made in other forms of capital)[11]. This implies that the modified Gross National Income (GNI*) was around €1 billion higher in 2016 than it would have been absent the investment.[12]

Telecommunications also support the digital economy

Telecommunications are an important input in all downstream markets. Indeed, it is hard to think of an element of economic activity that does not benefit from the recent advances that have been seen in telecommunication technologies.

For example, goods and services are produced and distributed more efficiently as telecommunications services enable new production processes. And, in addition, the widespread adoption of innovative telecommunication products and services by *consumers* has enabled new markets and services, such as mobile applications, social networks, music and video streaming and mobile advertising.

In this regard, the digital economy[13] is particularly enabled by telecommunications services. This is because in order to develop, create and distribute digital goods, it is necessary to use telecommunications networks: it is the ability to send and receive data between users over telecommunications networks which supports the applications and devices.

As noted above, an estimate of the economic contribution that telecommunications make to the economy should consider their impact compared to a state where telecommunications were unavailable. However, for obvious reasons it is not possible to directly observe outcomes where telecommunications services are not available (since there are no examples of economies where telecommunications are not used). One thought experiment which can be used to conceptualise the impact that telecommunications have on the economy could be to consider the impact of a long lasting catastrophic failure of telecommunications networks. In this case, it is likely that producers could substitute to alternative (more costly or less effective) inputs. For example firms could communicate using mail, or face to face meetings; and use physical discs for sharing data. In some cases this would imply that suppliers throughout the economy have higher costs, and lower value inputs. This would increase costs for consumers, and reduce demand for services.

[11] This relates to the increase in the size of the ICT capital stock as a result of ECS investments made (37%) and the elasticity of TFP with respect to changes in ICT capital stock (a 1% increase in the ICT capital stock is linked with a 0.017 percentage point increase in TFP).

[12] GNI* is the preferred method for assessing national income in Ireland as recommended by the Economic Statistics Review Group (2016, report available at https://www.cso.ie/en/csolatestnews/eventsconferencesseminars/resrg/). It adjusts GNI to exclude the depreciation attributable to relocated capital assets and the impact of re-domiciled firms. In doing so, it should provide useful information for analytical and economic modelling purposes, such as budgetary forecasting.

[13] There is no standard definition of “the digital economy”. It includes the creation and supply of intangible goods, whether software, broadcasting content, books and newspapers, or music which are now distributed more efficiently over ECS networks. Intangible goods whether investments in brand, software or legal and other professional services are now also vital inputs across all sectors of the economy. It can also relate to the gathering and use of digital data to support and enable innovative services which benefit consumers.

Furthermore there are some services (such as social media) that would simply not exist in the absence of telecommunications.

This report identifies the sectors where telecommunications play a particularly important role in two ways. First we identify sectors that are intensive users of telecommunications services. Second, we identify those sectors which are in the "digital economy" (we do this by identifying sectors which are large users of digital inputs).

In combination, these sectors directly create €69bn of value added. This represents approximately 40% of GNI* in 2016[14]. Obviously, all of the value added created in these sectors cannot be ascribed to telecoms because, in the absence of telecoms infrastructure, many of these sectors would find alternative ways to deliver their goods and services. Nonetheless, this does signify the crucial role that telecoms plays in supporting GVA across the economy.

Telecommunications supports the creation of Social value

Telecommunications services also support social aims. Such social benefits can arise from the more efficient provision of social goods (such as healthcare or education) or the support of social goals (such as supporting inclusivity, civic participation and mitigating inequalities).

Summary of impacts

In summary, telecommunications contribute to the Irish economy in the following ways (though these cannot be added as there is some overlap between the different estimates).

- **The sector produces economic value-added:** the total value added produced by suppliers of telecommunications goods and services produced in Ireland amounted to €2bn in 2016. Taking into account these indirect impacts and taxes on the telecommunications sector we estimate that **the total contribution of the sector to the Irish economy was €2.4bn in 2016.**
- **Telecommunications investments have a positive impact on productivity:** Investments in telecommunications in recent years contributed an estimated **€1bn to productivity in the economy in 2016 as a result of investments made between 2013 and 2015.**
- **Telecommunications have positive impacts on the wider economy by enabling economic activity in other sectors:** telecommunications have an important enabling role in sectors that are intensive users of telecommunications, or more generally of digital goods and services. It is a crucial enabler in these sectors which produced up to €69bn of value added in 2016.

[14] Note however that GVA is not directly comparable to GNI*. Footnote 18 explains the difference between GVA and GNI*.

- **Telecommunications support a range of social impacts across the economy.**

1 INTRODUCTION

Investments in telecommunications services, such as broadband and mobile services, support change and innovation across the entire Irish economy. This is because telecommunications services have become much broader than purely a means to communicate; they also support economic activity across the whole economy. Amongst other things, investments in telecommunications have transformed how we communicate, work and consume.

- Telecommunications have supported the transformation of economies towards the production and supply of digital goods and services[15].
- Telecommunications also support competitive outcomes reducing barriers to entry and lowering transaction costs. Consumers now expect to be able to compare prices quickly and easily over the internet, and suppliers can quickly reach consumers.
- Beyond digitisation, innovation in telecommunications technology has also contributed to change in production and supply processes - all sectors now rely on telecommunications networks and equipment to support efficient production and distribution.
- It is likely that in the coming years consumers and enterprises will increasingly use telecommunications services, as a growing number of devices are connected using telecommunications networks, known as the "Internet of Things" ("IoT").

Telecommunication services also support social aims. Such social benefits can arise from the more efficient provision of social goods (such as healthcare or education) or the support of social goals (such as supporting inclusivity, participation and mitigating inequalities).

ComReg has commissioned Frontier to estimate the impact that telecommunications have on the Irish economy and our findings are set out in this report.

1.1 Defining the telecommunications sector

In our analysis we have defined the telecommunications sector as those sectors which provide telecommunications goods and services, including manufacturers and retailers of telecommunications equipment. Given the growth of the IoT and the growing number of devices that are connected to the internet (whether cars, thermostats, or lightbulbs), in principle, suppliers of any devices that connect to telecommunications networks could be considered as "telecommunications devices". However, in this study we only include suppliers of devices whose principle purpose is to support communications over telecoms networks. Therefore, we include for example smartphones but exclude laptops or smart TVs. As devices are increasingly likely to be connected to telecommunications networks, the delineation between devices which are designed to support

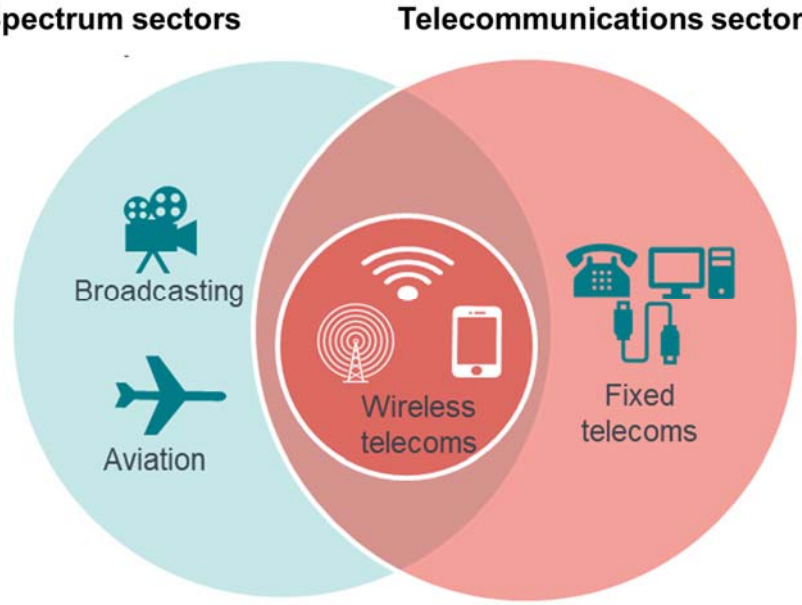
[15] For example the DCCAE announced that the digital and internet economy was growing by 40% between 2012 and 2015. https://www.dccae.gov.ie/en-ie/news-and-media/press-releases/Pages/Trading-Online-Enterprise-Impact-Reports.aspx

telecommunications networks, and other electronic consumer devices will increasingly be blurred.

ComReg has previously published a report by Frontier which set out the economic contribution that spectrum makes to the economy[16]. There is a degree of overlap between the telecommunications sector and those sectors that rely on spectrum (Figure 1). Though both reports use a consistent methodology there are differences in the sectors covered: telecommunications includes some sectors which do not rely on spectrum, whereas spectrum is a core input in some sectors which are not related to telecommunications.

- Spectrum-related technologies include many forms of telecommunications but exclude telecommunications that principally rely on wired technologies (fixed broadband and telephony services).
- Sectors that rely on the use of spectrum include non-telecommunications sectors such as broadcasting or aviation. Broadcasters use spectrum to support the production of content, as well as the transmission of content via terrestrial or satellite transmission. The aviation sector relies on spectrum to support communication, navigation and telemetry monitoring. However, these sectors are not considered to be telecommunications sectors.

Figure 1 Overlap between telecommunications and spectrum sectors



Source: Frontier

Inevitably there are many sectors of the economy, and products and services that consumers use, which rely on spectrum or incorporate telecommunications services but are not included above. For example many sectors now incorporate wireless digital technologies, from maritime, and logistics to education and agriculture. Furthermore wireless digital technologies are integral to many consumer applications in the home, from video streaming services (which are streamed from our broadband router to our internet connected TV via our home Wi-Fi networks); Bluetooth devices such as speakers or personal digital assistants;

[16] ComReg document 18/118a.

or the digital cordless phones we use in our homes. Therefore in considering the economic impact of the telecommunication sector, it should be remembered that there is no clear, bright-line boundaries delineating the "telecommunications sector", and alternative definitions of the sector to the ones used in this report could be wider or narrower.

1.2 Sources of economic value

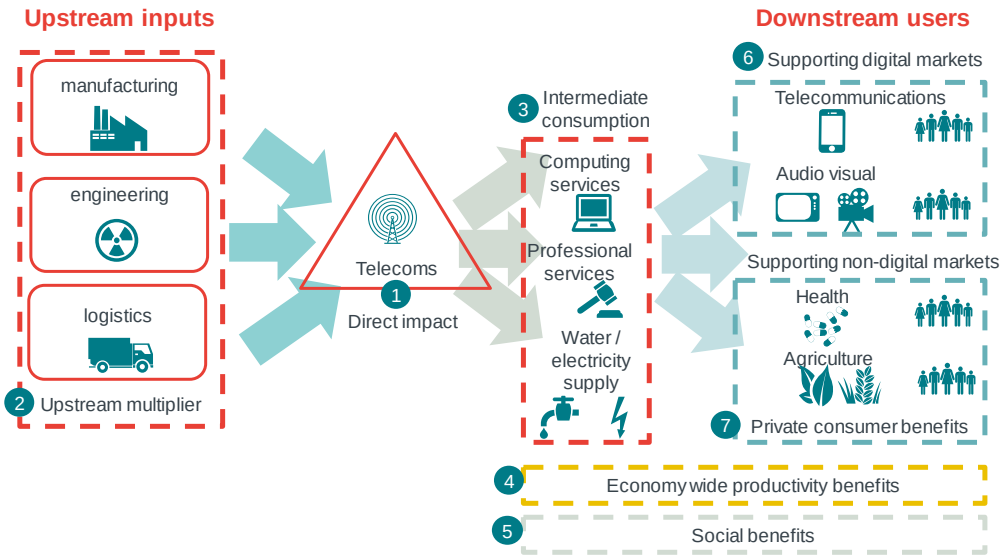
There are many different sources of economic value that could be attributed to telecommunications. These are described in the value chain set out in Figure 2 below (where each source of economic value is labelled from 1 to 7).

The value chain describes production and use of telecommunication services. It illustrates how the sector relies on upstream inputs and how telecommunications services are supplied directly to consumers, as well as being an important input in many downstream markets.

Therefore, the contribution of telecoms to the overall Irish economy is not just the economic value added that is created in the telecoms sector (1). In addition, there are a number of other sources of economic value. These are:

- **Upstream effects (2)**. A number of other inputs are required to create and supply telecommunications services. Therefore, for a given incremental output in telecommunications markets, suppliers need to acquire a number of inputs from upstream markets. The incremental value added in those upstream markets which supply inputs can, therefore, also be attributed to telecommunications services.
- **Telecommunications services are also important inputs** in a number of downstream markets (3 and 6). Where telecommunications are "important" inputs in these markets, then the economic value-added in these markets can be partly attributed to the use of telecommunications. Similarly telecommunications services are important in facilitating the use of the digital products in the wider digital economy.
- **Economy-wide productivity benefits (4).** Telecommunications services permeate every section of the modern economy. The adoption of these services can improve efficiency and lower costs of production. Where these benefits "spill over" to other sectors of the economy, they can lead to far reaching productivity gains.
- **Social benefits and publicly provided goods (5).** Telecommunications can also support a wide variety of social benefits and have an important role to play in supplying public goods.
- **Private consumer welfare benefits (7).** Consumers derive welfare benefits from consuming telecommunications services. In principle, it is possible to value these benefits, as the economic value of the incremental well-being derived from the consumption of telecommunications services.

Figure 2 The role of telecommunications in the wider value chain



Source: Frontier

1.3 Measuring the economic contribution of the sector

ComReg previously consulted on its approach for measuring the contribution that spectrum makes to the Irish economy[17]. To ensure consistent results across the two studies, we have adopted the same approach in this report, which we summarise below.

Figure 3 Summary of impacts studied

Economic impact	Description
The economic value produced in the telecommunications sector (section 2)	The sum of: the value added ***directly*** produced within the sector; plus the value added produced supplying inputs to the sector (i.e. ***indirect*** impacts)
The economic impact of investments in telecommunications on productivity of the Irish economy (section 3)	The role that investments in telecommunications have on economy wide productivity
The importance of telecommunications as an input in downstream markets (section 4)	The value created as telecommunications are used as an input in downstream markets
Telecommunications support the creation of social value (section 5)	Telecommunications enable positive social outcomes (health, education, inclusivity and civic engagement)

[17] See ComReg 18/74 https://www.comreg.ie/publication/proposed-strategy-for-managing-the-radio-spectrum-2019-2021/, ComReg 18/74a https://www.comreg.ie/publication/frontier-report-measuring-the-economic-value-of-spectrum/; ComReg 18/118a https://www.comreg.ie/publication-download/the-economic-contribution-of-radio-spectrum-to-ireland

The economic value added produced in the telecommunications sector

The first measure considers the economic activity in the telecommunications sector. Specifically, using data from both the Companies Registration Office (CRO) and Central Statistics Office (CSO), it measures the GVA produced in the Irish economy by suppliers of goods and services in the telecommunications sector.

The GVA of a given sector (or sectors) can be compared to national income metrics such as Gross Domestic Product[18] or GNI*, to estimate the (percentage) contribution of those sectors to the overall economy. We also estimate employment in telecommunications sectors.

In addition, we note that when producing output in a given sector, there is incremental "indirect" value created in upstream sectors that supply inputs to that sector. We therefore estimate the incremental "indirect" value added[19] of the telecommunications sector, based on Input-Output tables provided by the CSO.[20]

The economic impact of investments in telecommunications on productivity of the Irish economy

The second measure looks at the impact that investments in telecommunications technologies make to the productive capacity of the Irish economy[21].

Investment in telecommunications capital can improve firm efficiency. This is because it can enable firms to move to more efficient production processes and organisational structures while also facilitating new technologies and innovative services. This can, in turn, lead to economy-wide efficiency gains which increase the productivity capacity of the economy.

The importance of telecommunications as an input in downstream markets

The third measure identifies those sectors which particularly rely on telecommunications. Some sectors of the economy are highly reliant on telecommunications. More generally, modern economies are increasingly supplying digital goods and services in "the digital economy". These intangible assets, whether research and design (supported by patents), copyrighted works

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18 Gross Domestic Product (at market prices) is equal to Gross Value Added at basic prices plus taxes on products less subsidies on products (such as VAT or excise duties). It represents total expenditure on the output of final goods and services produced in the country ("final" means not for further processing within the country) and valued at the prices at which the expenditure is incurred. Gross National Income (GNI) is the sum of a nation's Gross Domestic Product and the net income it receives from overseas. Gross National Income at market prices is equal to Gross Domestic Product minus primary income payable by resident institutional units to non-resident units plus primary income receivable by resident units from the rest of the world. GNI* is the preferred method for assessing national income in Ireland. Modified Gross National Income at current market prices is equal to Gross National Income at current market prices less the factor income of redomiciled companies, less depreciation on research and development-related intellectual property imports and less depreciation on aircraft related to aircraft leasing.

19 For the reasons set out in the annex, the estimates of indirect value added are necessarily less precise than the estimates of the direct effects.

20 The Supply and Use and Input-Output Tables provide a detailed picture of the transactions of goods and services by industries and consumers in the Irish economy in a single year. They highlight the inter-industry flows that lie behind the National Accounts' main aggregates, such as gross output, operating surplus and external trade movements.

21 As we explain below, there is a degree of double counting between value added created in the telecommunications sector, and incremental productivity generated by telecommunications investments. Where economy-wide productivity gains are reflected in incremental output in the telecommunications sector, this will be double counted with the estimate of telecoms sector GVA.

(such as artistic works, TV, film and music), or software, rely on telecommunications networks for the purposes of both development and distribution.

We have developed an approach to identify the sectors which rely on telecoms, (either as intensive users of telecoms, or as users of digital goods and services). We then assess the value added created in Ireland in these sectors. Of course, this value added cannot be ascribed fully to the presence of telecommunications networks. Nonetheless, it illustrates the importance of telecommunications as an input across the economy.

Telecommunications support the creation of social value

Social value relates to the role that telecommunications have in supporting the supply of "social goods" such as health and education; as well as the role that it plays in enabling social spillovers (such we well-being, inclusivity, civic engagement or positive environmental outcomes). Social value is not directly measurable as greater income or lower prices, it is nonetheless of significant value.

1.4 Structure of this report

The remainder of this report is set out as follows:

- Section 2 sets out the direct contribution of the telecommunications sector to the economy in Ireland;
- Section 3 estimates the contribution of telecoms to productivity;
- Section 4 considers how telecommunications have an enabling impact on the wider digital economy;
- Section 5 describes how telecommunications support the creation of social value; and,
- Section 6 summarises these impacts.

2 THE ECONOMIC VALUE PRODUCED IN THE TELECOMMUNICATIONS SECTOR

The contribution of the telecommunications sector to the economy is estimated as the "value added" of the sector. The value added can be estimated in a number of ways but conceptually it is the difference between the total sector revenues and the costs of bought-in inputs ("the direct impact").

However, in order to understand the sector's entire contribution to the economy, it is also necessary to include any value added created in sectors that provide inputs to the telecommunications sector ("the indirect impact"). For example, telecommunications firms will buy inputs such as equipment, financial or legal services, advertising and branding, or logistics. Where these inputs are produced in Ireland, they also contribute to the Irish economy.

In combination, the direct impact, indirect impact and product taxes[22] sum to the total *direct* contribution of the sector to the Irish economy[23]. Our estimate of the scale of this contribution is set out below, and the suppliers included in our analysis are listed in ANNEX B.

2.1 Direct impact of the sector

According to our estimates, the total GVA of telecoms services in Ireland in 2016[24] was around €2bn.

The total value added in the sector has declined moderately over the period studied (since 2013). This is against a context of a steady decline of ARPU over the period. "Blended" mobile ARPU fell from €28 per month in 2013 to €25 per month in 2018[25]. The decline in ARPU relates to continued competition in the sectors, as well as competition from the "Over The Top" ("OTT") communications providers (such as VoIP and instant messaging).

At the same time, operators have been increasing their investments. In mobile sectors over the period, operators have continued to increase geographic coverage as well as invest in 4G networks. In 2012 there was significant investment in spectrum as a result of ComReg's Multi-Band Spectrum Award.

Fixed operators have upgraded existing fixed networks, as well as invested in new fixed fibre networks in certain geographic areas. eir has upgraded its copper network to enable NGA services, Virgin Media has upgraded its network to DOCSIS 3.0 and SIRO has rolled out its FTTH network.

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22 Taxes such as income tax are already included in the assessment of value added (since they are included within compensation of employees). Taxes on production relate to taxes which are applied to producers, but do not vary with the quantity produced.

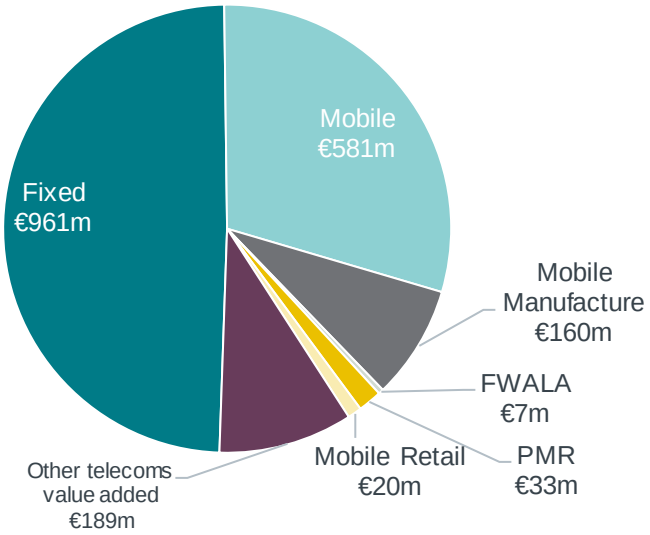
23 Our methodology for calculating GVA is set out in previous reports published by ComReg. See ComReg 18/74 https://www.comreg.ie/publication/proposed-strategy-for-managing-the-radio-spectrum-2019-2021/ , ComReg 18/74a https://www.comreg.ie/publication/frontier-report-measuring-the-economic-value-of-spectrum/; ComReg 18/118a https://www.comreg.ie/publication-download/the-economic-contribution-of-radio-spectrum-to-ireland

24 The most recent year for which data was available given that there is a lag between annual accounts being submitted to CRO.

25 ComReg Quarterly data report. ComReg 18113 and ComReg 1419.

We estimate that total GVA in the *telecommunications services* sector (which encompasses fixed and mobile services, FWA, and PMR but excludes retailing and manufacturing) was €1.8bn in 2016[26], with mobile device manufacturing and mobile retailing creating around €180m of value added. As set out below in Figure 4, this value added is dominated by the contribution of fixed and mobile telecommunications services.[27]

Figure 4 Total Direct GVA of Ireland telecoms services, 2016



Source: CRO, Frontier calculations

Notes: Other telecoms value added includes sector-wide production taxes (these amounted to €35m in 2015 though data was unavailable for 2016). It is not possible to allocate these to specific sub-sectors.

However, in interpreting the split between sub-sectors, it is important to note that:

- It may not be possible to identify all the firms within the sectors of interest. Smaller firms[28] are not required to submit full financial accounts and are therefore not included in the data. These are captured in the "other telecoms valued added" category above (approximately €189m in 2016).
- Some firms provide telecommunications services in a number of sub-sectors (for example Virgin Media provide fixed telecommunications and mobile services). Firms generally do not report their financial data (profit, depreciation or compensation of employees) by sector. Therefore, where data is available (for example on the split of revenues by sub-sector) it is necessary to make assumptions to allocate profit and compensation of employees to each sub-sector[29].

26 CSO.

27 We note that, using our methodology, there is no "double counting" in the value added identified in each sub-sector even where one sector supplied inputs to another. For example the value added in the mobile services sector includes wholesale income derived from MVNOs, whereas the value added in the MVNO sector is net of payments made to mobile services providers.

28 Smaller firms satisfying two of the following three conditions are not required to submit full accounts: balance sheet total not exceeding €6 million; turnover not exceeding €12 million; employees not exceeding 50. See: https://www.cro.ie/Annual-Return/Financial-Statements-Requirements/Small-Company

29 Where data is available, we allocate profit and compensation of employees according to revenues earned by the different activities.

- Where it is not possible to assign a firm's activities to particular subsectors we assign each firm to one of the sub-sectors in the chart above, based on their dominant activity.

2.1.1 Fixed telecommunications services

This sub-sector includes the suppliers of fixed telephony, broadband and business connectivity services to consumers and businesses (notably eir, Virgin Media, BT Ireland and Vodafone) as well as smaller ISPs. It excludes cable TV services, even though it includes broadband and telephony services provided by Virgin Media. We note that services such as cable TV (broadcasting) are a sector which is an "intensive" user of digital inputs and hence is likely to significantly rely on telecommunication services.

In estimating the value added of fixed telecommunications services, we have included value added relevant to voice and broadband. Where necessary, we have allocated firm-wide value added to fixed services, in proportion to revenues which are derived from fixed services.

Figure 5 Direct GVA and employment: fixed telecommunications services

	2013	2014	2015	2016
GVA at basic prices (€'000s)	€ 1,061,000	€ 929,000	€ 955,000	€ 961,000
Employment	6,000	5,000	5,000	5,000

Source: CRO, Frontier calculations. Figures are rounded.

2.1.2 Mobile telecommunications services

The mobile sector in Ireland includes the three Mobile Network Operators (MNOs): eir, Three and Vodafone. These operators provide mobile network voice and data services to consumers and businesses. At the end of September 2018, there were 6,238,772 mobile subscriptions in Ireland. This includes 974,719 Machine to Machine ('M2M') subscriptions[30].

The sector also includes the value added from Mobile Virtual Network Operators (MVNOs) such as Tesco Mobile, Lycamobile and Virgin Mobile. These operators purchase wholesale services from MNOs and use these to supply mobile services to consumers.

Direct GVA and employment estimates are presented in Figure 6. We note that telecommunications services GVA expressed as a percentage of retail revenues is lower for the mobile segment compared to the fixed segment. This could be for a number of reasons: the mobile sector is more competitive which would tend to lower margins. Furthermore, fixed networks may support a greater volume of higher-value business services (for example high-capacity connectivity services for corporate customers).

[30] See: https://www.comreg.ie/publication/quarterly-key-data-report-q3-2018/

Figure 6 Direct GVA and employment: operation of mobile services

	2013	2014	2015	2016
GVA at basic prices (€'000s)	€ 477,000	€ 386,000	€ 545,000	€ 581,000
Employment	2,500	2,900	2,500	2,500

Source: CRO, Frontier calculations. Figures are rounded.

Notes: There are also macro estimates available from the CSO for wireless telecommunications services (NACE2 code: 612). They estimate that the GVA of the sector was approximately €630 million in 2016, which is comparable to our micro-level estimates.

2.1.3 Manufacture of mobile devices

The manufacturing of mobile equipment can include the manufacture of mobile devices and mobile network equipment. In this sub-sector, there are a number of suppliers that base Research and Design services in Ireland. For example, Ericsson employs 1,200 staff in its Athlone and Dublin campuses,[31] Huawei has operations in Ireland supplying telecommunications infrastructure[32] and Adaptive Mobile, based in Ireland, provides mobile network security services to worldwide customers.

Direct GVA and employment estimates for this sub-sector are presented in Figure 7.

Figure 7 Direct GVA and employment: manufacture of mobile devices

	2013	2014	2015	2016
GVA at basic prices (€'000s)	€ 127,000	€ 148,000	€ 159,000	€ 160,000
Employment	1,400	1,600	1,700	1,700

Source: CRO, Frontier calculations. Figures are rounded.

Note: There was no data available for Adaptive Mobile for 2016. We have assumed that the company's GVA in 2016 was the same as in 2015.

2.1.4 Sale of mobile devices

Within this category, we also consider a number of independent wholesalers and retailers of mobile services.[33] Note that to a small extent, these companies also sell devices that are not directly relevant to this analysis (such as laptops or tablets). As we noted above, while these devices use telecommunications networks, we have defined the telecoms sector as including the sale of devices whose primary purpose is to support communications on telecoms networks (such as smartphones) and so exclude such devices.

Direct GVA and employment estimates for this sub-sector are presented in Figure 8.

31 See: https://www.siliconrepublic.com/companies/ericsson-job-cuts-ireland

32 See: http://www.huawei.com/en/press-events/news/2016/10/new-Dublin-office

33 Mobile operators are also involved in the sale and distribution of devices. However, the GVA associated with this activity will have been included in the segment discussed in Section 2.1.2 above.

Figure 8 Direct GVA and employment: sale of mobile devices

	2013	2014	2015	2016
GVA at basic prices (€'000s)	€ 20,000	€ 18,000	€ 11,000	€ 20,000
Employment	700	700	700	700

Source: CRO, Frontier calculations. Figures are rounded.

Note: The sharp reduction in 2015 GVA is due to a significant decrease in The Carphone Warehouse's EBIT.

2.1.5 Fixed wireless (FWA)

Fixed wireless technologies are used to connect fixed locations (e.g. buildings) via a wireless link. They are often used in the provision of internet and other services to areas of low population density, where the construction of wired telecommunications infrastructure may not be economic.

Our analysis focuses on fixed wireless providers and includes service providers Imagine and Digiweb. There are also many regional providers that are small and do not report the financial information required for the GVA calculation in their financial accounts. Furthermore, broadcasters, mobile operators and utility providers may self-supply fixed wireless to support their services. This self-supply will not be included within the estimates below. As such, we may be underestimating the GVA contribution of the fixed wireless sector.

Nevertheless, our estimates of direct GVA and employment in the FWA sub-sector are presented in Figure 9.

Figure 9 Direct GVA and employment: fixed wireless

	2013	2014	2015	2016
GVA at basic prices (€'000s)	€ 8,000	€ 7,000	€ 18,000	€ 7,000
Employment	200	200	200	200

Source: CRO, Frontier calculations. Figures are rounded.

Note: Imagine had negative GVA in 2016 (i.e. negative profits which were not offset by compensation of employees), which has a significant effect on the results. There was no data available for Digiweb for 2016. We have assumed that the company's GVA in 2016 was the same as in 2015. The sharp increase in 2015 GVA is due to a significant increase in Digiweb's EBIT.

2.1.6 Private Mobile Radio (PMR)

Private mobile radio services are specialised mobile communication services that are often used by police forces and fire brigades, as well as certain commercial sectors. Providers of PMR services in Ireland include Sigma Wireless, ESB Telecoms and Tetra Ireland Communications.

Our estimates of direct GVA and employment for this sub-sector are presented in Figure 10.

Figure 10 Direct GVA and employment: private mobile radio

	2013	2014	2015	2016
GVA at basic prices (€'000s)	€ 31,000	€ 30,000	€ 32,000	€ 33,000
Employment	100	100	100	100

Source: CRO, Frontier calculations. Figures are rounded.

2.1.7 Summary of direct impacts

The total direct contribution amounts to €1.95bn (see Figure 11).

Figure 11 Direct contribution of telecommunications

Summary GVA (€ '000s)	2013	2014	2015	2016
Fixed	€ 1,061,000	€ 929,000	€ 955,000	€ 961,000
FWALA	€ 8,000	€ 7,000	€ 18,000	€ 7,000
Mobile	€ 477,000	€ 386,000	€ 545,000	€ 581,000
Mobile Manufacture	€ 127,000	€ 148,000	€ 159,000	€ 160,000
Mobile Retail	€ 20,000	€ 18,000	€ 11,000	€ 20,000
PMR	€ 31,000	€ 30,000	€ 32,000	€ 33,000
Other unidentified GVA	€ 384,000	€ 475,000	€ 232,000	€ 189,000
Total	€ 2,108,000	€ 1,994,000	€ 1,951,000	€ 1,952,000

Source: Frontier. Figures are rounded.

Notes: Other telecoms value added includes sector-wide production taxes (these amounted to €35m in 2015, although data was unavailable for 2016). It is not possible to allocate these to specific sub-sectors.

2.2 The indirect contribution generated by the sector

In a modern economy, supply chains are complex, meaning that many industries may be involved in the provision of a final good or service. However, the direct GVA assessed above does not capture the GVA of economic activities upstream that are used to supply telecommunications services. These sub-sectors will all, to some degree, have used, as inputs, other goods and services produced in Ireland. These inputs include the equipment used to provide the services (where this is not captured in the direct estimate set out above) or the vehicles, power, advertising, financial services or legal services which may also be used as inputs. The mobile sectors will also use "spectrum" as an input. However, the licence which permits mobile network service operators to use a given amount of spectrum is not considered an input from another sector.

The GVA of such upstream activities (indirect GVA) can be estimated using a multiplier approach. The relevant multipliers describe the relationship between the output of each sector and *total GVA* (direct plus indirect) arising in the entire economy, as a result of output in the specific sector. Frontier has estimated relevant multipliers using data and analysis published by the CSO.

Figure 12 Total GVA, €000's

	2013	2014	2015	2016
Direct	€ 2,108,000	€ 1,994,000	€ 1,951,000	€ 1,952,000
Indirect	€ 478,000	€ 443,000	€ 442,000	€ 444,000
Direct + Indirect	€ 2,586,000	€ 2,437,000	€ 2,393,000	€ 2,396,000

Source: Frontier. Figures are rounded.

Again, however, in interpreting these results it is important to note:

- The multipliers we use are estimated based on data from CSO.
- These multipliers are only available at the 2-digit NACE code level, meaning that they do not map perfectly to our definitions of sectors.[34]
- These multipliers are only available for 2015, and the GVA-to-output ratios may vary from year to year, depending on the performance of the given sector.

2.3 Comparison of GVA to national output

Given the analysis presented above, we estimate that the economic activity, measured by GDP, resulting from the supply of telecoms goods and services in Ireland, amounted to approximately €2.4bn in 2016. This amounted to 1.4% of GNI*, (GNI* was €176bn in 2016).

In order to compare sector value added to the wider economy (GDP or GNI*) it is necessary to include the relevant product taxes (net of subsidies) also generated by the sector[35]. At an economy-wide level (i.e. not at the level of each sector), we therefore also estimate the product taxes which result from a given level of output based on multipliers calculated by the CSO. Product taxes relate to taxes that vary with volume (such as Value Added Tax, excise duties etc).

There has been a decline in sector GVA over time, which is driven by reductions in GVA from eir (both declining operating profit and declining payments to labour).

[34] For example, while our GVA estimates for mobile service producers should be based on multipliers for the wireless telecommunication sector (NACE code 612), only the multiplier for the telecommunications sector as a whole is available (NACE code 61). We consider this to be a suitable proxy for wireless telecommunications. Similarly we use the multiplier for the entire "Retail Trade" (NACE code 47) for the mobile retail sub-sector.

[35] Since GDP can be calculated as GVA plus product taxes net of subsidies.

Figure 13 Total GVA associated with core telecoms sectors

	2013	2014	2015	2016
Direct GVA at basic prices (€'000s)	€ 2,108,000	€ 1,994,000	€ 1,951,000	€ 1,952,000
Indirect GVA at basic prices (€'000s)	€ 478,000	€ 443,000	€ 442,000	€ 444,000
Product taxes less subsidies (€'000s)	€ 47,000	€ 44,000	€ 43,000	€ 43,000
Total contribution to GDP (€'000s)	€ 2,633,000	€ 2,481,000	€ 2,436,000	€ 2,439,000
Contribution to GNI*	1.9%	1.7%	1.5%	1.4%

Source: Frontier

Notes: The analysis does not compare the contribution of telecoms and related sectors to GDP or GNI. This is because the specific characteristics of the Irish economy mean that GDP and GNI can be volatile in a way that does not reflect the productive capacity of the Irish economy. Therefore, the CSO publishes "GNI" in order to remove three specific contributors to the volatility in Irish national accounts and to better reflect the living standards of Irish residents (the effects of redomiciled headquarter of multinational public limited companies; the aircraft leasing sector, on-shoring of intellectual property assets[36]). Figures are rounded.*

2.4 Total employment

Figure 14, below, shows the total employment associated with the sub-sectors forming part of the telecommunications sector (note that this excludes the employment in sectors that supply inputs to the telecommunications sector). In total, we estimate that approximately 10,000 full time equivalent (FTE) workers were employed in the sector in 2016.

Figure 14 Total employment

Employment (FTEs)	2013	2014	2015	2016
Fixed	6,000	5,000	5,000	5,000
Mobile	2,500	2,900	2,500	2,500
Mobile Manufacture	1,400	1,600	1,700	1,700
FWALA	200	200	200	200
PMR	100	100	100	100
Mobile Retail	700	700	700	700
Total Employment	11,400	10,900	10,000	10,100

Source: Frontier, CSO Notes: CSO did not publish employment data for the Aviation sector in 2013 or 2014. Figures are rounded.

Our analysis suggests telecoms-related economic activities tend to be associated with higher labour productivity, which is a key driver of economic growth. One measure of labour productivity is GVA per worker. This measures the economic output produced for each worker. We estimate that total GVA (at basic prices[37]) per full-time employee in the telecommunications sector in Ireland was around €177,000 in 2016[38]. This compares to a GNI* per full time employee of €91,000

[36] See: https://www.finance.gov.ie/wp-content/uploads/2018/05/180504-GDP-and-Modified-GNI-Explanatory-Note-May-2018.pdf

[37] GVA at basic prices excludes net product taxes and subsidies.

[38] Note: this is based on the GVA of those sub-sectors where we identify suppliers (totalling €1.76bn) and the number of employees in these sectors (9969).

across the economy as a whole.[39] GVA per worker has increased over the period (see Figure 15). This partly relates to the reduction in employees in the fixed sector, where the number of employees has declined by 24% over the period studied.

Figure 15 GVA per worker telecommunications (€000)

	2013	2014	2015	2016
Telecoms value added per employee	152	139	173	177

Source: Frontier

[39] Total employed FTEs were 1.98m on average in 2017 (source: https://www.cso.ie/en/statistics/labourmarket/labourforcesurveytimeseries/), total GNI* was 181bn in 2017). GVA at basic prices per full time employee (€135k). Note that the economy-wide GNI* (Modified GNI) is not a perfect comparator to GVA. However, we have decided to use the GNI-based figure as, in practice, Irish GVA (and GDP) figures can be volatile for the reasons set out in the notes to Figure 13.

3 CONTRIBUTION OF TELECOMS TO PRODUCTIVITY

Telecommunications services are an important input to economic activity across many sectors of the economy. For example, investment in telecommunications can lead to economy-wide productivity gains by enabling production and distribution efficiencies; lowering barriers to entry and expansion and supporting innovation. More generally, as advanced economies tilt towards the production of digital goods and services, telecommunications networks obviously play a critical role in supporting the production and supply across the economy.

In combination, these effects could increase the productive potential of the economy. Indeed, a rich economic literature discussed in this section, developed over the last 15 years, has generated evidence to show that investment in Information and Communication Technology (ICT) leads to productivity gains that exceed those from investing in other types of capital.

In this section of the report, we draw on this literature to estimate the impact that investments in telecommunications have on economy-wide productivity. In this, we define productivity as 'Total Factor Productivity' (TFP): the output produced in an economy, for a given set of inputs used in production (capital and labour). We have focused on the impact of investments made in the period 2013 -2015 because: this is the most recent period for which data is available; it reflects the period of analysis that ComReg commissioned Frontier to examine; and it is consistent with the literature which examines the impact of marginal changes in the stock of ICT capital.

The remainder of this section is structured as follows

- We first set out our approach;
- We then set out the results of the analysis;
- Finally, we present a sensitivity analysis of our results.

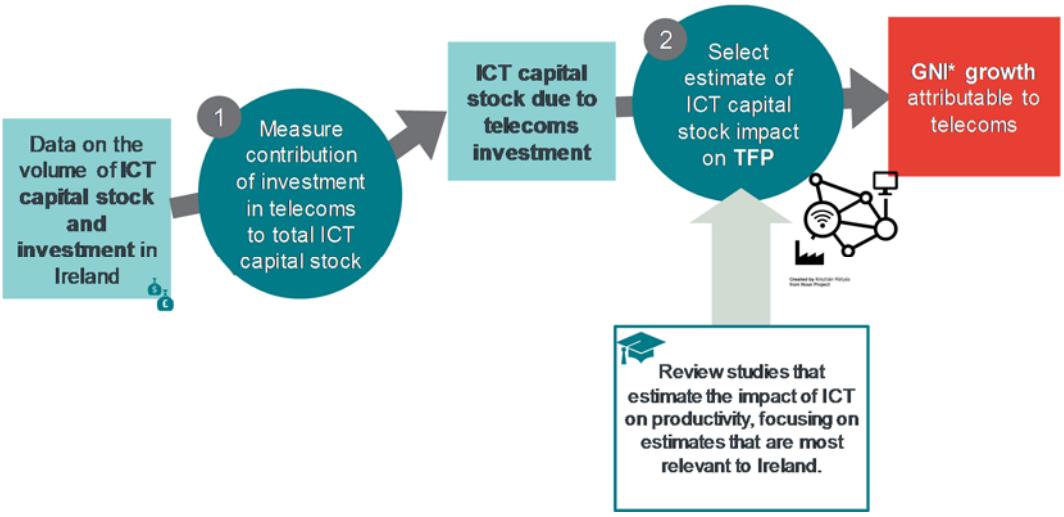
We briefly summarise the literature on the relationship between productivity and investment in telecommunications in ANNEX A.

3.1 Our approach

To estimate the impact that investments in telecommunications have on economy-wide productivity we have used the following approach.

- First, we estimate the change in the ICT capital stock in Ireland as a result of recent telecommunications investments; and
- Second, based on economic literature, we estimate the impact of changes in the ICT capital stock on productivity in Ireland.

Figure 16 Overview of our approach



3.1.1 Step 1: estimate the change in the ICT capital stock in Ireland as a result of investment in telecommunications

We use the most recent Eurostat data available (2013-15)[40] to measure the contribution of recent telecommunications investment to the Irish ICT capital stock[41]. We note that this period includes investment in mobile networks (to roll out 4G services and increase coverage), and fixed networks (as operators upgrade fixed networks and started to roll out new fibre networks).

In doing so, we conservatively assume that none of the computing capital stock is enabled by telecommunications, even though it is plausible that a share of computing equipment (e.g. personal computers) would not be in place if telecommunications investment had not taken place.

In each year, investment in telecoms-related equipment contributes to the overall stock of ICT capital in the economy. We estimate that investments in telecoms equipment in Ireland during the period 2013-15 mean that the real value of the ICT capital stock is 37% higher than it would have been absent the investment. [42]

All figures used in this calculation are at constant prices, and therefore are not influenced by inflation.

[40] ComReg's interest was on the impact that telecommunications have had on the economy during 2013-2016. The literature considers the impacts of marginal changes in the capital stock therefore we consider a period of investment which can be considered "marginal change" i.e. 2013 - 2015.

[41] The capital stock is defined as fixed assets so excludes the value of intangible assets such as spectrum licences software and databases - namely, the intangible component of ICT - to be consistent with the academic literature we review, which considers the sole impact of tangible ICT on TFP.

[42] In a 'counterfactual' scenario with no investment in telecommunications capital, ICT stock in year 2 would be: ICT stock in year 1 minus depreciation of the ICT stock occurring between year 1 and 2; plus ICT investment in computing and non-spectrum related telecommunications capital. Technically the measure of investment use is Gross Fixed Capital Formation.

3.1.2 Step 2: estimate the impact of changes in ICT capital stock on productivity

We have reviewed the economic literature on the relationship between changes in ICT capital and productivity. We set out below a summary of the estimates of this relationship taken from the literature. We also present the cross-checks that we have taken to verify the robustness of our central estimate.

Further detail on our approach to the literature review is provided in ANNEX A.

Summary of the estimates from the literature

Figure 17 lists the studies that we have used in our analysis. This group excludes studies focusing on the United States (US). This is because the effect of ICT on TFP in the US has been shown to be larger than in European countries.[43] We therefore focus on European studies which provided or allowed us to infer the estimated impact of ICT on TFP – specifically, the additional TFP associated with a 10% increase in ICT capital.

Figure 17 Studies estimating the impact of ICT capital on TFP in Europe

Study	Geography	Time period	Impact of 10% increase in ICT capital on TFP (percentage points)
van Reenen (2010)	13 EU countries (excluding Ireland)	1999-2008	0.07
van Leeuwen and van der Weil (2003)	Netherlands	1994-1998	0.079
Frontier Economics (2011) – lower estimate	UK	1980-2007	0.15
Spiezia (2012)	18 OECD countries (including Ireland)	1995-2007	0.17
Frontier Economics (2011) – higher estimate	UK	1980-2007	0.18

Figure 17 shows there are potentially three challenges with using the estimates taken from this literature:

- The most recent data is 2007-2008, before the explosion in use of mobile data observed in the last 10 years;
- There are no studies that have generated estimates of the impact of ICT capital specific to Ireland (though there are studies which explore the impact of ICT and productivity in different ways which we explore below, and use to check the sensitivity of our results); and

[43] Bloom et al. (2012); van Reenen et al. (2010).

- There is some uncertainty in the size of the effect, which varies from 0.07 to 0.18 percentage points for a 10% increase in ICT capital.

We have considered these issues and conclude that drawing on this literature can nevertheless provide a robust assessment of the impact of telecommunications capital in Ireland between 2013 and 2015.

Firstly, although the data used in these studies is now relatively old, the estimates they provide are still likely to be valid. On the one hand, the amount of ICT capital in advanced economies is now greater than in 1990-2007, and therefore a given proportional increase in ICT capital (say, 10%) now implies that more new equipment is installed[44]. On the other hand, the impact of *additional* capital is likely to be lower now that the starting installed base is larger[45]. These two forces will balance out to some extent and it is not clear which could dominate. Therefore, older estimates of the impact of ICT are not clearly likely to either under- or over-estimate the impact of ICT capital now. Indeed, despite the acceleration in mobile data use observed since the late 2000s, advanced economies have typically not experienced a structural change in productivity growth compared to the 1990s and early 2000s.

Secondly, we have considered:

- Whether the impact of ICT capital in Ireland is likely to be higher or lower than in other European countries.
- What can be learnt from other available Ireland-specific evidence.

Despite the fact that in recent years large multinational, digitally intensive companies have located their headquarters in Ireland, there is no clear evidence that Ireland is particularly different from other European countries in ways that would make ICT capital more effective. For example, Ireland lies around the European average in many of the dimensions considered in the European Commission's Digital Economy and Society Index, and in the flexibility of its product and labour markets.[46]

While we are not aware of any studies estimating the impact of ICT capital on productivity in Ireland, other studies have considered the link between availability and take-up of broadband in Ireland.

- Haller & Lyons (2018) and Haller & Lyons (2015) estimate the effect of broadband *availability* on TFP, using data on services and manufacturing firms respectively. They find mixed results: broadband availability has no effect on TFP in manufacturing; broadband availability has a weakly statistically significant effect (90% confidence) on TFP of service firms; and it has a stronger effect in the ICT and Administrative and Support services sectors.

[44] For example: a 10% increase starting from 10 computers implies 1 additional computer, starting from 100 computers implies 10 new computers

[45] The impact of the 110th computer is likely to be lower than the impact of the 10th computer

[46] According to Product Market Regulation and Employment Protection Legislation indices collected by the OECD. Unfortunately these indices have not been updated since 2013. Several studies including Bloom et al. (2012), Bresnahan et al. (2002) have linked greater product and labour market flexibility with greater impact of ICT capital on productivity.

- Doherty, Ramsey, Harrigan, Ibbotson (2016) find positive effects of broadband adoption on the performance of Irish small and medium enterprises.

We do not directly incorporate these estimates in our results, because they focus on the effect of earlier availability of DSL services, rather than on the overall impact of telecommunications on productivity. However it is worth noting, based on this research, that the benefits of telecommunications for productivity are likely to differ by firm size and by industry.

Thirdly, a degree of uncertainty in the estimation of the relation between ICT capital and TFP is to be expected: the available studies could not rely on experiments, which are the 'gold standard' in measuring causal effects; moreover, measuring TFP is in itself a complex exercise, and some measurement error is likely to be involved even in the best data sources available.[47] We reflect this uncertainty in presenting a range of estimates of the impact of telecommunications on productivity.

Spiezia (2012) is the only study which considers the impact of ICT capital on TFP that includes data on Ireland, along with other countries. Its estimate that a 10% increase in ICT capital leads to 0.17 percentage points of additional annual TFP growth, is very close to the central figure in the range of estimates we have collected, which is 0.15 percentage points both when we only consider the studies listed in Figure 17 above, and when we also include additional evidence (see Figure 18 in the next section). Therefore, we use 0.17 as our preferred estimate, but also show how our results would change if we used other estimates, in Section 3.3 below.

Cross-checks with estimates of ICT and other measures of economic output

We note that the literature set out above is a relatively small portion of the available literature on the impact of ICT. This is because we exclude not only studies based on the US (as noted above) but also those studies that estimate the impact of ICT on outcomes other than TFP (including GVA and GDP) and output per worker. In this regard, it is worth noting that the estimates we have excluded typically indicate somewhat larger effects of ICT – for example, a meta-analysis of US studies (Stiroh, 2002) reports that the median estimate of the impact of a 10% increase in ICT capital on output, across 20 econometric studies, is 0.46 percentage points.

As a cross-check, we therefore also consider four more studies that estimated the impact of ICT on output per worker, and infer the likely size of TFP effects implied by their estimates, and report this in Figure 18 below. Spiezia (2012) and van Reenen et al. (2010) show that the impact of a 10% increase in ICT capital on output, is in the order of 0.56 and 0.23 percentage points respectively, of which 0.17 and 0.07 percentage points are the effects on TFP, as reported in Figure 17 above. Their estimates therefore imply that TFP effects are around 30% of the total impact on output.[48] TFP effects reported in the rightmost column of Figure 18 below

[47] Measuring TFP requires measuring accurately all inputs in the economy, including tangible (e.g. machinery) and intangible (e.g. databases) capital, as well as the number and the quality of hours worked.

[48] The exact ratios are 0.17/0.56 = 30.3% for Spiezia (2010) and 0.07/0.23 = 30.4% for van Reenen et al. (2010).

are thus based on multiplying the impact on output per worker reported in the studies (second column from the right) by 30%.

Figure 18 Studies estimating the impact of ICT capital on output per worker in Europe

Study	Geography	Impact of 10% increase in ICT capital on output per worker (percentage points)	Implied impact of 10% increase in ICT capital on TFP (percentage points)
Bloom et al. (2012)	UK	0.15	0.05
Hempbell (2005a)	Germany	0.41	0.12
Hempbell (2005a)	Germany	0.22	0.07
Hempbell (2005b)	Germany	0.49	0.15
Hempbell (2005b)	Germany	0.60	0.18
Venturini (2009)	EU-15	0.94	0.29

3.2 Investment in telecommunications has a positive impact on productivity

We estimate that investment in telecommunications capital in Ireland between 2013 and 2015 (as opposed to other forms of investment) has led to additional productivity (TFP) growth, adding €1.01 billion to modified GNI in 2016.[49]

This estimate focuses on the impact of investments in telecommunications capital stock on productivity (not the impact that investments have on total output). This is the effect that telecommunications investments have by making the Irish economy more efficient in combining workers and capital equipment to produce economic output. Therefore, the estimates only include the returns to ICT equipment that are *in excess* of typical returns to capital assets such as buildings, plant machinery, and others.

To derive this estimate, we have used data on the share of telecoms in total ICT capital investment; then, we have computed how much higher the total ICT capital stock is as a result of this investment. This allows us, in the final step of our calculations, to use existing estimates of the relationship between the ICT capital stock and TFP growth to estimate the increase in TFP in Ireland as a result of this investment.

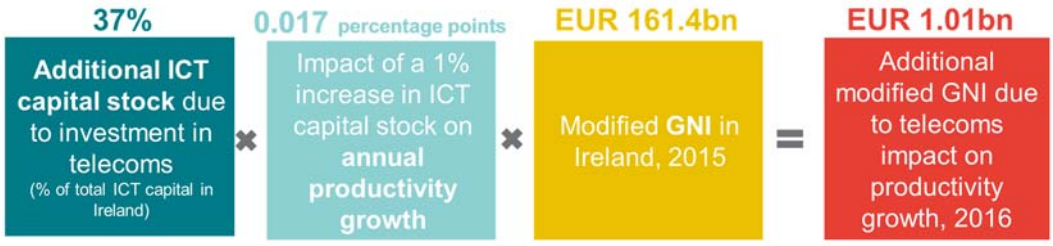
We estimate that, as a result of investment in telecommunications capital between 2013 and 2015, total ICT capital stock in Ireland is 37% higher at the end of the period (2015) than it would have been absent the investment. We consider the

[49] GNI* is the preferred method for assessing national income in Ireland as recommended by the Economic Statistics Review Group (2016, report available at https://www.cso.ie/en/csolatestnews/eventsconferencesseminars/resrg/).

2013-2015 period, as this is consistent with the impact of a "marginal change" in the capital stock as analysed in the literature.

Figure 19 then shows how this estimate is used to derive the impact on productivity.

Figure 19 Calculation of estimated impact, 2016



Source: Frontier calculations based on CSO, Eurostat, International Telecommunications Union data and existing economic literature.

Interpreting this analysis

This analysis provides an estimate of the impact that telecommunications investments make to productivity. However it is not possible to *add* the €1bn to the *direct estimate* of the impact of telecoms to the Irish economy. Doing so would involve double counting and would overestimate the total impact that telecommunications have on the Irish economy since some of the incremental productivity would be reflected in greater output in the telecommunications sector.

To avoid double counting when estimating the total impact telecoms have on the Irish economy (specifically GNI*), it is necessary to isolate the productivity impact that has been generated *outside* of the telecommunications sector. However, this is not possible given the available data, as there is limited information on the ICT capital and TFP growth specific to the telecommunications sector in Ireland.

We can make a high-level estimate of how much of the productivity effect is produced outside the telecommunications sector, using data on ICT capital from other countries and making assumptions on how the impact of ICT on productivity varies across sectors. For example, in the UK, as of 2015, 16% of total ICT capital stock was installed in the telecommunications industry.[50] Therefore, if we assume that this proportion is similar in Ireland, and that the impact of ICT capital on TFP is constant across sectors, this would imply that around 84% of the impact of telecommunications on GNI* we have estimated could be *additional* to the direct impact of telecommunications. However, given the uncertainties in the distribution of ICT capital stock across different sectors of the Irish economy, and difficulties in estimating the how capital stock affects TFP at a sectoral level, the precise degree of double counting is difficult to estimate.

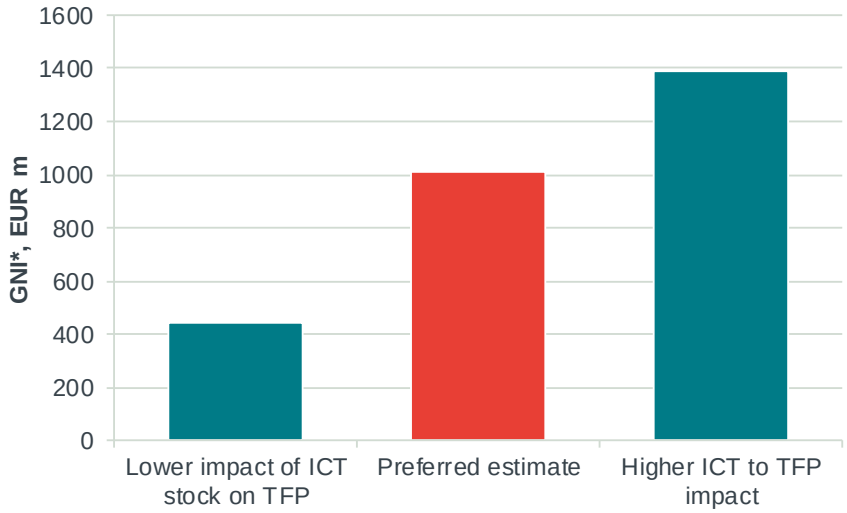
3.3 Sensitivity estimates

Our estimate of the impact of telecommunications investments on GNI* through increased TFP relies on an estimate of the impact of ICT capital on TFP. As

[50] This proportion is lower than the 37% contribution of total investment in telecoms equipment to ICT capital stock because investment in telecoms equipment can take place outside the telecoms industry. Source: Eurostat.

discussed above, the estimate we use is chosen from a range of estimates generated by existing studies. Figure 20 below shows how basing our estimate on different coefficients from within that range would affect our results, compared to the base case.

Figure 20 Robustness of results to modelling assumptions, 2016



Source: Frontier Economics calculations

This is then set out in more detail in Figure 21, below.

Figure 21 Alternative modelling inputs

Estimate	Input 1: Additional ICT capital due to telecoms (% of total ICT stock)	Input 2: Additional TFP growth due to 10% ICT capital increase (percentage points)	Impact of telecoms on GNI*, 2016 (€ m)
Lower impact of ICT stock on TFP	37%	0.075	442
Preferred estimate	**37%**	**0.17**	**1,009**
Higher ICT to TFP impact	37%	0.176	1,387

Source: Frontier Economics calculations based on data from CSO and Eurostat, and on economic literature summarised earlier in this note.

4 TELECOMMUNICATIONS HAVE AN ENABLING IMPACT ON THE WIDER DIGITAL ECONOMY

Telecommunications are an important input in all downstream markets. Indeed, it is hard to think of any economic activity that does not benefit from the recent advances in telecommunications technologies.

For example, goods and services are produced and distributed more efficiently as telecommunications enable new production processes. And, in addition, the widespread adoption of innovative telecommunications products and services by *consumers* has enabled new markets and services, such as mobile applications, whether games, social networks, music and video streaming and mobile advertising.

It is likely that, in the coming years, the reliance on telecommunications across the economy will increase. Advances in power supply (cheaper, lighter, smaller, and better performing batteries), alongside advances in computing (smaller, cheaper computer chips) mean that there will be a growing use of telecoms in equipment and services where it is not currently used. In turn, this means a growing number of devices will be connected to the internet – ultimately relying on telecommunications networks. In this regard, the digital economy[51] is particularly enabled by telecommunications services. This is because in order to develop, create and distribute digital goods, it is necessary to use telecommunications networks. Therefore telecommunications services make an important contribution to the economy across a wide range of sectors.

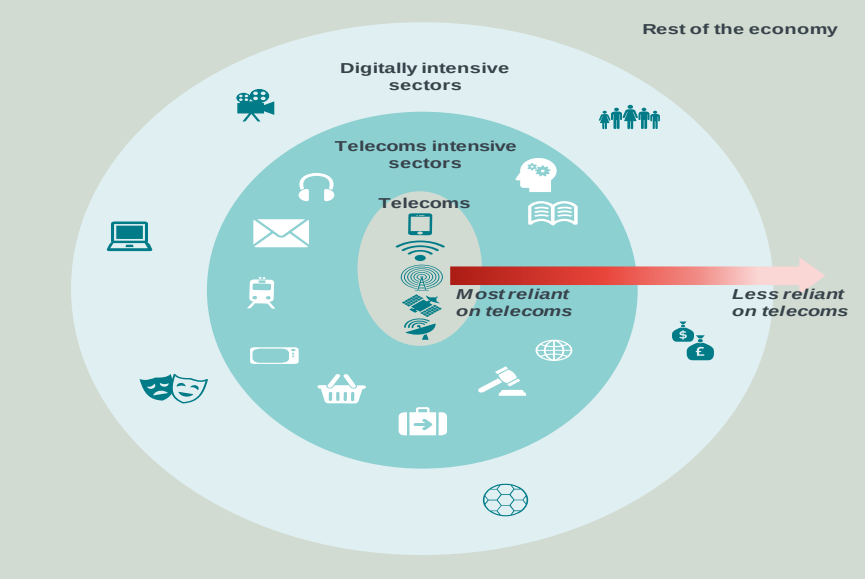
It is not possible to isolate the contribution that *telecommunications* make to the (digital) economy as distinct from other inputs (i.e. what the difference in economic output would be if telecommunications services were unavailable). Conceptually, a thought experiment can consider what the impact of a long-lasting catastrophic failure of telecommunications networks would be. Given the importance that telecommunications play in enabling the production and distribution of goods and services, a catastrophic failure of networks would cause a large negative shock on most sectors of the economy. For example, some sectors might substitute from telecommunications inputs to other more costly or less effective inputs (e.g. physical data storage, or printed distribution for publishing services). Communication could take place in person or via mail. As a result, end products would be less valuable (of lower quality or produced less efficiently) and some services would not be produced (such as social networks).

Sectors that use a high proportion of telecoms inputs or digital inputs would be most affected, economic output in other sectors might be less affected if telecommunications services were unavailable. The net outcome would be lower economic output, although the impact would vary across different sectors, with

[51] There is no standard definition of "the digital economy". It includes the creation and supply of intangible goods, whether software, broadcasting content, books and newspapers, or music, which are now distributed more efficiently over ECS networks. Intangible goods, whether investments in brand, software or legal and other professional services, are now also vital inputs across all sectors of the economy. It can also relate to the gathering and use of digital data to support and enable innovative services which benefit consumers.

some more affected than others depending on their reliance on telecommunications (Figure 22).

Figure 22 Sectors vary in their reliance on telecommunications



Source: Frontier

In this section, therefore, we seek to identify those sectors that most rely on telecommunications, and assess the economic value added created in those sectors. First, we identify those sectors that are *intensive* users of telecommunications services.

Second, we identify those sectors which could be defined as being in the "digital economy" (we do this by identifying sectors which are heavy users of digital inputs).[52]

While our intent is to identify sectors that are directly enabled by telecommunications, the results should not be interpreted as an exhaustive list. The impact of telecommunications goes beyond these sectors, and contributes significantly to a broad range of industries. Furthermore, the value added created in the sectors that use or rely on telecommunications cannot be ascribed to telecommunications: clearly there are many important inputs that are used in digital sectors and in the absence of these sectors, resources may be deployed elsewhere in the economy. Nonetheless, the analysis illustrates the importance of telecommunications throughout the economy.

[52] This approach builds on a methodology previously published by Frontier, which identifies digital sectors in the UK economy. See: http://www.technology-ireland.ie/Sectors/TI/TI.nsf/vPages/Influence~Working_Groups~data-working-group/$file/TI+Brexit+Impact+Report+WEB.pdf

4.1 Identifying sectors which are enabled by telecommunications

We have identified, firstly, sectors that are intensive users of telecommunications, and secondly, digitally intensive sectors (which therefore rely on telecommunications).

4.1.1 Sectors that are intensive users of telecoms inputs

We have identified two alternative measures to rank sectors by their use of telecommunications. For this, we have used data sourced from the 2015 Input-Output tables obtained from Ireland's Central Statistics Office (CSO). For 2015 (the most recent year for which Input-Output data is available), the CSO provides the volume of a given sector's inputs by all sectors in the Irish economy, for each sector[53].

Using this data, we classify "intensive telecommunications users" as sectors (defined at NACE 2[54]) ranked above the 85th percentile[55] in the following two metrics[56]:

- telecoms inputs as a proportion of output; and,
- the proportion of total inputs that are telecommunications inputs.

These are the sectors that require a relatively high proportion of telecommunications inputs in order to create their output.

4.1.2 Digitally intensive sectors that rely on telecommunications

In addition to telecoms-intensive sectors, telecommunications support and enable digitally intensive sectors. We define these as sectors intensive in the use of digital inputs, defining digital inputs as either:

- publishing, audio-visual and broadcasting services inputs; or,
- computer programming, consultancy and information service activities inputs.

Publishing and audio-visual services, as well as computer programming and software services are fundamentally digital in nature. In order to incorporate these digital inputs into firms' production and supply processes, it is likely that firms would have a high reliance on telecommunications.

[53] The 2015 results were released on 23 October 2018.

[54] CSO publishes data on economic activity in Ireland which is disaggregated into 57 distinct sectors.

[55] This corresponds to the top 9 of the 57 sectors defined by CSO. To assess the robustness of our results, we check how the list of industries changes when considering sectors in the 75th percentile of the respective categories (i.e. the top 14 of 57 sectors).

[56] The calculations rely on 2015 CSO Use Tables at purchasers' prices. Intensity of output was calculated as the proportion of total inputs (domestic and foreign) out of total output by sector at basic price. Intensity of inputs was calculated as the proportion of total inputs (domestic and foreign) out of total intermediate consumption.

We classify a "digitally enabled sector" as a sector that is ranked above the 85th percentile[57] in its use of either publishing or computer programming inputs,[58] (as a proportion of total inputs and total output).

4.2 Summary results

Telecommunications clearly play an important role in enabling all kinds of economic activity. We have identified those sectors which are likely to have a particularly high reliance on telecommunications. This is because they are intensive users of telecommunications, or because they are more generally digitally intensive sectors.

In combination, these sectors directly created €69bn of value added in 2016, representing approximately two fifths of GNI* in 2016. As noted, the total value added created in these sectors cannot be ascribed to telecoms. Nonetheless, this does still show the crucial role that telecoms has in supporting the wider Irish economy.

The proposed methodology allows us to identify three relevant categories of sectors that are enabled by telecommunications:

- Digitally intensive-sectors which do not have a high intensive of telecoms inputs: the list includes sectors reliant on digital equipment and services, for example, publishing and computer programming, but also manufacturing services benefiting from more innovative production processes.
- Digitally and telecoms intensive sectors: these include the advertising industry and postal services.
- Telecoms-intensive sectors that are not digitally intensive: these sectors, although not using a large proportion of digital inputs, are still reliant on telecommunications services.

The figure below displays the complete list of sectors by category.

[57] That is, the top 9 out of the 57 sectors defined by CSO. To assess the robustness of our results, we check how the list of industries changes when considering sectors in the 75th percentile of the respective categories (top 14 out of 57 sectors).

[58] Note that percentile choice is arbitrary.

Figure 23 Digitally intensive sectors enabled by telecommunications

Digitally intensive sectors which do not have a high intensity of telecoms inputs	Digitally intensive sectors with high intensity of telecoms use	High intensity of telecommunications services but not digitally intensive
Publishing, film and broadcasting services	Other financial activities	Rental and leasing activities
Computer programming, consultancy and data processing	Head office and management consultancy activities	Public administration
Insurance, reinsurance and pension funding	Advertising, market research, other professional & scientific services	Legal and accounting activities
Recreation and sports activities	Postal and courier services	Security, office and business support activities
Manufacture of fabricated metal products	Water collection, treatment and supply	Telecommunications services
Other personal service activities	Repair of consumer goods	Sewerage, waste collection and remediation services
Membership organisation services		
Printing and reproduction of recorded media		
Manufacture of pulp, paper and paper products		
Water transport services		

Source: *Frontier Economics calculations based on CSO data*

Notes: *Telecommunications services rely on telecommunications inputs, for example a number of retail telecommunications services rely on various wholesale inputs from eir or others.*

Figure 24 sets out the GVA generated in telecoms or digitally intensive sectors in 2016. The sectors where telecommunications play an important enabling role jointly accounted for €69bn of value added produced in the Irish economy in 2016[59]. Telecoms-intensive sectors account for €39bn, while digitally intensive sectors account for €40bn.

[59] Of which €10bn related to sectors which have a high reliance on telecommunications inputs and digital inputs and; €30bn related to sectors which have a high reliance on digital inputs but relatively less reliance on telecommunications; and €29bn related to sectors which have a high reliance on telecommunications inputs but relatively less reliance on digital inputs.

Figure 24 GVA generated in telecoms or digitally intensive sectors (2016)

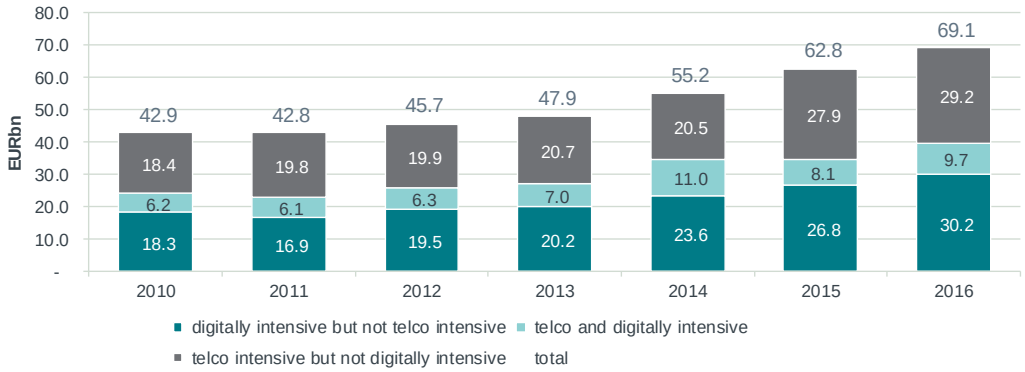
Digitally intensive sectors which do not have a high intensity of telecoms inputs	Digitally intensive sectors with high intensity of telecoms use	High intensity of telecommunications services but not digitally intensive	Total
GVA €30bn	GVA €10bn	GVA €29bn	GVA €69bn

Source: Frontier Economics calculations based on CSO data

Note: The sum of the first two columns represents the total GVA for digitally intensive sectors €40bn, while the sum of columns 2 and 3 represents the total GVA for telecoms-intensive sectors €39bn.

As shown in the figure below, GVA in digitally and telecommunications-intensive sectors has been increasing over time in the last decade.

Figure 22 GVA trends in telecoms or digitally intensive sectors



Source: Frontier Economics calculations based on CSO data

4.3 Sensitivity

The results presented above identify the sectors that are "intensive" users of telecommunications or digital inputs. Inevitably the threshold to determine whether a sector is intensive or not is arbitrary. Therefore we consider two sensitivity checks in addition to the baseline scenario using a lower threshold:

- Baseline scenario: intensive sectors are those above the 85th percentile (top 9 sectors of all 57 sectors defined by CSO in the Input-Output tables).
- Sensitivity 1: intensive sectors are those above the 80th percentile (top 12 sectors).
- Sensitivity 2: intensive sectors are those above the 75th percentile (top 14 sectors).

Figure displays additional sectors that would be included in each category when lowering the percentile threshold.

Figure 23 Incremental sectors as a result of using a lower "intensity threshold"

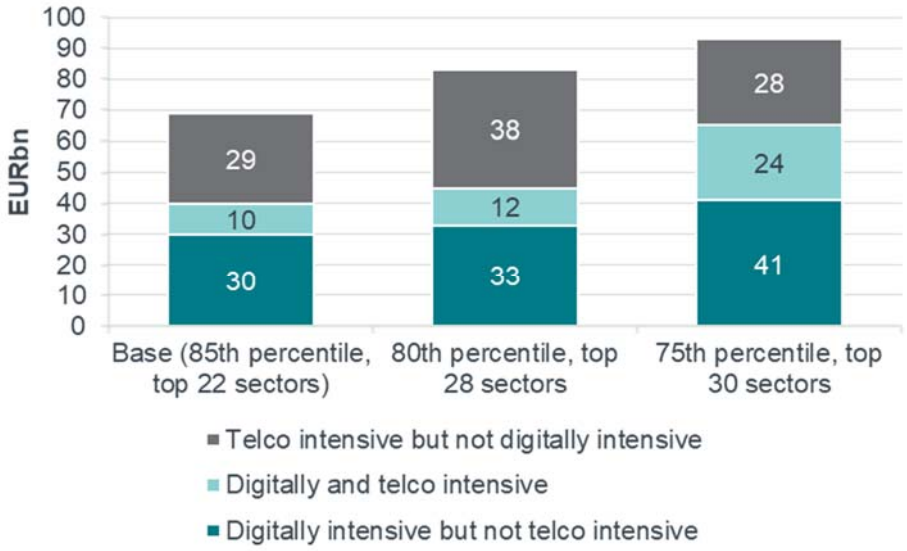
	Digitally intensive sectors which do not have a high intensity of telecoms inputs	Digitally intensive sectors with high intensity of telecoms use	High intensity of telecommunications services but not digitally intensive
Sensitivity 1: 80th percentile (i.e. the top XX of YY sectors)	Mining, quarrying and extraction; Air transport services	Manufacture of textiles; Membership organisation services.	Employment services ; Education services.
Sensitivity 2: 75th percentile (i.e. the top XX of YY sectors)	Manufacture of beverages and tobacco products; Financial service activities	Air transport services; Education services.	

Source: Frontier Economics calculations based on CSO data

*Note: All sectors indicated with * change from one category to another as a result of the change in the percentile rule.*

Lowering the threshold to the 75th percentile results in an additional €25bn in the GVA estimate compared to the baseline scenario.

Figure 24 GVA of telecoms and digitally intensive sectors



Source: Frontier Economics calculations based on CSO data

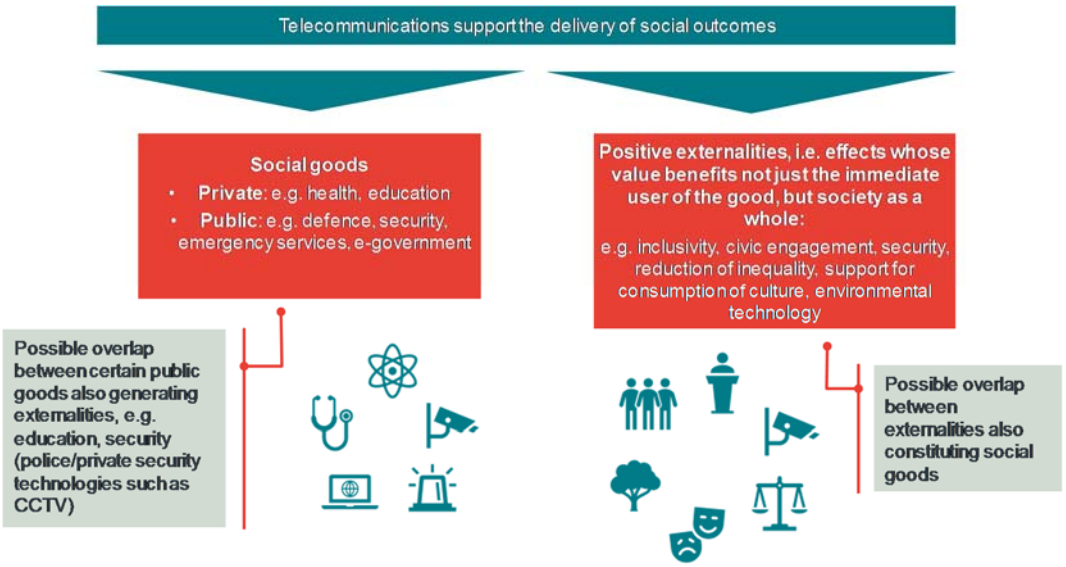
Note: Figures are based on 2016 GVA data

5 TELECOMMUNICATIONS SUPPORT THE CREATION OF SOCIAL VALUE

Telecommunications services play a fundamental role in delivering social outcomes. While it may be difficult to quantitatively estimate the economic value that telecommunications create in delivering social outcomes, it is important nonetheless to recognise its role.

There are a number of channels through which telecommunications enable "social value" (see Figure 25). The first is the supply of goods and services which are social in nature (these for example could include services such as education and health or public goods). The second type of social value could be derived from "spillover" effects. Spillovers are defined as effects (positive or negative) which result from the consumption of goods and services that do not accrue to those who consume the goods and services. Where these spillovers relate to "social" effects, they can be considered as supporting social value.

Figure 25 Different types of "social value"



Source: Frontier

There is often an overlap between social goods and externalities, since private "social" goods, such as education and health, can lead to positive economic spillovers. For example, "individual" education creates a positive externality by improving social cohesion and economic productivity. Likewise, the provision of healthcare does not only benefit the individual who consumes it, but also society in general since it prevents the spread of infectious disease and it increases overall well-being and productivity.

5.1 The role of telecommunications in enabling social goods

Telecommunications can be said to provide social value through their support of health, education and other "public" goods, such as emergency services and e-government.

Education

Telecommunications play an important role in delivering education. According to a document published by DCCAE, broadband technologies can contribute to the improvement of quality and accessibility of education in a number of ways:

- "*the online availability of educational tools which supplement the in-class learning experience in the case of primary and post-primary education;*
- *facilitating greater access to relatively specialist teaching resources in sparsely populated areas, through the running of online tutorials and/or live webcasts;*
- *enhancing the quality of physical engagement with teaching staff;*
- *enhancing the national and global accessibility, and by extension, affordability of private education services through remote learning programmes;*
- *enabling online student fora and project teams, with additional learning potential*."[60]

The Irish Government has recognised the role that ICT investment plays in delivering education. To support the use of telecommunications as a tool to enable education, the Government has allocated funds directly to schools.[61] The Irish Government's "Digital Strategy for Schools 2015-2020[62]" set out the Department of Education and Skills' plan for embedding ICT in Irish schools. Elements of the plan included reforming the curriculum so that ICT be embedded in all emerging curricular specifications, the continuing rollout of a €210 million capital investment programme and a progressive programme of high-speed broadband connectivity.

Alongside government investment to support e-learning, it is estimated that on average, parents will spend €213 per child on internet-connected devices and tools intended for schoolwork this year[63].

[60] PwC's 2015 report on the benefits of Ireland's National Broadband Plan, NGA (Next Generation Access, i.e. high-speed and high-quality) https://www.dccae.gov.ie/en-ie/communications/consultations/Documents/80/consultations/Benefits%20of%20High%20Speed%20Broadband.pdf

[61] Under the Schools 100Mbps project, which is jointly co-ordinated by the Department of Communications and the Department of Education, 100Mbps broadband has been rolled out to all secondary schools in Ireland. In addition, the Digital Strategy for Schools action plan, published earlier this year (2017), includes €30 million in ICT grants to schools, as well as a programme to enhance high-speed broadband connectivity in primary schools. See: https://www.irishtimes.com/business/technology/parents-up-in-arms-over-poor-broadband-connectivity-in-schools-1.3195581

[62] Department of Education and Skills, Digital Strategy for Schools 2015-2020, Action Plan 2017. Available at https://www.education.ie/en/Publications/Policy-Reports/Digital-Strategy-Action-Plan-2017.pdf

[63] According to an article published by the Irish Times in August 2017.

Healthcare

Telecommunications play an increasing role in delivering healthcare and supporting positive health outcomes. Telecommunications technology in healthcare, or "telehealth", involves using technology to enable healthcare professionals to remotely monitor data on a patient's health. Examples include video consultations/videoconferencing, monitoring patient data remotely, as well as providing the patient with electronic prescriptions and other information relevant to the treatment or management of their condition. Telehealth delivers more personalised, targeted and thus more effective healthcare but it can also be vital in saving the life of a patient who needs immediate specialist care but is unable to physically reach the specialists in a remote area.

Ireland has had a comprehensive eHealth strategy in place since 2013 and eHealth was confirmed as an investment priority in the National Development Plan 2018-2027. The Irish Government has promised "***access to telehealth and telecare … where appropriate***."[64] As of 2016, there were at least seven providers in the Irish market offering, or about to offer, online services that put a patient in contact with a GP via a computer, tablet or smartphone. Companies are now offering a wider range of services typically associated with a GP, such as the examination of symptoms and the treatment of minor ailments and injuries via online consultation. For example, in 2017 the National Association of GPs (NAGP) launched a GP-Online service which would enable patients to talk to their family doctors without physically going.[65]

e-government

e-government is the use of ICT technologies for the provision of public services to citizens. Telecommunications play an important role in delivering government services in Ireland.

According to the European Commission's DESI 2018 detailed Country Report[66] for Ireland, the country ranks 10th in the European Union in Digital Public Services. International indices find that Ireland is ahead of other countries in the supply of e-government services (Figure 26), ranking 22nd out of 193 surveyed countries for the United Nations' E-Government Development Index (EGDI)[67].

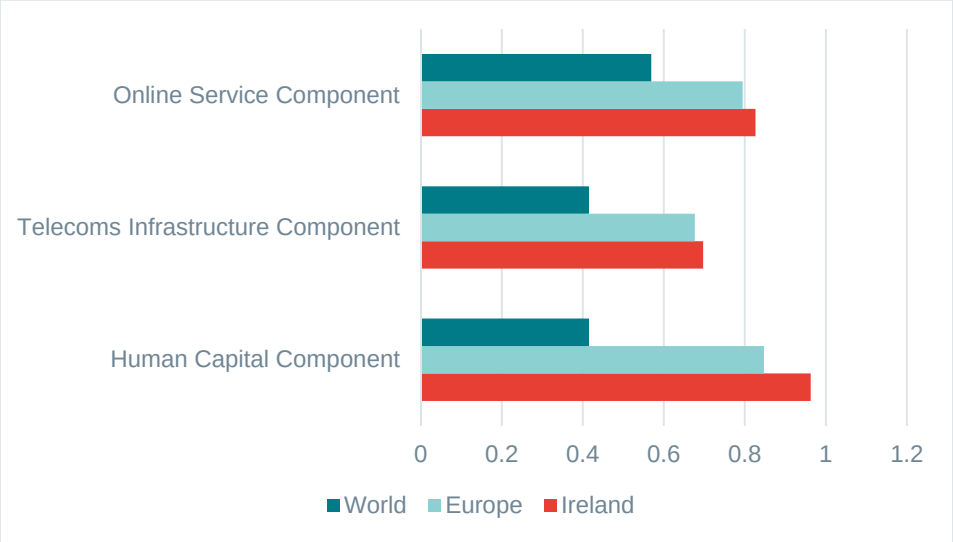
[64] Department of Health, 2012, Future Health – A Strategic Framework for Reform of the Health Service 2012-2015, page 17. Available at https://health.gov.ie/wp-content/uploads/2014/03/Future_Health.pdf

[65] NAGP, 2017. Available at https://nagp.ie/gp-online-to-be-launched-at-primary-care-partnership-conference/

[66] European Commission, Digital Economy and Society Index Report 2018 – Country Report Ireland, pages 2,10. Available at http://ec.europa.eu/information_society/newsroom/image/document/2018-20/ie-desi_2018-country-profile_eng_B4406C2F-97C3-AA9A-53C27B701589A4F3_52225.pdf

[67] United Nations, E-Government Survey 2018 – Annexes, page 229. Available at https://publicadministration.un.org/egovkb/Portals/egovkb/Documents/un/2018-Survey/E-Government%20Survey%202018_FINAL%20for%20web.pdf

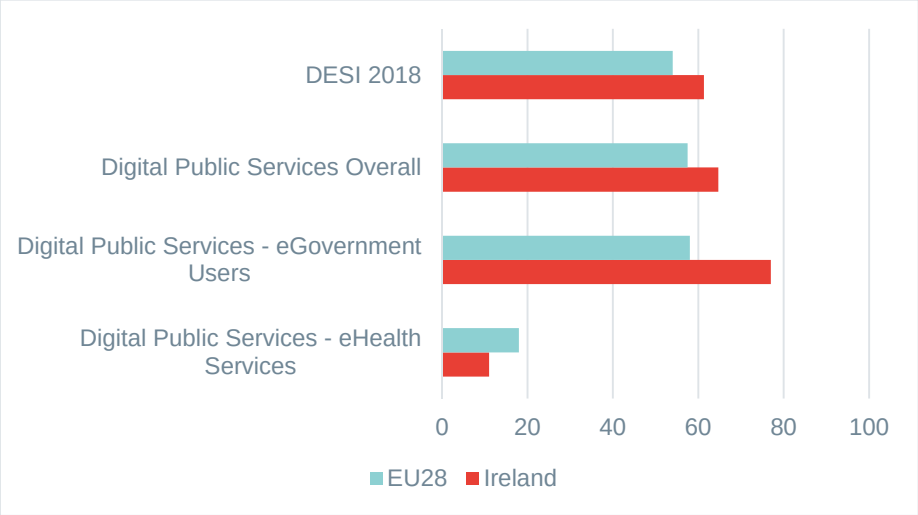
Figure 26 UN E-Government Development Index (EGDI) 2018



Source: United Nations, E-Government Survey 2018 – Annexes, pages 229, 233. Available at https://publicadministration.un.org/egovkb/Portals/egovkb/Documents/un/2018-Survey/E-Government%20Survey%202018_FINAL%20for%20web.pdf

Similarly, according to the European Commission's Digital Economy and Society Index (DESI) 2018 report, Ireland ranks highly in its provision and use of e-government[68] .

Figure 27 EU Digital Economy and Society Index (DESI) 2018



Source: European Commission, Digital Economy and Society Index Report 2018 – Country Report Ireland, pages 2,10. Available at http://ec.europa.eu/information_society/newsroom/image/document/2018-20/ie-desi_2018-country-profile_eng_B4406C2F-97C3-AA9A-53C27B701589A4F3_52225.pdf

[68] The DESI assesses Connectivity, Human Capital, Use of Internet Services, Integration of Digital Technology and Digital Public Services. Ireland has the European Union's sixth most advanced digital economy, while the EU28 average ranks 15th. European Commission, Digital Public Services – Digital Economy and Society Index Report 2018, pages 2-5, 8. Available at http://ec.europa.eu/newsroom/dae/document.cfm?doc_id=52244

5.2 The role of telecommunications in supporting positive social externalities

Positive externalities are defined as benefits which affect not just the immediate user of the good, but society as a whole. The use of telecommunications services and related services (such as communication applications) can have a number of positive "social externalities". Examples are the role that telecommunications play in the promotion of social inclusion, civic engagement, security, reduction of inequality, increased consumption of culture and environmental technology.

Social inclusion

The use of telecommunications, social networks and other communications applications can create positive externalities by supporting social inclusion. These services strengthen the ties within and between different communities and social groups, which can lead to increases in productivity and increased labour force participation. Greater social inclusion can have a number of spillover impacts: higher labour participation, greater work productivity, improved and more efficient health outcomes.

The role of ICT in fostering greater social inclusivity for groups less able to access certain services, has been acknowledged through government programmes such as the National Disability Inclusion Strategy (2017-2020), which sets out targets to support the inclusion of disabled persons. This includes measures such as ensuring that public sector information is available in accessible formats and promoting the use of ICT in schools as a tool for students with special educational needs. Furthermore, according to a report for Enable Ireland[69], ICT can enable people with disabilities, the elderly or residents of rural areas to become more engaged members of society by relying on telecoms networks such as the sharing economy.

Civic engagement is enabled by telecommunications

Telecommunications technologies can also play a critical role in encouraging citizens' participation in public debate and engagement with the community, which in turn has a positive effect on productivity, social cohesion and overall well-being. A recent example could be Ireland's 2018 referendum on abortion, where social media and digital campaigning were vital in mobilising large segments of the population (especially younger people) to vote. Using social platforms such as Facebook, Twitter and Instagram, both sides of the debate used social media to reach voters and mobilise their supporters. Increased engagement in civic procedures and public life enriches social dialogue, improves social cohesion and can stimulate overall productivity.

[69] Enable Ireland, Annual Report 2017. Available at https://www.enableireland.ie/sites/default/files/publication/2017%20Enable%20Ireland%20Annual%20Report%20Final.pdf

Easier access to culture has positive spillover effects

ICT has clearly had an impact on how culture is accessed and consumed by various social groups. Advances in telecommunications networks, alongside communication applications, services and devices mean that consumers can view all manner of cultural content at the click of a button. Social media and other digital platforms enable authorities, event organisers and artists to expand their audiences and attract new talent. Meanwhile, cultural products such as Irish cinema, theatre, music and art can also be accessed online at a much lower cost by a wider audience. This can promote Irish content, increasing opportunities for Irish artists and stimulating the Irish cultural scene. The consumption of culture can lead to positive social spillovers such as the promotion of Irish culture and the preservation of Irish heritage, which can nurture social cohesion, improve well-being and address policy challenges associated with ageing, mental health and more[70] [71].

Environmental spillovers of using telecommunications

The use of telecommunications can have a positive environmental impact and foster sustainable development. The use of telecommunications to send and distribute services digitally, rather than in physical forms, has obvious positive environmental impacts. Telecommunications and ICT directly support the energy industry in meeting environmental objectives. For example, telecommunications technologies support the monitoring and control of the national energy network to more efficiently distribute energy.[72] Similarly the agriculture sector increasingly relies on telecommunications to promote efficiency and yield management, which in turn will have positive environmental impacts[73].

[70] All-Party Parliamentary Group on Arts, Health and Wellbeing, 2017. Available at http://www.artshealthandwellbeing.org.uk/appg-inquiry/

[71] A recent report by European Research Partnership on Cultural and Creative Spillovers described the various spillovers that result from the creation and consumption of cultural goods. These were categorised as either (i) knowledge spillovers such as new ideas, innovation and processes developed within arts organisations and by artists and creative businesses which spill over into the wider economy and society; (ii) industry spillovers, which are benefits to the economy and society in terms of productivity; and (iii) network spillovers which relate to the presence of a high density of arts and/or creative industries in a specific location (such as a cluster or cultural quarter). See: https://ccspillovers.weebly.com/evidence-review-2015.html

[72] Sustainable Energy Authority of Ireland, 2019. Available at https://www.seai.ie/blog/smart-grid/

[73] Eolas Magazine, 2017. Available at http://www.eolasmagazine.ie/new-technologies-driving-agriculture/

6 SUMMARY IMPACTS

In this report we have set out, and sought to estimate, the various channels though which telecommunications benefit the Irish economy, whether through private economic benefits (such as the value added of certain sectors, or the impact of investment in telecommunications on productivity, more generally) or through social value. We have demonstrated that this impact is far-reaching and indeed, we believe it is likely to continue to grow, as almost all sectors in the economy become more digitally intensive.

In summary, we find that:

- The total value added created by suppliers of telecommunications goods and services in Ireland amounted to €2bn in 2016. Taking into account the indirect impacts and taxes[74] on the telecommunications sector we estimate that the total contribution of the sector to the Irish economy in that year was €2.4bn. This accounted for 1.4% of Irish GNI*[75]. We estimate that the total employment within the sector was approximately 10,000 employees and the value added per employee in the sector amounted to €177k. This compared to the value added per employee across the whole economy of €91k per employee.
- We estimate that, as a result of investment in telecommunications capital in Ireland between 2013 and 2015 (as opposed to other forms of investment), TFP was 0.63 percentage points higher in 2016 than it would have otherwise been[76]. This implies that the productivity impacts of telecommunications investment mean that modified Gross National Income (GNI*) was around €1 billion higher in 2016 than it would have been absent the investment.[77]
- Sectors that are intensive users of telecommunications, or are more generally digitally intensive sectors, directly created €69bn of value added in 2016. This represents approximately two fifths of GNI* in 2016. Obviously the total value added created in these sectors cannot be ascribed to telecoms. Nonetheless, this does show the crucial role that telecoms plays in supporting the whole economy.
- Telecommunications play an important role in supporting the supply of "social goods" whether health, education or public services more generally. Furthermore, there are a number of positive social impacts that result from the use of telecommunications. The use of telecommunications can positively increase social inclusivity, or promote civic engagement which has positive "spillover" impacts on the economy.

[74] In order to understand the full contribution to the economy, it is necessary to include product taxes which are levied on products and services which are not included within GVA.

[75] GNI* relates to estimate modified Gross National Income.

[76] This relates to the increase in the size of the ICT capital stock as a result of ECS investments made (37%) and the elasticity of TFP with respect to changes in ICT capital stock (a 1% increase in the ICT capital stock is linked with a 0.017 percentage point increase in TFP).

[77] GNI* is the preferred method for assessing national income in Ireland as recommended by the Economic Statistics Review Group (2016, report available at https://www.cso.ie/en/csolatestnews/eventsconferencesseminars/resrg/).

ANNEX A REVIEW OF LITERATURE ON THE RELATIONSHIP BETWEEN PRODUCTIVITY AND TELECOMMUNICATIONS

For our analysis of the impact of telecommunications on productivity, we focus on productivity defined as Total Factor Productivity (TFP), which measures how efficiently an economy combines its inputs (labour and capital) to generate output. This is for two reasons:

- Differences in TFP are more important in explaining long-run differences in economic growth over time and between countries than differences in the quantity or quality of inputs (see for example Hall & Jones, 1999);
- Focusing on TFP allows us to focus on the additional effect of ICT equipment, on top of what might be achieved through other investments. Investment in any form of capital leads to greater productivity, measured as output or GVA per worker. However, there is evidence that ICT capital has an additional impact compared to other forms of capital – its impact on TFP.

To estimate the likely impact of ICT capital on productivity growth, we carried out a review of the available literature, including:

- Academic working papers and articles published on peer-reviewed journals;
- Studies published by public sector institutions in the UK and internationally;
- Research undertaken by organisations within the communications sector and industry analysts.

We restricted our search to studies published in the last 15 years that provide robust quantitative estimates of the impact of ICT investments. These estimates are typically obtained by comparing productivity growth in countries or firms that use varying levels of ICT capital.[78] Restricting the scope of our analysis to robust econometric studies excludes:

- 'Growth accounting' studies, which observe what proportion of total productivity growth has taken place in industries which produce ICT equipment (e.g. manufacture of computers, computer programming) and industries which use ICT (typically including Finance, Research & Development and other Professional Services, among other sectors);
- Studies providing simple correlations between ICT use and productivity, not controlling for any other possible factors.

[78] For the purposes of this report, we define as 'robust' estimates that use econometric methods to credibly control for other factors that may be driving the relation between ICT capital and productivity. For example, if better-managed firms also use more ICT, a simple comparison between firms that use more and those that use less ICT would overestimate the impact of ICT on productivity – the estimated impact would reflect not only the role of ICT but also the role of good management.

Having completed our review, we have also excluded estimates based on data from the United States (US)[79]. This is because there is robust evidence that the impact of ICT on productivity has been larger in the US than in Europe, and therefore using US figures would have likely led us to overestimate the impact of ICT investment on productivity in Ireland. For example:

- Productivity growth in ICT-producing and ICT-using industries between 1995 and 2005 has been greater in the US than in those European countries for which equivalent data is available;
- O'Mahony & Vecchi (2005) and van Reenen et al. (2010), among others, estimate the impact of ICT, using data from both the US and other countries, and find the impact to be larger in the US. Bloom, Sadun & van Reenen (2010) also find that US multinationals based in Europe benefited more from ICT than European firms with local owners.

[79] According to 'Bloom et al. (2012), one of the reasons for the greater impact of ICT in the US is the prevalence of tougher 'people management' practices in US firms. It is also possible that the difference is related to the fact that the US are and were leaders in the development of ICT – but we have not identified studies that investigate this potential explanation.

ANNEX B LIST OF FIRMS CONSIDERED

We set out below the providers considered in each sub-sector of the telecommunications sector. These were identified based on discussion with ComReg and Frontier research.

Figure 1 Fixed telecommunications

BT Communications Ireland Limited
Casey Cablevision Limited
Colt Technology Services Limited
Digiweb Holdings Limited
Eircom Limited/Eircom Holdings (Ireland) Limited
Equant Network Services International Limited
EUNetworks Ireland-Private Fiber Limited
Hibernia Atlantic Cable System Limited
Magnet Networks Limited
Pure Telecom Limited
Sky Ireland Limited
Virgin Media Ireland Limited
Vodafone Ireland Limited

Source: CRO company data

Figure 2 Mobile services

Eircom Limited/Eircom Holdings (Ireland))
Lycamobile Ireland Ltd
O2 Communications Ltd
Tesco Mobile Ireland Ltd
Three Ireland (Hutchison) Ltd
Verizon Ireland Ltd
Vodafone Ireland Ltd
Virgin Media Ireland

Source: CRO company data

Figure 3 Mobile manufacture

Adaptive Mobile
Ericsson
Huawei
Nokia

Source: CRO company data

Figure 4 Mobile retail

The Carphone Warehouse Ltd

Source: CRO company data

Figure 5 Fixed wireless

Digiweb Holdings Limited (512402)
Imagine Communications Group Limited (309126)

Source: CRO company data

Figure 6 PMR

ESB Telecoms Ltd)
Sigma Wireless
Tetra Ireland Communications Ltd

Source: CRO company data

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