Economic Impact of Meta's Subsea Cable Investments in Europe

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1. Overview

This analysis describes the economic impact of Meta's investment in the MAREA subsea cable and the potential economic impact of future cable landings that Meta plans in Europe.[1] As the anchor tenant on the cables analysed herein, Meta's investments made the subsea cable projects economically viable for other consortium members which include both private and public network providers. Meta's investments thus expanded broadband capacity for a vast array of uses. Therefore, this report quantifies the total economic impact of the cables, which includes benefits derived from all capacity supplied by the cables, both public and private.

MAREA catalysed an economic impact of €16.7 billion per year since 2019 (the year after it became operational). To put this in context, between 2015 and 2019 (prior to the economic slowdown caused by the COVID-19 pandemic), Europe's gross domestic product (GDP) per capita grew at a rate of about 1.5% annually. This means that, for Europe, the annual economic impact of MAREA is equivalent to about 6% of a typical year's economic growth (Table 1).

MAREA is a 6,600 km transatlantic cable running from Virginia Beach, United States, to Bilbao, Spain, supplying a total capacity of roughly 240 Tbps through its eight fibre pairs. As one of the highest capacity cables in the world, it supplies Europe with a tremendous amount of bandwidth, offering the lowest latency route between the United States and Southern Europe and providing a diverse path across the Atlantic (Qiu, 2019). These features enable MAREA to keep pace with advances in technology better than pre-existing cables. Many industrial applications increasingly require low latency to remain competitive. The boost in international bandwidth delivered by MAREA induced a reduction in fixed (wired) broadband prices and an increase in penetration of approximately 3.9%, holding all else constant. These effects on the broadband market translate to economic impact by enabling increases in data consumption for commercial uses.

The bandwidth supplied by MAREA has turned out to be especially timely and needed given the surge in demand brought on by the COVID-19 pandemic. The pandemic has highlighted the importance of stable and fast broadband connections. With places of business, schools, and social gatherings forced to transition to online settings, connectivity has become especially vital, as the backbone of business and leisure activities. This forced transition to an online setting increased the use of digital services[2] in Europe from 81% to 95% (de Vet et al., 2021).

Planning for future transatlantic subsea cables is underway and Meta plans to land two cables in 2024 and 2027. We expect that these cables will have an annual economic impact of €27.2 billion and €32.4 billion, respectively, all else held equal. Contextually, the potential annual impact of the two cables, respectively, is approximately equivalent to 9% and 10% of Europe's typical yearly growth (based on Europe's 1.5% GDP per capita compound annual growth rate [CAGR] since 2015).

Table 1. Economic Impact of MAREA and Meta's Potential Subsea Cables on Europe's GDP, Annually

	MAREA	POSSIBLE SUBSEA CABLE LANDING IN 2024	POSSIBLE SUBSEA CABLE LANDING IN 2027	TOTAL
Impact on GDP per capita	0.090%	0.137%	0.157%	0.384%
Impact on GDP, 2020 Euros	16.73 billion	27.19 billion	32.40 billion	76.32 billion
Impact as a share of Europe's typical growth (CAGR)	5.9%	9.0%	10.3%	25.2%

Note: CAGR = compound annual growth rate; GDP = gross domestic product. Estimates reflect the estimated GDP impact of the subsea cables, which for each year post-arrival represents a persistent difference between the actual and the counterfactual GDP of Europe.
Source: Authors' calculations. See Section 6 for methodological details.

1 For our analysis throughout, we defined Europe as the current European Union member states plus Norway, Switzerland, and the United Kingdom.
2 Use of digital services is defined as using one or more digital services among the banking, entertainment, social media, telecoms, grocery, apparel, utilities, public sector, travel, and insurance industries over the last 6 months.

The combined impact of MAREA and the two possible future cables is economically meaningful. In any given year, parts of the economy contract or completely disappear while new areas of growth emerge, and the net is the observed economic growth. While small as a share of total GDP, in the context of typical growth rates, the combined impact of the cables analysed is a meaningful addition to GDP, equating to about 25% of typical yearly growth for Europe.

Interviews with broadband connectivity experts highlighted opportunities and challenges to full realization of the benefits of subsea cable investments. Key issues include the need for international capacity to keep pace with the rapidly increasing demand for data, to increase the diversity of routes and landing points, and to expand terrestrial fibre to reach more of Europe's population.

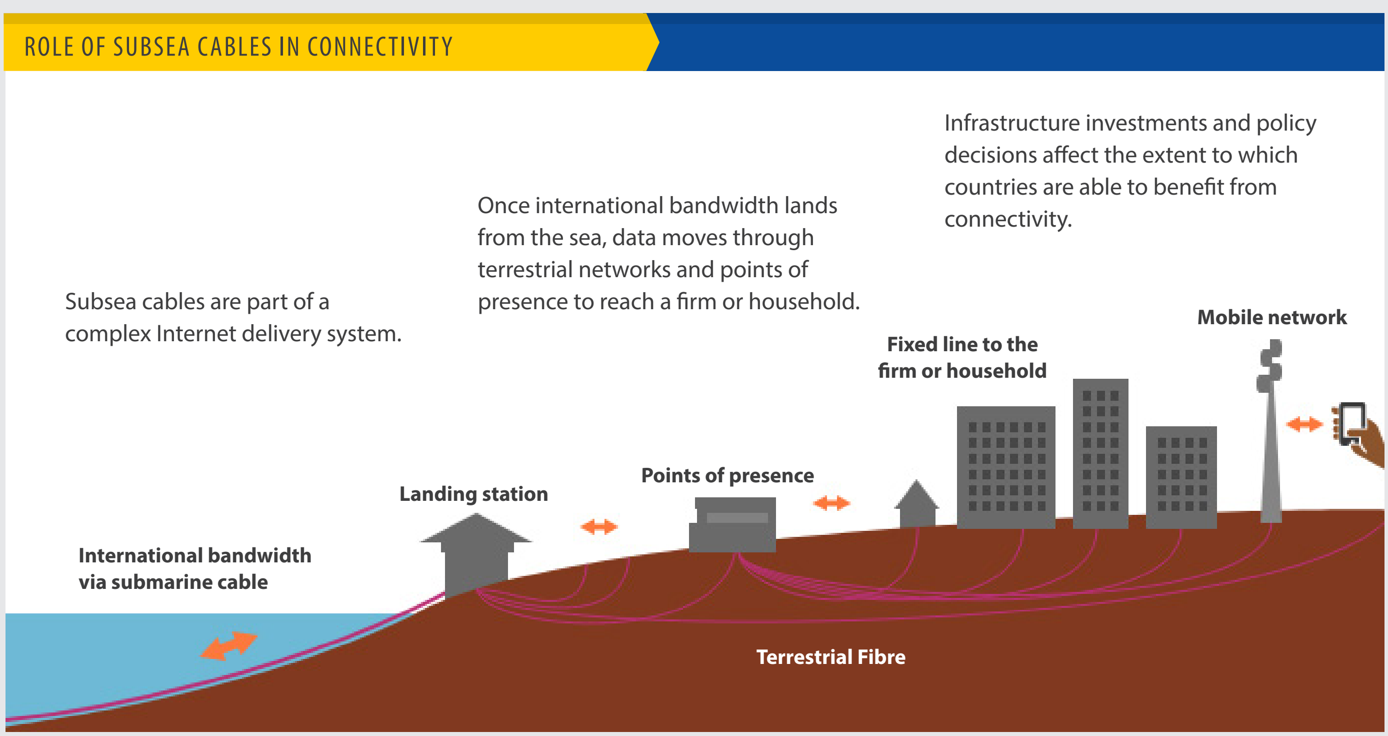
Additionally, Section 8 of this report presents a case study of Ireland, analysing the economic impacts of past and potential subsea cables at the national level. The case study delves further into national-level policy issues relating to subsea cable infrastructure investments and how those policies may accentuate or attenuate the economic impact of subsea cables. The results of this analysis provide evidence of economically significant impacts of subsea cables on the landing country, while also highlighting a range of contextual factors and policy issues that should be considered to maximise the potential economic growth from subsea cables and to ensure that growth is equitably distributed.

2. Role of Subsea Cables in Connectivity

Submarine fibre optic cables, or subsea cables, are among the most important components of the Internet's infrastructure, but they are often the least well known. They are the global backbone of the Internet, connecting people, businesses, and economies around the world. About 99% of international communications traffic is carried by subsea cables (Brake, 2019), as is roughly €8.6 trillion per day in financial transfers (Sunak, 2017).

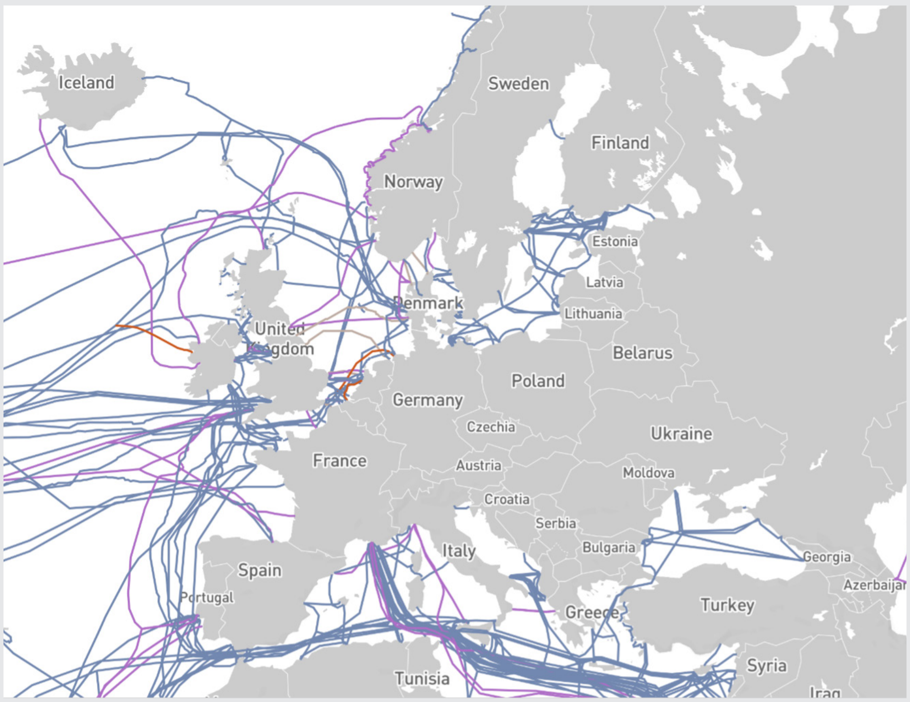
As shown in Figure 1, subsea cables connect the domestic terrestrial fibre network to cloud services and data resources around the world. The more robust the connection between

Figure 1. Role of Subsea Cables in Internet Connectivity



the user and the data resource, the faster, better, and more productive the user experience. Poor connections render some services unusable. Many industry applications depend critically on reliable, low-latency broadband Internet and international bandwidth, including financial trading, e-commerce, and cloud computing, which is increasingly leveraged by various industries. Broadband Internet is also playing an increasingly key role in education, health care (telehealth), and agriculture (precision agriculture).

Figure 2. Map of Active and Planned Subsea Cables in Europe



Note: Active cables are depicted in blue; planned cables are depicted in purple.
Source: Infrapedia (2021).

Projections estimate that the demand for broadband Internet is likely to double every 2 years (van der Vorst, 2018), further increasing the importance of subsea cable infrastructure. An increasing number of users, combined with greater data consumption per user, is creating a surge in demand for bandwidth. If the available bandwidth to carry that data cannot keep up, users can experience increased latency and prices for broadband may rise in order to efficiently allocate scarce bandwidth. As the backbone of the Internet, subsea cables can do much to balance this demand-side pressure by greatly increasing international bandwidth capacity.

Figure 2 depicts subsea cables that land or are expected to land in Europe. Countries within Europe have been quick and plentiful adopters of subsea cable technology. The first subsea telephone cable was the TAT-1 which was built in 1955, connecting Newfoundland to Scotland. The first commercial subsea fibre optic cable was the UK – Belgium 5, connecting the eponymous countries, constructed in 1986. Since this first fibre optic cable, European Union (EU) countries have been a part of every successive generation of cables. The first cables in the late 1980s, such as UK - Belgium 5, the TAT-8, and the UK-Netherlands 12 transmitted in the hundreds of Mbps. In the late 1990s and early 2000s Europe would lead again, with the AC-1 and AC-2 cables of 1999 and 2000, respectively, both reaching over 100 Gbps and the GTT Atlantic reaching over 10 Tbps in 2001.

The newest subsea cables have made a great leap to capacities of over 100 Tbps. The first cable to do so was the C-Lion 1 between Finland and Germany, which was established in 2016. Other notable cables of the newest generation include the AEConnect-2, which nearly doubles the existing cable capacity between Ireland and the United States, by adding 108 Tbps in capacity. The MAREA cable from the United States to Spain, which Meta has stake in, adds roughly 240 Tbps in capacity.

A major advancement that has taken place over the history of European subsea cables is the development of major cable hubs in strategic landing points. Due to geographical location, Lisbon, Portugal; Marseille, France; Helsinki, Finland; and Widemouth Bay, UK, have all become major hubs for subsea cables, serving as the landing point for at least nine cables each. This puts those respective countries in an advantageous position for attracting and facilitating business growth in the modern economy, as it gives companies an incentive to do business in these locations.

3. Trends in Economic Growth and Connectivity in Europe

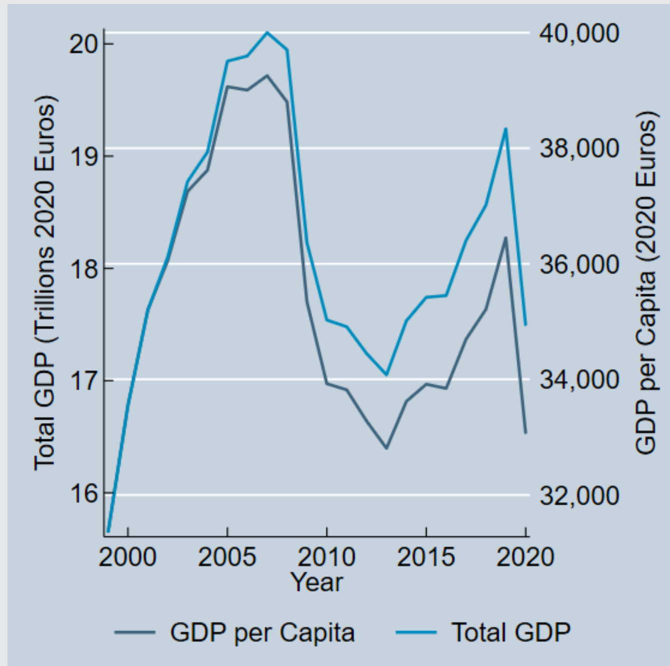
This section provides background information about economic growth and Internet connectivity. Our goal is not to be comprehensive—the multitude of country markets and substantial variability in market conditions within each market make that far beyond the scope of this work—rather, we provide enough information from which readers can appreciate the results of our analysis. We review the overall size of Europe's economy and present highlights about the general state of connectivity.

Europe's combined GDP—the most common measure of the total value of all goods and services produced by an economy—is €17.5 trillion (Table 2). However, there are substantial differences in price levels, living conditions, and other salient factors across all countries. A simple aggregation of the GDP of all European countries grossly underappreciates these differences.

Over the past decade, Europe has experienced middling but relatively stable growth, bookended by two major recessions. The global financial crisis of 2008 significantly affected Europe's economy, inducing economic contraction followed by a sluggish recovery (Figure 3). By 2014, Europe was back on a steady growth trajectory until the COVID-19 pandemic rocked the economy and GDP per capita fell by 9.3% from 2019 to 2020 (Table 3).

The macroeconomic crises have differentially affected countries across Europe. Following the Great Recession, most European countries experienced a mild decline in GDP, while some experienced tremendous losses. Greece, the epicentre of much of the collapse, experienced an annual decline of GDP per capita of about 5% from 2009 to 2012. Meanwhile, some countries, such as Lithuania and Poland, emerged relatively unscathed and grew throughout this period. The

Figure 3. Trends in Total GDP and GDP per Capita for Europe



Note: GDP = gross domestic product.
Source: World Bank (2021).

Table 2. Population and Economic Indicators for Europe, 2020

TOTAL POPULATION (MILLIONS)	TOTAL GDP (TRILLIONS OF 2020 EUROS)	GDP PER CAPITA (2020 EUROS)	CHANGE IN GDP PER CAPITA, 2019 –2020 (%)
529.03	17.49	33,057.75	-9.30

Note: GDP = gross domestic product.
Source: World Bank (2021).

Table 3. Real Annual Growth Rates of GDP per Capita for Europe

2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
-0.31%	-1.60%	-1.41%	2.48%	0.88%	-0.21%	2.52%	1.49%	3.51%	-9.30%

Note: Growth rates reflect growth in terms of 2020 Euros.
Source: World Bank (2021).

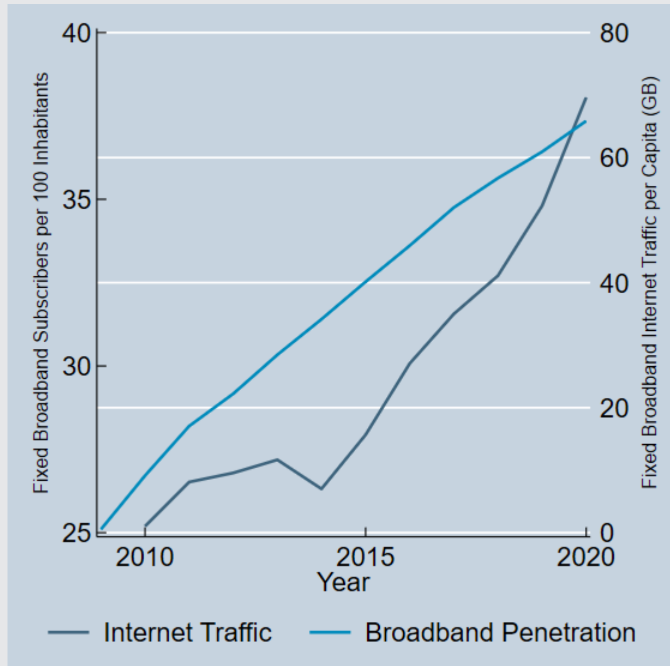
impact of the COVID-19 pandemic has had similar variability. The only European countries to experience GDP per capita growth in 2020 were Denmark, Ireland, Latvia, and Poland.

Broadband in one form or another is available across Europe, but fixed-line broadband accounts for only a fraction of that. Europe is still in the process of ensuring reliable, high-quality, and affordable connections to all, which is generally provided through fixed-line broadband. Over the last decade, Europe has gradually increased fixed broadband penetration from 25 to 37 subscriptions per 100 (Figure 4), however, 10% of European households still are not covered by any fixed broadband network (European Commission, 2020).

There is substantial variation in fixed-line broadband coverage among European countries. Although 13 countries have achieved geographic coverage of over 99% of their populations, four, including Poland, Lithuania, Romania, and Slovakia remain under 90%. Additionally, as Europe comes close to achieving 100% geographic coverage by fixed broadband infrastructure, the next target of 100% next-generation (above 30 Mbps) broadband coverage will follow. On average across EU member states, next-generation coverage has increased from 48% in 2011 to 86% in 2019. Two countries, Cyprus and Malta, have achieved 100% next-generation coverage, with 11 more having achieved 90%. Lithuania and France trail behind as the only two European countries under 70% next-generation access (European Commission, 2020).

The broadband market is extremely dynamic because of the rapid evolution of technology and because of users' rapidly increasing demand for data. On the supply side, broadband expands with the continuous evolution, development, and deployment of fibre optic technology and data storage, which enable faster connections and more data-intensive applications for more people. However, expanding terrestrial networks over larger geographical areas also contributes to increased demand for connectivity and perpetuates the need for greater domestic and international bandwidth. This is because adding new users increases total demand for domestic and overseas content, which, in turn, increases demand for international bandwidth capacity. If greater numbers of users are consuming greater amounts of data without commensurate increases in domestic and international capacity supplied, then available bandwidth per user can stagnate and broadband prices can rise to allocate these scarce resources.

Figure 4. Trends in Fixed Broadband Penetration and Traffic in Europe



Source: International Telecommunication Union (2021).

Table 4. Compound Annual Growth Rates of Select Supply, Demand, and Price Indicators in Broadband Market for Europe

	FIXED BROADBAND SUBSCRIBERS PER 100 INHABITANTS		BROADBAND INTERNET TRAFFIC PER CAPITA		INTERNATIONAL INTERNET BANDWIDTH PER INTERNET USER		FIXED BROADBAND PRICE	
	CURRENT LEVEL (2020)	CAGR[1]	CURRENT LEVEL (2020)	CAGR[2]	CURRENT LEVEL (2020)	CAGR[1]	CURRENT LEVEL (2020)	CAGR[3]
Europe	37.35	3.7%	70 GB	27.0%	286.84 Kbps	15.6%	€35.19	3.4%

[1] Timespan: 2009–2020. [2] Timespan: 2011–2020. [3] Timespan: 2009–2017.

Note: CAGR = compound annual growth rate. The fixed broadband price measured by the International Telecommunication Union refers to the monthly subscription charge for fixed (wired) broadband Internet service, which is defined as any dedicated connection to the Internet at downstream speeds equal to or greater than 256 Kbps. The time span used to calculate the CAGR for each indicator was determined based on data availability.

Source: International Telecommunication Union (2021).

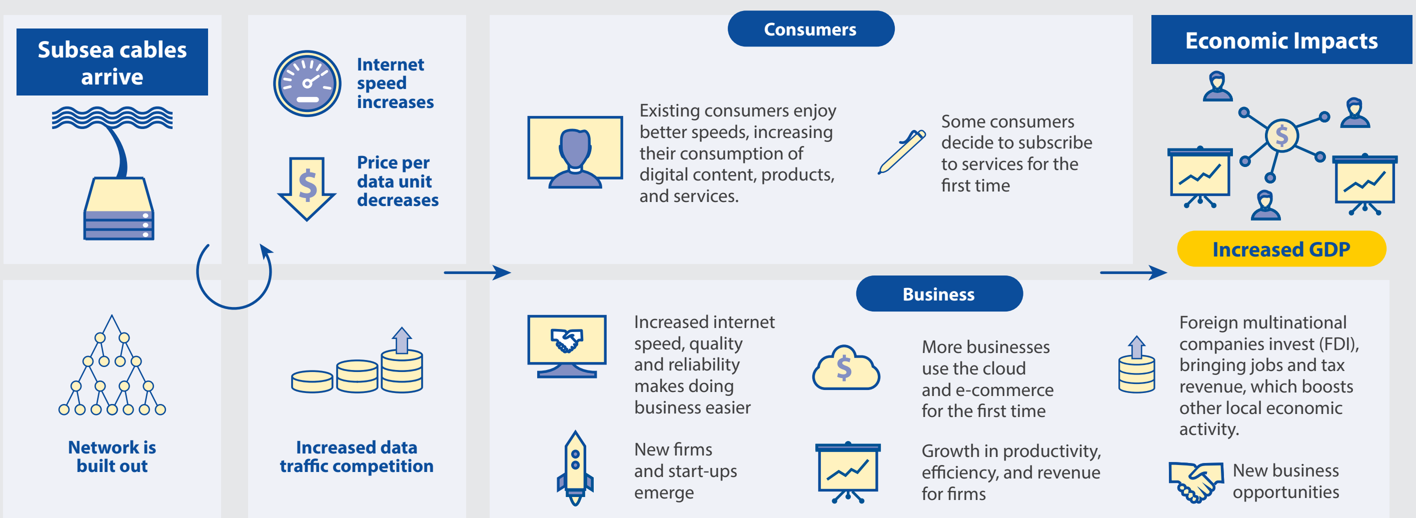
Table 4 shows the CAGR of select indicators of demand, supply, and price in Europe. Together these indicators suggest that capacity is struggling to keep up with growth in demand. The number of fixed broadband subscriptions per 100 inhabitants has steadily risen at a CAGR of 3.7%, and the amount of traffic consumed by users has increased dramatically, with broadband traffic per capita increasing at a CAGR of 27%. Given these rates of increase in key indicators of demand, the 15.6% CAGR of international Internet bandwidth per user over roughly the same period is less impressive.

Across much of Europe there have been notable efforts to increase broadband access for more of the population. As networks gain more subscribers and existing subscribers consume more data, international bandwidth must keep pace or prices may rise. Indeed, broadband prices have trended upward at a CAGR of 3.4%. If international bandwidth capacity were to have grown any more slowly over the past decade, users would have faced additional bottlenecks and latency and prices would likely have risen at an even greater rate to allocate the scarce bandwidth. These potential latency and bandwidth issues would significantly hamper economic benefits from digitally enabled services, as many industrial applications, such as algorithm-based financial transactions, require low latency to remain competitive (Kiesel et al., 2020). To balance the sharp increases in demand, which show signs of accelerating, more international capacity will be needed to keep broadband access fast, reliable, and affordable.

4. How Subsea Cables Catalyse Economic Growth

Subsea cables can drive economic growth through both business and consumer channels. New cable landings catalyse a series of changes within the broadband market and economy, which can ultimately translate into economic development (Figure 5).

Figure 5. How Subsea Cables Catalyse Economic Impacts



Note: GDP = gross domestic product.

to existing customers and reach new ones. One way this can occur is by providers developing and expanding terrestrial networks. In certain cases, the development and expansion of terrestrial networks can lead to more competitive dynamics, which benefits both existing and new subscribers.

Subsea cables are fundamental and complementary to terrestrial broadband infrastructure. The increased capacity delivered by new subsea cables expands international bandwidth, which creates opportunities to enhance service

Consumers gaining access to or gaining improved quality of broadband service benefits the economy at large. As value, quality, affordability, and access to broadband increase, the new and existing users will leverage the benefits in various ways. Individual consumers entering the market or enjoying faster speeds will result in increased consumption of digital content, products, and services.

Additionally, increased speeds and reliability increase business efficiency and productivity. Businesses operating in many different sectors leverage these improvements in connectivity in myriad ways. Some leverage the technology for digital transactions, as in the case of the financial services industry. Others leverage connectivity improvements to access a global marketplace and opportunities to expand their supply chains and customer bases (Kende, 2017). This expansion also encourages business to try cloud platforms and e-commerce for the first time, further expanding customer reach and speed of business operations.

The benefits to business channels are significant. In 2019, it was estimated that €1.1 trillion of EU exports and €1.1 trillion of EU imports were reliant on modern information and communications technology (ICT), amounting to 55% of all services exports to non-EU countries and 63% of all services imports from non-EU countries (Hamilton & Quinlan, 2021).

In addition to the effects of Internet speed and reliability on business efficiency and productivity, increased Internet performance impacts economic outcomes through the additional business-side channel of attraction of foreign direct investment (FDI). Because firms are aware of the benefits of Internet infrastructure on business efficiency and productivity, multinational firms make choices of where to invest in part based on the infrastructure that a country has built up. This results in a secondary benefit to the economy, in addition to helping existing businesses within a country, as the attraction of new businesses can provide great boosts to a country's economic standing. Over the last 10 years, the average EU country has received roughly 3.5% of their GDP in foreign investment, however countries such as Cyprus, Malta, and Ireland far exceed this with FDI worth 131%, 25%, and 24% of their GDP, respectively (World Bank, 2021).

5. Prior Analyses of the Economic Impacts of Subsea Cables

Subsea cables and broadband policy are receiving increased attention from policymakers as a mechanism for economic growth, especially in the headwinds of the global COVID-19 pandemic and slowing overall GDP growth rates in Europe and North America. Fortunately, the economic significance of broadband Internet has been a focus of policymakers and development experts for well over a decade and has led to a sizable body of research analysing its economic impact. Most of this research has documented the important role of broadband for economic growth and has substantiated the need to pay attention to broadband policy and invest in subsea cables.

Empirical evidence of economic impacts is essential to designing policies and prioritizing infrastructure investments that will be most effective for growth in certain contexts. As the body of evidence has grown, economists have developed a more nuanced understanding of the differential effects of broadband and subsea cables, for example, based on a country's level of development and the development of its broadband market. Recent research has also done more to shed light on the key mechanisms through which broadband investments drive economic growth. In our analysis of subsea cable investments made in Europe in the recent past and near future, we draw upon the empirical evidence that is most relevant to this context. As discussed in Section 3, Europe comprises primarily high-income countries, and most of its citizens live in places with relatively mature broadband markets compared with other world regions.

One of the first econometric studies that generated excitement about the impact of broadband was a study by the World Bank. It estimated that for developing countries, each 10% increase in fixed broadband penetration appears to boost the average annual GDP growth rate by 1.2% (Qiang et al., 2009). The authors of this study acknowledged, however, that demand for broadband services rises with wealth and that their model did not deal with this problem explicitly, hence a potential bias from reverse causality exists that is unaddressed.

To better isolate the impact of broadband on GDP, models were developed to deal with the endogeneity of demand for broadband and the reverse causation issue. An approach to modelling these complexities that gained traction for the analysis of broadband derives from an article published in the *American Economic Review* in 2001. This research provided an econometric framework for future studies based on simultaneous equations models (SEMs) (Roller & Waverman, 2001).

This approach makes an explicit attempt to control for the reverse causation that may not be adequately addressed in single-equation cross-country regressions. That is, as the economy grows, there is more likely to be increased broadband penetration and data consumption. SEMs in fact estimate the magnitude of the effects going in both directions, and the identification of income effects underscore the importance of using approaches like SEM as to not overestimate the impact potential of connectivity improvements. Later, we will use evidence from SEM analyses to quantify the potential impacts from subsea cable investments in Europe to ensure we do not overstate the economic impact potential.

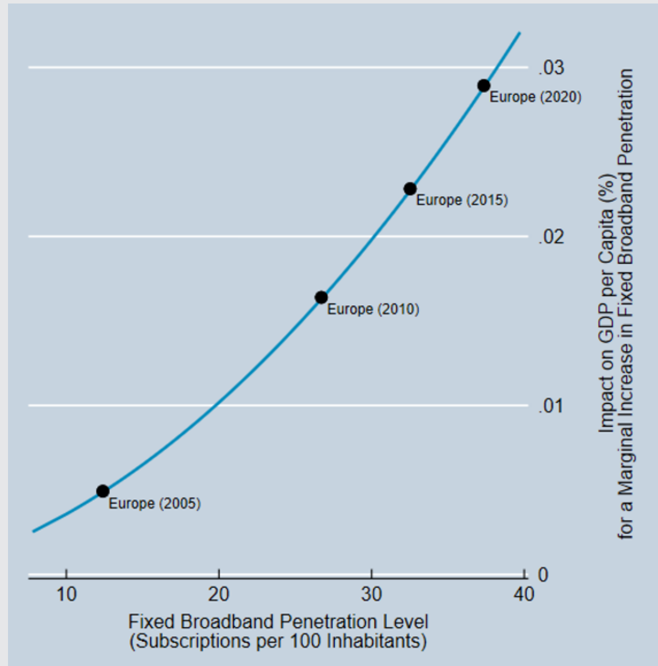
Studies that have applied the SEM approach to examine the impact of broadband in developed countries have still found economically significant effects. In what is the most relevant study to our analysis, effects were identified for a set of 22 Organisation for Economic Co-operation and Development (OECD) countries. The analysis grouped countries by their broadband penetration levels, which identified how the effect on GDP of an incremental change in broadband penetration varies depending on the current penetration level.

For each 10% increase in fixed broadband penetration, the effect on GDP per capita was an increase of 0.08%, 0.14%, and 0.23%, for countries with low levels, medium levels, and high levels of broadband penetration, respectively (Koutroumpis, 2009). Figure 6 depicts this relationship as well as where Europe has fallen on this curve at various points in time.

Evidence that the effect of fixed broadband penetration on GDP increases with the country's broadband penetration level implies positive network effects and increasing returns of fixed broadband infrastructure, at least up to the broadband penetration level thresholds studied (up to about 40 subscriptions per 100 inhabitants). For most of the 2010s and onward, Europe's fixed broadband penetration level has been above what was identified as above the high-penetration threshold of 30 subscriptions per 100 inhabitants identified by Koutroumpis.

Other studies, conducted both at the national and subnational level, have had similar findings. A study using county-level data in Germany[3] found comparable effect sizes. Moreover, when splitting the dataset between counties with high and low fixed broadband penetration, the authors found a similar relationship between fixed broadband penetration level and effect size, corroborating the presence of positive network effects for fixed broadband (Katz et al., 2010).

Figure 6. Relationship Between Impact on GDP per Capita for Incremental Increase in Broadband Penetration and Existing Broadband Penetration Level



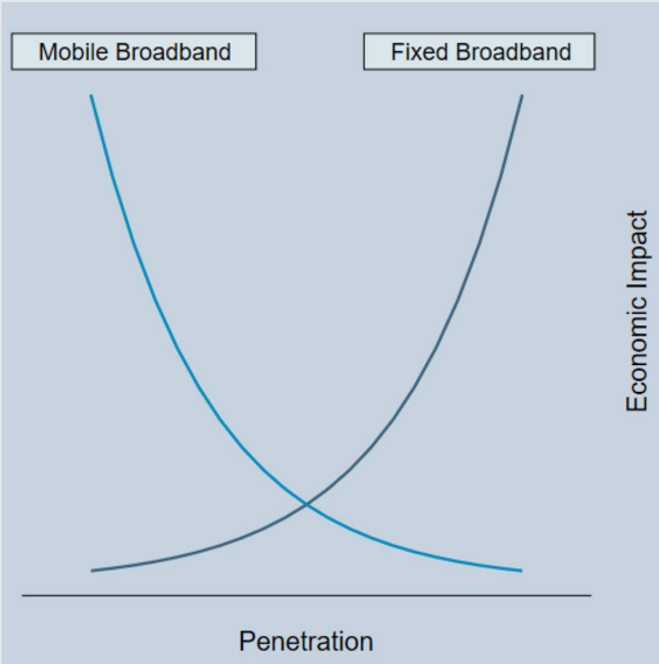
Note: GDP = gross domestic product.

Recently, a large global study applied an SEM approach to test hypotheses about whether the impact of fixed and mobile broadband penetration varies by national income level. For high-income countries, the authors found large effects of increases in fixed broadband but identified no effect of mobile broadband on GDP per capita, thus bolstering our understanding of fixed broadband playing a preeminent role in economic growth in these contexts (Katz & Callorda, 2018). More specifically, their results provide additional empirical support of increasing returns to scale for fixed broadband while providing evidence of a saturation point and diminishing returns to mobile broadband. This stylised relationship, which is based upon evidence from multiple econometric studies is depicted in Figure 7.

A systematic review of the econometric literature exploring the relationship between broadband and economic growth conducted in 2016 by the World Bank points to the consensus in the empirical literature that a certain penetration threshold is necessary before a significant economic impact is discernible from fixed broadband and that until that point is reached

3 The unit of analysis was a Landkreisse, an administrative unit beneath a Länder.

Figure 7. **Returns to Scale for Fixed and Mobile Broadband Based on Penetration Levels**



Source: Adapted from Katz & Callorda (2018).

mobile broadband is more salient to growth (Minges, 2015). However, after that threshold is reached, fixed broadband potentially has increasing returns while the role of mobile broadband in growth is negligible.

Empirical studies focusing specifically on the role of mobile broadband also support this conclusion. For example, a recent study based on data for 135 countries for the period 2002–2014 found that the economic effect of mobile broadband disappears within 6 years of introduction for a country with the median average growth of mobile broadband penetration (Edquist et al., 2018). Additionally, a study conducted by Deloitte for GSMA using data provided by Cisco Systems on 14 middle- and high-income countries did not find effects that were significant at the 5% level for mobile data usage on GDP per capita (Deloitte, 2012). Given the body of evidence that exists, if this study were restricted to high-income countries, the effects would have likely been smaller and even less significant.

For the present study on Europe, we therefore focus on the effects of increases in fixed broadband penetration on GDP per capita caused by the arrival of subsea cables. This way we avoid overestimating the effects of subsea cables and we can be more confident that the channels through which the economic impact occurs are realistic. Indeed, there is an exciting new body of econometric evidence accumulating about the channels and mechanisms via which subsea cables impact growth. So far, this research supports the conclusion that effects on GDP for high-income countries occur mostly through increases in fixed broadband. A study by the European Central Bank, for example, identified large effects of subsea cables on electronic trade volumes and foreign exchange markets (Eichengreen et al., 2016). Such growth necessarily relies on fixed broadband infrastructure and, notably, capital markets often play a critical role in enabling growth in other sectors of the economy (outside the financial sector) by allocating investment capital for companies to expand production and to research and develop new and improved products and services.

6. Analysis Approach

Our study paired rigorous econometric analyses with insights from over a dozen market experts in the European Internet ecosystem. Interviewees included European broadband connectivity experts with telecommunications firms, the subsea cable industry, trade and business associations, and other related sectors (e.g., Internet service providers, content providers, app and service developers, data centre providers). We also interviewed experts with non-governmental organisations (NGOs), non-profit organisations, and academics focused on digital connectivity and telecommunications, all of whom possess extensive knowledge of broadband market conditions and policy dynamics. Their insights were complementary to our empirical analysis of the effects of subsea cables on the broadband market and on the economy. This section describes how we analysed the impact of Meta's past investment in the MAREA cable on Europe and estimated the impact of two hypothetical cables landing in Europe in 2024 and 2027, each consisting of 24 fibre pairs.

Note that because terrestrial fibre and wireless networks connect users to subsea cables' landing stations, we account for them in the analysis. However, we emphasise that the impacts quantified herein are specific to the effects of the subsea cables and not terrestrial Internet connectivity. Our analysis focuses explicitly on the added value of the subsea cables, taking account of trends involving nationally hosted Internet exchanges, local content delivery networks, data centres, and other infrastructure that are bringing data resources onshore in many countries and may also affect broadband markets and economic growth.

6.1 QUANTITATIVE METHODS

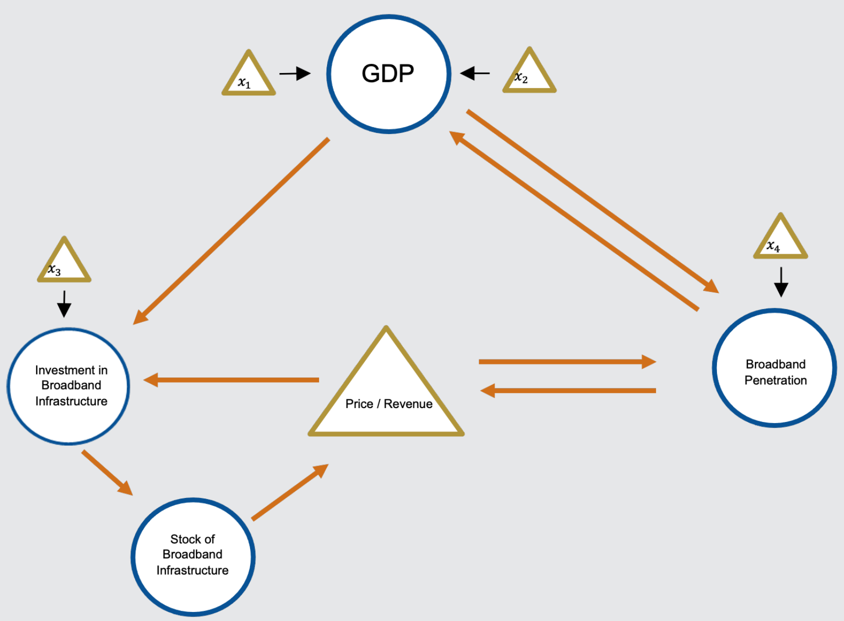
Our approach to estimating the impact of subsea cable investments combines original empirical analysis of changes in the broadband market due to subsea cable arrivals with context-relevant econometric evidence of the effects of broadband market changes on GDP. We conducted original statistical analyses to understand how particular subsea cable investments have affected or will likely affect broadband price and penetration in the European broadband market. Meanwhile, existing econometric literature provides us with a solid basis for estimating how GDP will be affected by broadband price and penetration changes.

6.1.1 Simultaneous Equations Model

Econometric analyses employing an SEM approach have identified crucial relationships between (1) broadband penetration and GDP and (2) broadband price and penetration. Moreover, the research has identified how these relationships differ depending on a country's current broadband penetration level. This differentiation is important because of the non-linear network effects associated with increases in fixed broadband penetration. We are therefore able to leverage evidence that is highly relevant to the European context. In particular, the elasticities we leverage come from an SEM analysis of 22 OECD countries (17 of which are in Europe[4]). The analysis categorised the countries according to their broadband penetration levels and constructed bins for low, medium, and high broadband penetration that ultimately comprised eight, nine, and five countries, respectively.

Among analyses focused on the macroeconomic impacts of broadband connectivity, econometric strategies that employ an SEM are arguably the best at isolating the portion of macroeconomic growth attributable to changes in the broadband market. There is an obvious strong correlation between broadband and economic growth (GDP per capita) (The Economist Intelligence Unit, 2017), but this alone does not reveal anything about the causal relationship between broadband penetration and GDP per capita. It could be that broadband penetration has positive effects on GDP per capita, if broadband availability and speed enable the formation of new start-ups or the growth of existing businesses. Meanwhile, or alternatively, it could be that GDP per capita has a positive effect on broadband penetration because more resources are available to invest in subsea cables and other broadband infrastructure. Moreover, it could be that broadband penetration does not cause a change in GDP per capita (or vice versa) and, instead, the two vary together because they are driven by other distinct variables. These complexities are illustrated in Figure 8.

Figure 8. Simultaneous Equations Model Schema



Note: GDP = gross domestic product.

Jointly estimating the system of equations representing the aggregate economy and the dynamics of supply and demand within the broadband market enables a more accurate approximation of the causal impact of broadband and subsea cables on GDP per capita. The SEM approach accounts for the mutually reinforcing relationships (potential feedback loops arising from reverse causality) and other key explanatory factors, thus isolating the effects of (1) increases in economic growth attributable to broadband penetration and (2)

4 The non-European countries were Australia, Canada, Japan, New Zealand, and the United States.

increases in the demand and supply of broadband penetration attributable to increases in economic growth. Notably, the system of equations helps isolate other important relationships including the change in broadband penetration for a given change in price, which is critical for our purposes.

The price elasticities of demand and the effects of broadband penetration on GDP help us to estimate the impact of Meta's past and potential future subsea cable investments in Europe. The elasticities we use come from the SEM analysis most relevant to our context, which are listed in Table 5.

For Europe's broadband penetration level at a certain point in time, the elasticities quantify by how much broadband penetration may increase for a given price reduction, and by how much GDP per capita is expected to increase for a given increase in broadband penetration. These elasticities take into account prevailing supply and demand trends in the market (e.g., other complementary infrastructure projects and increases in digital adoption), holding all else equal.

The elasticity representing the effect of increases in broadband penetration on GDP is greater for higher fixed broadband penetration levels. During the MAREA cable landing, Europe's broadband penetration level was already at a level characterised as "high" (above 30 subscriptions per 100 inhabitants), but based on prevailing trends, in the context of subsea cable arrivals in 2024 and 2027, Europe's broadband penetration level will have grown substantially.

To understand the likely effect on GDP per capita of an incremental change in broadband penetration at these higher future penetration levels, we first applied a linear model to project Europe's fixed broadband penetration level out to 2027. Then, using the exponential relationship between broadband penetration level and effect on GDP per capita identified by Koutroumpis (2009), we predicted the marginal effects on GDP per capita at the projected fixed broadband penetration levels for 2024 and 2027. These elasticities provide the foundation for our estimation, but an additional critical piece of information is required: the effects on market prices associated with the past and future subsea cable investments.

6.1.2 Time Series Analysis

To answer the question of how prices have or will be affected by subsea cable investments, we performed original statistical analysis using country-level time series data from the International Telecommunication Union on fixed broadband prices. The method we employed to examine effects of the arrival of the MAREA cable on prices draws upon intuition of econometric techniques, where the objective is to estimate a counterfactual and compare that to what was observed to infer the effect on prices.

The counterfactual estimates tell us what prices likely would have been in the absence of the subsea cable arrival. To estimate the counterfactual, we take as given the price trends up to the point in time the cable goes into service, and we use that pre-trend to quantify the typical year-over-year change in price. Next, we apply the change in the price of broadband for a typical year to estimate the counterfactual price for the year following the subsea cable arrival. The counterfactual represents the prices that would have been charged in the broadband market 1 year after the cable arrived, if in fact the subsea cable had not arrived. Finally, by comparing the observed price for the year following the subsea cable to the counterfactual, we can infer the change in broadband prices attributable to the subsea cable, over and above the price change that would be otherwise be expected for a typical year.

Table 5. Estimated Elasticities of Broadband Penetration to Changes in Price and Effect of Broadband Penetration on GDP per Capita

	EUROPE IN 2018 (BASED ON 2018 FIXED BROADBAND PENETRATION LEVEL)	EUROPE IN 2024 (BASED ON PROJECTED 2024 FIXED BROADBAND PENETRATION LEVEL)	EUROPE IN 2027 (BASED ON PROJECTED 2027 FIXED BROADBAND PENETRATION LEVEL)
Price elasticity of demand (broadband penetration) †	−1.005	−1.005	−1.005
Effect of penetration on GDP per capita PPP	0.023	0.035	0.040

† The coefficient representing the price elasticity of demand was log-linear in the econometric model and was exponentiated here for interpretive simplicity.
Note: GDP = gross domestic product; PPP = purchasing power parity.
Source: Koutroumpis (2009). Projected values based on authors' calculations.

For a past subsea cable investment such as MAREA, we can perform this counterfactual estimation directly. For hypothetical subsea cable investments, we must extrapolate from similar past investments because post-landing price data are not available. For the possible cable landings in 2024 and 2027, the recent MAREA cable landing provides a representative case for modelling the likely price impact.

6.1.3 Summary of Calculations

In summary, the impacts of the subsea cables on fixed broadband prices serve as an input, which we apply to the relevant elasticities from SEM analyses to arrive at macroeconomic impact estimates. In the time series analysis, we estimate the effect of subsea cables on fixed broadband prices. We then multiply the effect on prices by the price elasticity of demand for fixed broadband which yields the effect on fixed broadband penetration. The effect on broadband penetration is then multiplied by the elasticity representing the effect on GDP per capita from a marginal change in fixed broadband penetration (recall that this elasticity varies depending on the broadband penetration level of Europe at the time). The result is an impact on GDP per capita in percentage terms, which can easily be converted to monetary terms by multiplying the percentage by the GDP level in the year of the subsea cable arrival. This calculation is summarised in Equation 1.

Equation 1. Calculation of Percentage Impact on GDP per Capita from a Subsea Cable Arrival, Given Estimated Effects of Cable on Prices and Relevant Elasticities

$$\begin{aligned}\text{Impact on GDP per capita (\%)} \\ &= \text{Effect of subsea cable arrival on fixed bb price (\%)} \\ &\times \text{price elasticity of demand for fixed bb} \\ &\times \text{effect of fixed bb penetration on GDP per capita}_{\text{pen level}}\end{aligned}$$

Note: bb = broadband

Figure 9. Estimated Impact of MAREA on Fixed Broadband Prices in Europe

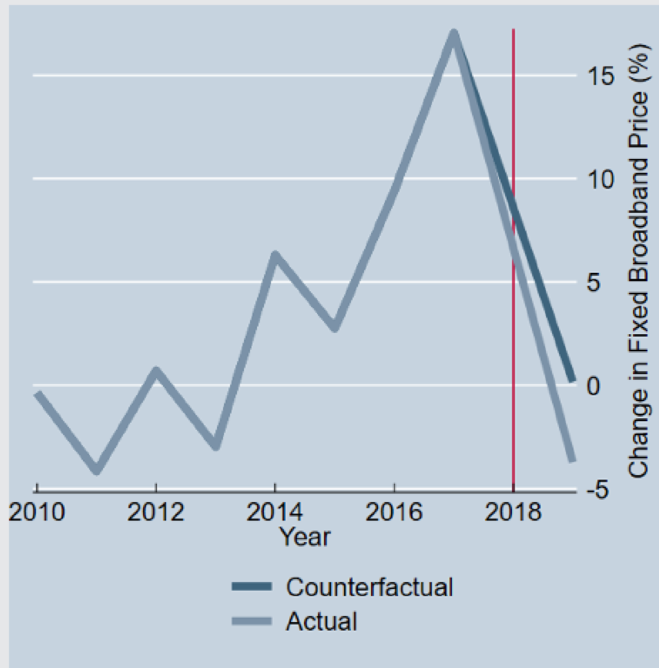


Table 6 presents the estimated effects of Meta's investment in the MAREA cable on broadband prices in Europe and possible future subsea cables in 2024 and 2027 consisting of 24 fibre pairs. We estimate that the MAREA cable caused fixed broadband prices to fall by 3.9%, which is a decrease in prices beyond what would be expected for a typical year given historical trends (see Figure 9). In 2018, the actual average price of fixed broadband was €40.45. The price fell to €39.24 in 2019, which is €1.28 below the counterfactual 2019 price of €40.52 in the absence of MAREA, and a percentage drop of 3.9% beyond the counterfactual. We estimate that the 2024 and 2027 subsea cable landings would each cause prices to fall by roughly the same amount, which represents a decrease beyond what would be expected otherwise, given prevailing trends and holding all else constant.

Table 6. Effects of Subsea Cables on Prices of Fixed Broadband in Europe

	EXPECTED CHANGE IN BROADBAND PRICE (COUNTERFACTUAL)	ACTUAL CHANGE IN BROADBAND PRICE	EFFECT ON PRICE ATTRIBUTABLE TO SUBSEA CABLE(S)
MAREA	+0.17%	-3.73%	-3.90%
Possible subsea cable landings (estimates based on MAREA landing)	+0.17%	-3.73%	-3.90%

Source: Authors' calculations using data from International Telecommunication Union (2021).

The price decreases of 3.9% translate to an increase in fixed broadband penetration of a roughly equivalent magnitude. The increases in penetration translate to increases in GDP per capita of 0.09% from MAREA and increases of 0.137% and 0.157% for the possible landings in 2024 and 2027, respectively, given the effects of an incremental change in penetration on GDP per capita for the specific landing years. The price change estimates used as inputs, the elasticities, and the estimated impacts are presented in Table 7.

6.1.4 Assumptions and Limitations

Uncertainty is always present in macroeconomic analyses, and in prediction particularly. However, our quantitative impact estimates should be considered conservative for several reasons.

First, we used the median to determine the typical annual change in broadband prices and utilised the complete time series of prices from the International Telecommunication Union. This method results in an estimate of the typical annual price change that is less (lower) than that which is achieved if the average annual price change is used as an alternative, or if the analysis is time-censored (because of a couple of unusual increases in broadband prices in recent years). Thus, comparing the actual price decrease in the year following the subsea cable arrival to the median annual price change results in a slightly smaller estimated effect of the particular subsea cable on prices than if we were to compare the actual change to the average annual change or if we were to consider only the past few years.

Second, the elasticities quantifying the effects of an increase in fixed broadband penetration on GDP per capita that we used come from a study employing an SEM approach that makes an explicit attempt to control for the significant challenges of reverse causality and unobserved variables. Any approaches that do not fully account for those biases will overstate the effect of subsea cables and the consequent increases in broadband penetration on economic growth.

Third, the possible 2024 and 2027 cable landings in Europe, each consisting of 24 fibre pairs, are projected based on our estimates of the impact of the 2018 MAREA cable landing in Europe. The 2024 and 2027 subsea cable investments we model will have significantly greater capacity than MAREA, which consisted of eight fibre pairs. Thus, extrapolating the impact of cables with greater capacity based on a cable with less capacity may underestimate the impact of the future cables. However, many other relevant variables and conditions can change between now and 2024 and 2027, some of which may attenuate the price impacts of future cable landings. Arguably, the capacities of the future cables will be commensurate with MAREA conditional on the state of technology and demand for data at the time. The COVID-19 pandemic has already accelerated many trends toward increased demand for data. Therefore, we believe that adjusting our forecast to account for the greater capacity supplied

Table 7. Impact of Past and Potential Subsea Cables on Europe's Fixed Broadband Penetration and GDP per Capita

	MAREA	POSSIBLE SUBSEA CABLE LANDING IN 2024	POSSIBLE SUBSEA CABLE LANDING IN 2027
Price change due to subsea cable [1]	-3.9%	-3.9%	-3.9%
Price elasticity of demand for broadband [2]	-1.005	-1.005	-1.005
Change in penetration due to subsea cable [1]	3.9%	3.9%	3.9%
Effect of penetration on GDP per capita PPP [2]	0.023	0.035	0.040
Impact on GDP per capita due to subsea cable [1]	0.090%	0.137%	0.157%

[1] Source: Author's calculations.

[2] Source: Koutroumpis (2009). Projected values based on authors' calculations.

Note: GDP = gross domestic product; PPP = purchasing power parity.

by possible future cables would ignore demand-side pressures and risk overestimating the impact of future cables. Given the relevant factors involved, basing the estimation of the future cables' likely impact on a cable with slightly lower capacity and that arrived at a time when there was arguably less excess demand for data yields conservative estimates.

6.2 EXPERT INTERVIEWS

We interviewed over a dozen European broadband connectivity experts with telecommunications firms, the subsea cable industry, trade and business associations, and other related sectors (e.g., Internet service providers, content providers, app and service developers, data centre providers). We also interviewed experts with NGOs, non-profit organisations, and academics focused on digital connectivity and telecommunications, all of whom possess extensive knowledge of broadband market conditions and policy dynamics.

Interview topics included current connectivity trends and challenges (e.g., network expansion, latency, affordability), public-sector priorities driving network expansion, role of subsea cables in the broader landscape of connectivity and Internet quality, role of connectivity in economic development, and future trends and issues which might accentuate or attenuate the economic impacts of subsea cables for Europe overall and for certain industries and geographic areas. We also identified key issues involving trends in connectivity demand and supply, and the implications for Europe's competitiveness going forward.

So that interviewees could be open and candid, we advised that participation would be confidential and that we would not attribute responses to individuals in our report.

7. Economic Impact of Meta's Subsea Cables in Europe

We estimate that Meta's investment in the MAREA cable generates an impact of approximately €16.7 billion (about 0.09% of Europe's GDP) annually. Based on Europe's GDP forecast for 2024–2027, we expect the impact of the two possible cable landings to add about €59.6 billion (the equivalent of 0.29% of Europe's 2027 GDP) annually. The impacts of the cables on Europe's GDP are listed in Table 8.

The impacts on GDP, which occur soon after the arrival of the subsea cables, constitute an increase in GDP over the counterfactual (in the absence of the cables) that persists for each future year. In other words, annual GDP for each year after 2027 will be about €76.3 billion greater given the landing of MAREA and two additional landings in 2024 and 2027 than it otherwise would be in the absence of these subsea

Table 8. Economic Impact of MAREA and Meta's Potential Subsea Cables on Europe's GDP, Annually

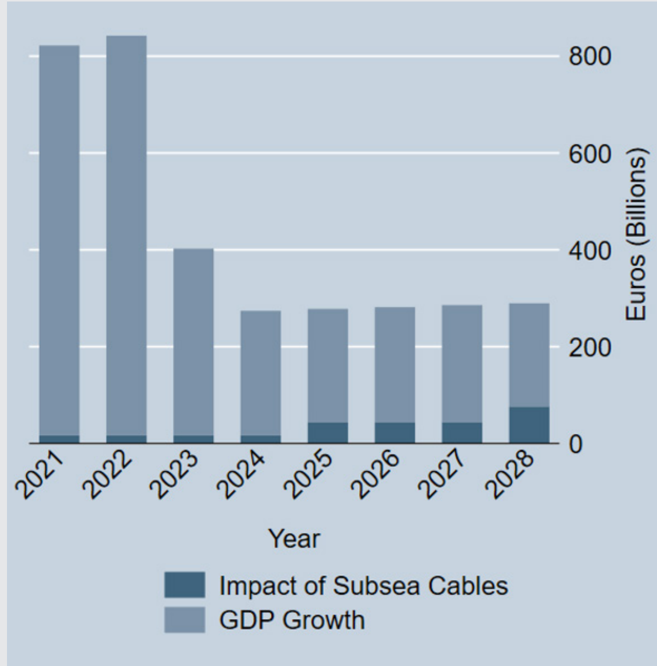
	MAREA	POSSIBLE SUBSEA CABLE LANDING IN 2024	POSSIBLE SUBSEA CABLE LANDING IN 2027
Impact on GDP per capita	0.090%	0.137%	0.157%
Impact on GDP, 2020 USD	18.01 billion	29.56 billion	35.22 billion
Impact on GDP, 2020 Euros	16.73 billion	27.19 billion	32.40 billion
Impact on GDP, USD PPP (2017)	21.15 billion	34.69 billion	41.33 billion

Note: GDP = gross domestic product; PPP = purchasing power parity. Estimates reflect the estimated GDP impact of the subsea cables, which for each year post-arrival represents a persistent difference between the actual and the counterfactual GDP of Europe.
Source: Authors' calculations.

cables. Figure 10 depicts the impact of the subsea cables in the context of Europe's projected annual GDP growth.[5] Illustratively, Europe's GDP is forecast to grow by about €289 billion from 2027 to 2028. In relation, the combined impact of the subsea cables is about 26.4% of that year's GDP growth.

Interviews with European connectivity experts reinforced the large contribution of subsea cables to economic growth. Experts believed the impacts of subsea cable arrivals to the Continent to be widespread, particularly with regards to major cities and well-connected areas. Benefits are generally largest in the countries and specific metropolitan areas where the cables land, while the benefits experienced by those areas most distant from the subsea cable landings are relatively lower, all else equal. Unconnected and poorly connected areas benefit very little if at all, which is a well-recognised issue by policymakers. Regulatory reforms and complementary public policy are needed to maximise the potential economic growth from subsea cables, while ensuring that the benefits are widely distributed across Europe's population.

Figure 10. Projected GDP Growth for Europe and Impact of Subsea Cables, 2021–2028



Note: GDP = gross domestic product.
Source: World Bank (2021); European Central Bank growth rate forecasts; and authors' calculations.

7.1 AREAS OF GROWTH CATALYSED BY SUBSEA CABLES

The highly competitive inshore market that exists across much of Europe means that, for most of the Continent, Internet access is now cheap, fast, and relatively ubiquitous. This also means that new subsea cable arrivals effectively increase international bandwidth not just where the landings are but across the Continent, enabling more intensive applications of broadband in various industries and helping the Continent to keep up with increases in demand for international bandwidth. Without the added international capacity supplied by subsea cables, there would be fewer adopters of industrial applications requiring reliable broadband and less intensive application by those who do adopt due to capacity constraints, which cause bottlenecks and latency.

The benefits to cities are particularly large. Much of the population living in Europe's major cities work in high-skill occupations, and these cities already serve as hubs for Internet traffic. Because these cities tend to be well-connected through robust terrestrial networks, they benefit from new subsea cables because they enable more intensive industrial applications of broadband that critically depend on overseas connectivity, specifically. Such is the case for cities with notable tech-based and logistics-based economies as well as financial services. Europe's biggest cities, Frankfurt, London, Amsterdam, and Paris (often abbreviated to FLAP) have long been the key magnets of connectivity and content and continue to reap added benefits with the arrival of new subsea cables to the Continent.

Trends are contributing to growth in a diversity of cities, however, and new cities are emerging as hubs for connectivity. As part of a long-term trend in which Over-the-Top players account for a greater proportion of international capacity—making up 64% of all used international capacity—the industry has shifted focus toward building connectivity in emerging markets where there remains a still untapped user base (TeleGeography, 2021). This has led, for example, to the emergence of Marseille, on France's southern coast, as a key data entrepôt, boasting not only the landing, or plans for landing, of 16 subsea cables, but also fast becoming a data centre hub, where Interxion, for example, is already working on its fourth data centre there. Housing content there can reduce latency to markets in Africa and the Middle East

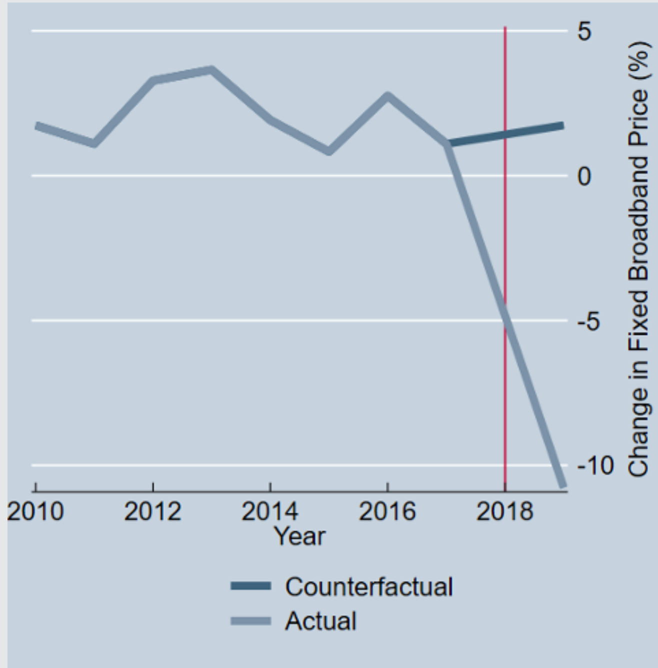
5 Note that the relatively large growth projected for 2021 and 2022 is due in large part to expectations around economic recovery from the COVID-19 pandemic.

while catering to existing markets in Europe by providing a shorter connection to cables in Spain and Portugal, such as the MAREA cable landing in Bilbao. This trend, according to sources in the industry, will only grow as the players seek more diversity, opening up ports further east in Italy and Greece. This is likely to have a knock-on impact on broadband speeds in regions that currently lag, such as in Greece, neighbouring North Macedonia, and Albania, which currently have some of the slowest speeds in Europe (between 30 and 35 Mbps, compared with 163 in France) (European Data Journalism Network, 2021).

While the economic benefits of subsea cables certainly extend geographically to many cities and regions well beyond the landing points, the benefits are typically most pronounced in the metropolitan areas and countries where the landings occur, all else equal. The primary mechanism is the improved international connectivity, which can set off a cascade of effects. First, direct proximity to the cable landing has a bigger impact on the international bandwidth capacity supplied by the subsea cable arrival relative to more distant locations requiring traffic to be routed through more exchange points and diluted across a broader geographic network. Second, subsea cable arrivals often catalyse other complementary infrastructure investments in data centres and terrestrial networks, which further enhance connectivity while driving increased competition in these markets. In turn, these two factors together can make investing in these locations more attractive to other industries seeking to leverage fast, reliable, and affordable broadband.

Even though the broadband market is driven largely by big commercial players, there has been a pronounced shift towards competition where cables land. These dynamics can take place even for relatively minor cables. One specific example of these dynamics on the ground is the Canary Islands, a Spanish archipelago off the coast of West Africa. Before the completion of the Canalink cable in 2011, connectivity on the islands was patchy and slow; its arrival had the immediate effect of adding more players to what was effectively a single-player market. This set off further effects in the local market. Telefonica, the incumbent, re-arranged its priorities to focus on providing the smaller islands in the archipelago with fibre-to-the-home (FTTH), completing rollout of fibre-optic service in Fuerteventura, La Palma, and Lanzarote by 2019, costing €1.8 million co-financed by the EU's regional development programme and local authorities (CommsUpdate, 2019). By 2020, 86.5% of the Canary Islands had access to 100 Mbps broadband, up from 74.6% in 2018 (The Spain Journal, 2020). Given that the islands are largely dependent on European holidaymakers, they are now closer to matching tourists' expectations of ubiquitous and fast access whether they are on the beach or in the hotel.

Figure 11. Estimated Impact of MAREA on Fixed Broadband Prices in Spain



Major subsea cables have large economic impacts that are felt at the national level. The MAREA cable was a boon for the Spanish economy. Based on the methodology described above, we estimate that MAREA caused broadband prices in Spain to fall by an average of 12.5% within a year of the cable landing (see Figure 11). In 2018, the actual average price of fixed broadband was €45. The price fell to €40 in 2019, which is €5.78 below the counterfactual 2019 price of €45.78 in the absence of MAREA, and a 12.5% drop beyond the counterfactual. The lower prices led to a 12.6% increase in broadband penetration and a 0.29% increase in GDP per capita relative to the expected change in MAREA's absence, all else equal. The economic impact of MAREA for Spain alone has been approximately €3.4 billion annually since 2019. In Section 8, we present a case study of Ireland to more extensively analyse the national-level impacts of subsea cables and related economic and policy considerations.

7.2 EQUITY CONSIDERATIONS

Despite the large impact of subsea cables in aggregate, significant disparities remain between countries in terms of the benefits derived from subsea cables. One reason is the wide gaps in Internet and broadband usage. The Digital Economy, Recovery Plan, and Skills Unit of the Directorate-General for Communications Networks, Content, and Technology published the Digital Economy and Society Index, based on data collected by Eurostat in 2019. It acknowledged that while in some European countries, 95% of the population used the Internet at least once a week (e.g., Denmark, Sweden, and the Netherlands), in some EU member states, more than a quarter of the population do not regularly go online (Romania, 28%; Bulgaria, 33%). Although these estimates pre-date the COVID-19 pandemic, which has hastened adoption and usage in many areas, wide gaps remain in terms of access and adoption across countries.

Uneven benefits of subsea cables are also related to the disparities in broadband access within countries, which often split along the divides of urban versus rural. The European Investment Bank has recognised the need for further investment to fill the gap of faster connectivity in rural areas. Harald Gruber, head of the Digital Economy division at the Projects Directorate of the European Investment Bank, said in July of 2021 that some €200 billion would be needed to build 100 Mbps access to Europe's rural population, most of it via financial instruments that leverage private with public money. This, however, requires not only incentivising commercial players to build connectivity to areas they had previously deemed uneconomic; it also needs agencies in member states to follow through on European Commission (EC) requirements. A report by Deloitte published in July, for example, highlighted that many member states had committed only the minimum proportion of budgets allocated under the EC's Recovery and Resilience Facility, meaning that "if the current trajectory of progress towards the Digital Decade targets continues, by 2030 the EU may not achieve many of the targets that have been set" (Deloitte, 2021).

Indeed, there is a growing awareness that talking about a broader digital agenda is premature while the necessary connectivity remains elusive in parts of Europe and the EU. Poor definition of what exactly the EC's vision of a "gigabit society" is has attracted some criticism, including from academics. While they acknowledge the EU, particularly the EC, has become increasingly pragmatic about how to achieve its policies, this has not necessarily helped achieve broad understanding of what is meant by, for example, an "advanced knowledge-based economy". David Howarth of the Université du Luxembourg told an online panel in early 2020 that "the central role of ICT (thus the Internet) in this process is obvious but always elusively defined" (Schafer et al., 2020). What is clear is that subsea cables have propelled growth in ICT-intensive industries such as tech and finance, which tend to concentrate in cities where the highly educated and highly skilled live and work. Bringing more of this type of growth to other parts of Europe will likely require both investment in infrastructure and complementary policies to support workforce development.

7.3 PUBLIC POLICY AND REGULATORY ISSUES

The EC's vision is to transform Europe into a gigabit society and to become a digital single market. The target in practical terms is to have 100 Mbps broadband coverage across all member states by 2025. But there is still some way to go, partly because of the COVID-19 pandemic, and partly because of challenges in finding the right balance among policy levers.

The EU's strategy to improve the quality and reduce the price of broadband connectivity has been to stimulate competition, while offering inducements to providing access to remote or less commercially attractive areas. The EU has treated broadband access as a public utility. This has largely been successful, although there is a recognition of two problems: that there are still significant parts of the EU that do not have adequate coverage—either in speed or last mile-access—and that broadband connectivity differs from other utilities in that it is technology dependent and therefore continually evolving. What may have been regarded as fast in 2010 is no longer acceptable in 2020, and while the advances in fibre optic technology have squeezed greater capacity out of existing cables, there is still a cyclical need to replace outdated or end-of-life infrastructure.

Ten years ago, the EU recognised this problem and launched a strategy, the Digital Agenda for Europe, to provide all Europeans with access to broadband speeds greater than 30 Mbps by 2020 and more than half of European households with access to super-fast connections of more than 100 Mbps. Between 2014 and 2020 some €15 billion was made available to fund this rollout. An audit in 2018 found that while the first target had largely been reached, there were still laggards (including France), and the second target was not met, particularly in rural areas.

This shortfall was evident when the COVID-19 pandemic required workers and students to work from home, putting pressure on networks which had been geared to handling day-time surges in streaming content and video calls, prompting the EU Internal Market Commissioner in March 2020 to call on the industry—both services and delivery providers—to take ownership of the problem. The problem can be seen in Speedtest's Global Index of fixed broadband speeds, in which Romania is the highest ranked EU country at 6th, followed by Denmark (8th) and France (10th). At the same time, Speedtest data also show how all countries experienced higher average download speeds by the end of 2020, suggesting that networks have adapted to cope with greater traffic, even as more users have been forced by lockdown and other pandemic-related circumstances to sign up for higher bandwidth services. The EC's flexible policy of allowing operators with significant market power to jointly invest in building infrastructure (co-investment) has also shown signs of bearing fruit; a French study published earlier this year found that the presence of co-investment led to a nearly 8% increase in FTTH adoption and an increase in competition (Aimene et al., 2021).

The EC's focus on protecting the consumer has meant a common regulatory framework throughout the EU, which has favoured greater competition, better services, and lower prices. But, while speeds are rising, they are not rising as fast as countries which might be considered at similar levels. U.S. average broadband speeds, for example, rose 91% between 2019 and 2020, according to the FairInternetReport (2020) which compares Internet speeds. Meanwhile broadband speeds in the EU overall rose 57% in the same period. Countries which lagged the United States included Germany, Poland, Italy, and France.

International connectivity beyond the boundaries of the European Continent is a core part of that equation, according to Hugo Santos Mendes, Portugal's deputy minister for communications, who told a conference in June 2021 that "in what concerns infrastructure such as subsea cables, the EU must provide a clear message that these investments are not merely national budgets, but essential tools for Europe to achieve its digital sovereignty". He called for focus on four strategic areas where Europe should develop international connectivity—the Atlantic region, the Mediterranean Sea, the Baltic to the Black Sea, the North Sea and the Artic—and pointed to the EllaLink cable, inaugurated in June, which connected Brazil with Portugal, via French Guiana, Madeira, the Canary Islands, and Cape Verde. The EC and Brazilian government contributed to the €150 million cable, which will be used by academics but also commercial traffic.

Diversity of subsea cable landing points is critical, but the most serious impediment to that is regulatory issues. Environmental assessments are required in the most accessible parts of a coast, and those usually take about 2 years. Contrary to the subsea cable industry's perception that landing permits are an area ripe for deregulation, such decisions are based on quite different criteria, which make it unlikely the timescale can be reduced. According to one source who has worked on both sides of the aisle, officials are keenly aware of the commercial benefits of allowing more subsea cables to land in their territory but must also consider thorny issues about what is, for most of the European coastline, common land, where the public's rights of access must remain paramount. Allowing a company to build on that space and prevent others from using that land for 20 to 25 years is a decision not made lightly. This is likely to remain an issue and is one reason why most of the large U.S. players prefer to work with a local partner on any cable landing.

Finally, Europe must reckon with political and strategic issues, whether it likes it or not. On the one hand, having more diverse subsea cable connections is a guard against cable breakage, either man-made or natural. But on the other hand, there are sound political and strategic reasons for not relying on any particular route. The UK, for example, is now no longer a part of the EU, and therefore it makes sense for the EU to build out cables which bypass it to North America, Ireland, the North Sea, and elsewhere, reducing any likelihood of additional legal restrictions that may arise in a post-Brexit world. Similarly, one of the features touted by EllaLink's Portuguese backers was that it did not require touching the United States on its way to South America.

The landing of the PEACE cable, led by a consortium headed by China's Hengtong Group and supplied by Huawei Marine, in Marseille from its starting point in Pakistan, has highlighted some of the challenges the EU will increasingly face in trying to build diversity in its international connectivity while also balancing geopolitical considerations. To this end the EU last month announced it would launch "Global Gateway" as a brand to compete with China's Belt and Road initiative in building "quality infrastructure, connecting goods, people and services around the world", in the words of EC President Ursula von der Leyen. A priority, she said, would be for the EU to discuss connectivity projects with Africa during a regional summit.

8. Economic Impact of Subsea Cables Investments in Ireland: A Case Study

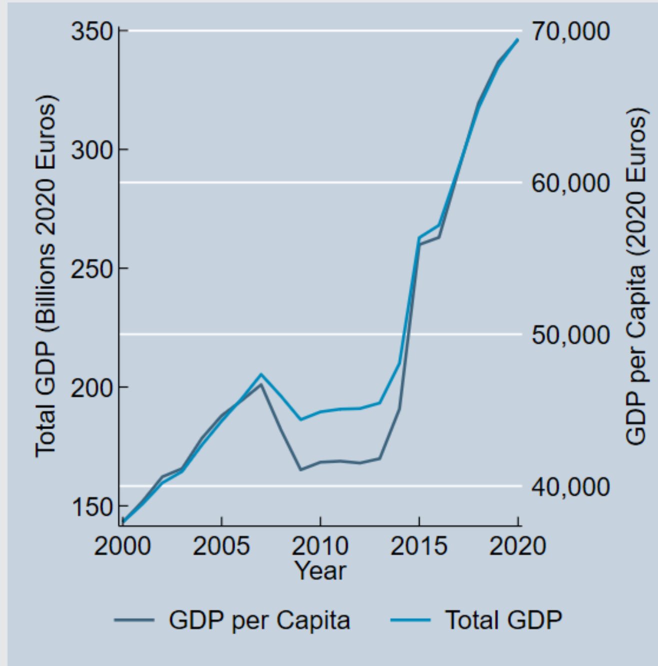
Ireland makes an interesting case study because, as a country, it faces many of the same general trends in the broadband market that are happening at the Continent level, but the trends and pressures are even more pronounced. Ireland critically relies on international bandwidth from subsea cables for its economic development strategies but faces challenges keeping up with the steep increases in demand. Meanwhile, Ireland lags Europe in terms of its broadband penetration rate because a relatively large share of its population—particularly in rural areas—lack access. In this case study, we analyse the impact of subsea cable landings in Ireland on its national economy and discuss how the context, including policy and regulatory issues, interact to accentuate or attenuate the economic impact of the cables.

8.1 BACKGROUND AND TRENDS IN ECONOMIC GROWTH AND CONNECTIVITY

Ireland is a small island nation of about 5 million people and has a GDP per capita of about €70,000, placing it among the richest countries in Europe (Table 9). Ireland has enjoyed impressive growth since recovering from the Great Recession (Table 10 and Figure 12), due in large part to its successful strategies for attracting FDI. However, there is a stark economic and digital divide between Ireland's urban and rural areas.

In 2014, Ireland embarked on a new strategy to attract ICT business to Ireland by investing in educational programmes to build a labour supply with core ICT and electronic or electrical engineering skills. IDA Ireland, an Irish statutory agency with the primary objective of attracting foreign businesses to

Figure 12. **Trends in Irish Total GDP and GDP per Capita**



Note: GDP = gross domestic product.
Source: World Bank (2021).

Table 9. **Population and Economic Indicators for Ireland, 2020**

TOTAL POPULATION (MILLIONS)	TOTAL GDP (BILLIONS OF 2020 EUROS)	GDP PER CAPITA (2020 EUROS)	CHANGE IN GDP PER CAPITA, 2019–2020 (%)
5.0	346.61	69,395.13	3.42

Note: GDP = gross domestic product.
Source: World Bank (2021).

Table 10. **Real Annual Growth Rates of GDP per Capita for Ireland**

2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
0.60%	0.13%	1.23%	8.64%	25.18%	1.99%	9.13%	8.52%	5.57%	3.42%

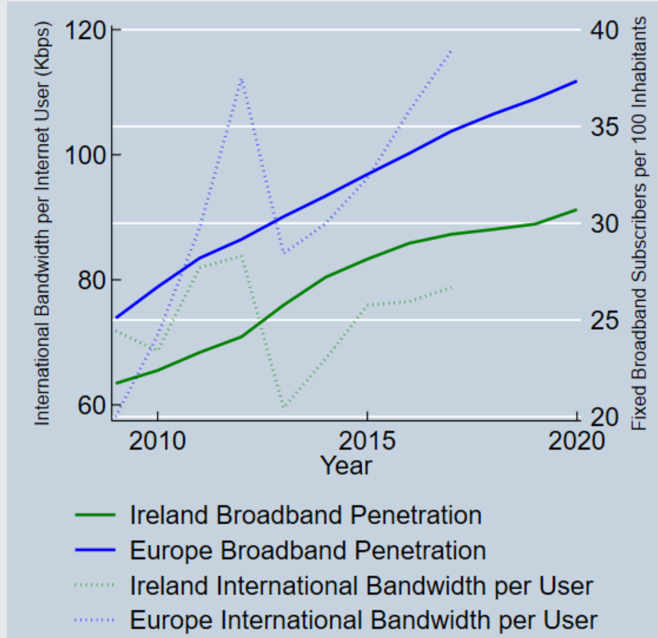
Note: Growth rates reflect growth in terms of 2020 Euros.
Source: World Bank (2021).

Ireland, had complementary initiatives to bolster this strategy and make Ireland more attractive for foreign investment. Notable aspects of this strategy included keeping the corporate tax rate low, the development of a capable ICT workforce, €150 million for an IDA property investment programme, and the operation of IDA Business and Technology Parks. The plan was dramatically successful, as Ireland outpaced both goals, amassing 1,209 investments and 112,327 new jobs over the life of the plan (IDA Ireland, 2020a).

Ireland's impressive GDP growth since 2013 is largely the result of this strategy, with exceptionally sharp jumps such as Ireland's 25% increase in GDP per capita in 2015 being principally due to the relocation of multinational corporations to Ireland, bringing both economic activity and intellectual property (Organisation for Economic Co-operation and Development, 2016). Despite its success attracting FDI to date, there are indications that Ireland may be failing to keep up with broadband demand, which may make attracting FDI more difficult in the future.

Table 11 shows the CAGR of select indicators of demand, supply, and price in Ireland versus the European average (weighted by population). Ireland's rate of growth in broadband traffic is remarkable in spite of the fact that Ireland's fixed broadband penetration rate has grown relatively slowly at a 2.9% CAGR, which is 0.8 percentage points behind the European average. These trends are depicted in Figure 13. The sluggish increase in penetration is indicative of Ireland's slow expansion of its terrestrial broadband network compared with much of Europe.[6] Today, Ireland is well behind the European average in terms of fixed broadband penetration with 30.7 subscribers per 100 inhabitants compared with Europe's 37.4. If Ireland were to achieve its targets specified in the National Broadband Plan (NBP) and connect a greater share of its population, demand for bandwidth would rise

Figure 13. **Trends in Fixed Broadband Penetration and International Internet Bandwidth per User in Ireland and Europe**



Source: International Telecommunication Union (2021).

Table 11. **Select Supply, Demand, and Price Indicators in Broadband Market for Ireland and Europe**

	FIXED BROADBAND SUBSCRIBERS PER 100 INHABITANTS		BROADBAND INTERNET TRAFFIC PER CAPITA		INTERNATIONAL INTERNET BANDWIDTH PER INTERNET USER		FIXED BROADBAND PRICE	
	CURRENT LEVEL (2020)	CAGR[1]	CURRENT LEVEL (2020)	CAGR[2]	CURRENT LEVEL (2017)	CAGR[3]	CURRENT LEVEL (2020)	CAGR[3]
Ireland	30.71	2.9%	309 GB	45.0%	78.79 Kbps	1.0%	€65.99	7.1%
Europe	37.35	3.7%	70 GB	27.0%	116.60 Kbps	9.1%	€35.19	3.4%

1 Timespan: 2009–2020. 2 Timespan: 2018–2020. 3 Timespan: 2009–2017.

Note: CAGR = compound annual growth rate. The fixed broadband price measured by the International Telecommunication Union refers to the monthly subscription charge for fixed (wired) broadband Internet service, which is defined as any dedicated connection to the Internet at downstream speeds equal to or greater than 256 Kbps. The time span used to calculate the CAGR for each indicator was determined based on data availability.

Source: International Telecommunication Union (2021).

6 Here, we focus on fixed broadband because mobile broadband (e.g., 5G) is not a viable alternative to fibre for many industrial applications requiring ultrafast, reliable Internet such as cloud computing services, which are responsible for most of the economic growth derived from subsea cables in highly developed countries.

even more sharply, necessitating that the supply of domestic and international capacity keep up with this pressure.

A couple of indications that demand is outpacing increases in capacity seem clear. First, Europe has surpassed Ireland in terms of international Internet bandwidth per user, which has grown at a mere 1.0% CAGR in Ireland compared with 9.1% CAGR in Europe. While Ireland held a 10 Kbps advantage over the average European country in 2009, as of 2017, Ireland had 38 Kbps less bandwidth per user than the European average. Second, broadband prices are rising for both Europe and Ireland, but in Ireland prices have risen at a much higher rate and are currently almost double the price level for Europe. As a way of allocating scarce resources, price increases are often a reliable indicator that demand is rising faster than supply. This means there is more intensive consumption of data from overseas, largely from industrial applications but also from consumers, without commensurate increases in capacity. These are concerning trends for a country trying to attract and retain foreign investment in the ICT sector.

8.2 ECONOMIC IMPACT OF META'S SUBSEA CABLES IN IRELAND

We analysed the impact of Meta's subsea cable investments in Ireland by applying the same quantitative and qualitative methods described in Section 6. The investments we analysed for Ireland were AEConnect-1 (2016), Havfrue/AEC-2 (2020), and a possible cable landing in 2024. AEConnect-1 was a critical cable for Ireland, as the first modern transatlantic cable connecting Ireland to the United States, offering a capacity of about 78 Tbps. AEC-2 is similarly important for Ireland, carrying a maximum capacity of 108 Tbps, with spurs to Denmark and Norway. For the possible landing in 2024, our model is based on a transatlantic subsea cable connecting Ireland and the United States consisting of 24 fibre pairs.

We estimate that Meta's past subsea cable investments in Ireland generate an impact of about €1.20 billion (about 0.39% of Ireland's GDP) annually, and that a possible 2024 cable landing would catalyse an additional €1.14 billion (about 0.29% of Ireland's 2024 GDP) annually. Together, the three cables constitute an economic impact equivalent to about 15% of a typical year's growth in GDP per capita (based on Ireland's 4.4% GDP per capita CAGR since 2015).

8.2.1 Quantitative Analysis

Table 12 presents the estimated effects of Meta's past subsea cable investments in Ireland and a possible future subsea cable in 2024 consisting of 24 fibre pairs on broadband prices. For AEConnect-1 we performed the counterfactual estimation directly. For Havfrue/AEC-2, the recent arrival of AEConnect-1 provides a reasonable basis for indirectly estimating Havfrue/AEC-2's impact on prices (since 2021 data were not yet available at the time of writing). For the possible 2024 cable landing we model for Ireland, the recent MAREA cable landing in Spain provides a representative case for modelling the likely price impact.

We estimate that each of the past subsea cables caused fixed broadband prices to fall by 13.9%, which is a decrease in prices beyond what would be expected for a typical year given historical trends. We estimate that the 2024 subsea cable landing would cause prices to fall by 12.5%, which represents a decrease beyond what would be expected otherwise, given prevailing trends and holding all else constant.

The price decreases of 13.9% and 12.5% translate to increases in fixed broadband penetration of roughly equivalent magnitudes (increases of 13.9% and 12.6%, respectively) and to increases in GDP per capita of 0.20% and 0.29%, respectively.

Table 12. Effects of Subsea Cables on Prices of Fixed Broadband in Ireland

	EXPECTED CHANGE IN BROADBAND PRICE (COUNTERFACTUAL)	ACTUAL CHANGE IN BROADBAND PRICE	EFFECT ON PRICE ATTRIBUTABLE TO SUBSEA CABLE(S)
Meta's past subsea cable investments (AEConnect-1 & Havfrue/AEC-2)	+2.75%	-11.10%	-13.86%
Possible subsea cable landing in 2024 (estimates based on MAREA landing in Spain)	+1.74%	-10.78%	-12.51%

Source: Authors' calculations using data from International Telecommunication Union (2021).

The price change estimates, relevant elasticities, and estimated impacts are presented in Table 13.

We estimate that Meta's past subsea cable investments in Ireland generate an impact of about €1.20 billion (about 0.39% of Ireland's GDP) annually. Based on Ireland's GDP forecast for 2024, we expect the impact of the planned cable landing to add about €1.14 billion (about 0.29% of Ireland's 2024 GDP) annually. The impacts of the specific cables on GDP are listed in Table 14.

The impacts, which occur soon after the arrival of the subsea cables, constitute an increase in GDP over the counterfactual (in the absences of the cables) that persists for each future year. In other words, annual GDP for each year after 2024 will be about €2.34 billion greater given Meta's past subsea cables and a 2024 cable landing than it otherwise would be in the absence of these subsea cables. Figure 14 depicts the impact of the subsea cables in the context of Ireland's actual and projected annual GDP growth. Illustratively, Ireland's GDP is forecast to grow by about €5.7 billion from 2026 to 2027. In relation, the combined impact of the subsea cables is about 40% of that year's GDP growth.

Table 13. **Impact of Past and Potential Subsea Cables on Ireland's Fixed Broadband Penetration and GDP per Capita**

	AECONNECT-1	HAVFRUE/AEC-2	POSSIBLE SUBSEA CABLE LANDING IN 2024
Price change due to subsea cable [1]	-13.9%	-13.9%	-12.5%
Price elasticity of demand for broadband [2]	-1.005	-1.005	-1.005
Change in penetration due to subsea cable [1]	13.9%	13.9%	12.6%
Effect of penetration on GDP per capita PPP [2]	0.014	0.014	0.023
Impact on GDP per capita due to subsea cable [1]	0.195%	0.195%	0.289%

[1] Source: Author's calculations.

[2] Source: Koutroumpis (2009).

Note: GDP = gross domestic product; PPP = purchasing power parity.

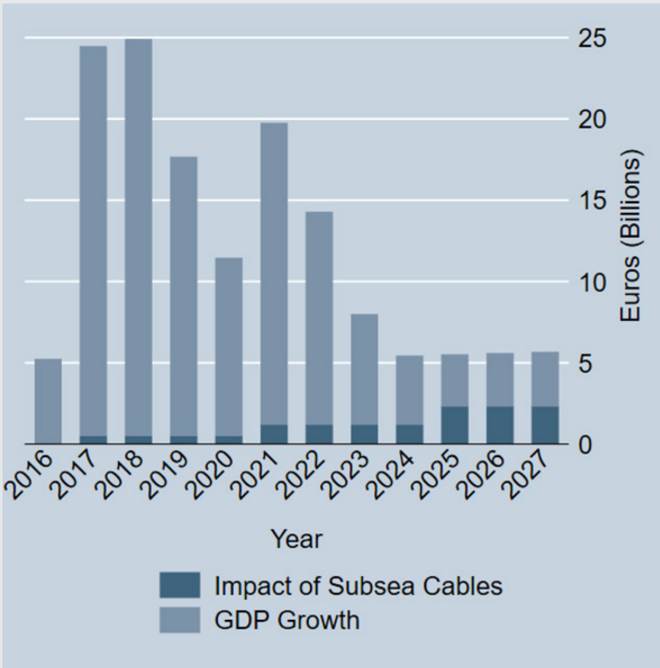
Table 14. **Economic Impact of Past and Potential Subsea Cables on Irish GDP, Annually**

	AECONNECT-1	HAVFRUE/AEC-2	POSSIBLE SUBSEA CABLE LANDING IN 2024
Impact on GDP per capita	0.195%	0.195%	0.289%
Impact on GDP, 2020 USD	0.58 billion	0.82 billion	1.38 billion
Impact on GDP, 2020 Euros	0.52 billion	0.68 billion	1.14 billion
Impact on GDP, USD PPP (2017)	0.67 billion	0.86 billion	1.46 billion

Note: GDP = gross domestic product; PPP = purchasing power parity. Estimates reflect the estimated GDP impact of the subsea cables, which for each year post-arrival represents a persistent difference between the actual and the counterfactual GDP of Ireland.

Source: Authors' calculations.

Figure 14. Irish GDP Growth and Impact of Subsea Cables, 2016–2027



Note: GDP = gross domestic product.
Source: World Bank (2021); European Central Bank growth rate forecasts; and authors' calculations.

8.2.2 Areas of Growth Catalysed by Subsea Cables

Ireland is home to a burgeoning tech scene, which has derived clear economic benefits from subsea cables. The tech economy ranges from local start-ups to major U.S. companies. Because of Ireland's small population, the industry is largely focused on overseas markets and therefore critically relies on international connectivity. Subsea cables address the gap connectivity-wise with the so-called FLAP cities of Frankfurt, London, Amsterdam, and Paris, which enjoy a latency advantage of over 7–8 milliseconds. In particular, more diverse paths to continental Europe and North America and less reliance on the UK help ensure redundancy and eliminate single points of failure.

Dublin has become a magnet, accounting for about 1.2 million people out of an Irish population of about 5 million. Naturally, Dublin is the epicentre of the Irish tech economy given its comparative advantages in connectivity and human capital and is where the majority of the economic benefits of subsea cables have accrued. Away from Dublin there are numerous small cities and, beyond them, a very dispersed rural population of about 1.8 million. While the government launched Metropolitan Area Networks to bring connectivity to some of those towns, much of the rural areas still lack connectivity as the prospect remained economically unappealing. The result is a dual economy: one consisting of traditional industry (e.g., agriculture and traditional manufacturing), and another that is technology-centric and built around foreign domestic investment.

Ireland's NBP was developed in large part to address the current geographic challenges and barriers to achieve both greater total economic benefits and a wider distribution of those benefits. The NBP includes provision of fibre to small and medium-sized enterprises outside the towns and the approximately 15% of the population that live outside towns and villages of a certain threshold, which are not considered economically viable to existing providers. However, expert opinion is mixed as to whether this will change the existing dynamic.

8.2.3 Equity Considerations

Some believe the timing could not be better to capitalise on benefits derived from connectivity across the country and transform the economic situation outside of Dublin. The COVID-19 pandemic has highlighted the strengths, and appeal, of working from home, and so, in the words of one interviewee, "small rural villages and towns will be revitalised by returning locals and new settlers. It will lead to a complete decentralisation and [balance out] the population density of the country."

Indeed, there are indications that this has already begun. A few tech companies have chosen to move some teams to bases in Cork, Galway, and Waterford, while several gaming companies run major operations in Mayo and Sligo. Additionally, the Commission for Communications Regulations will likely, next year, auction off a significant chunk of mobile spectrum, a step towards major rollout of 5G in rural and urban areas. The mobile technology 5G is seen as a key enabler of services that require very fast connections, although it is not a viable alternative to fibre for many industrial applications requiring ultrafast, reliable Internet such as cloud computing services.

The government is purposefully addressing the pronounced urban-rural divide through the NBP, which was first put forward in 2012 and only got underway in the past 18 months. The project promises to deploy high-speed broadband services to about half a million of the hardest-to-reach premises in Ireland within 7 years. The plan was announced in late 2015 and a final tender proposal received in September 2019 (McDermott, 2017).

The NBP is the largest infrastructural project in rural Ireland since electrification, spanning, according to the government, 96% of its land mass and 23% of its population. The project relies heavily on the assumption that the provision of high-speed broadband brings with it strong economic and social benefits. A report reviewing the National Development Plan Phase 1, issued in April 2021, identified broadband as an "essential element of a functioning modern society and economy". The report also acknowledged concern about ensuring that the NBP funding would be ring-fenced for rural communities, investment be targeted at supporting regional work hubs, and the migration of jobs and families be steered to less developed areas (Department of Public Expenditure and Reform, 2021).

Supporters of the NBP have argued it has already succeeded in some measure by incentivising companies to invest in rural areas. For example, Eir, the principal provider of fixed-line and mobile telecommunications services, has said it is investing €1 billion in connecting homes outside the purview of the NBP as part of its FTTH rollout, including 200,000 homes in rural and regional communities of less than 1,000 residents, which had previously been deemed too small for its earlier rollout (Weckler, 2021). The private broadband supplier, Imagine, has also announced that its fixed wireless broadband offering would be available to 1.1 million people at speeds of up to 150 Mbps, including 350,000 of the households due to be connected under the NBP (RTÉ, 2021).

The COVID-19 pandemic has accelerated support for the widespread broadband connectivity called for by the NBP. Recently, complementary initiatives such as funding for a cluster of wireless hubs to add capacity to existing remote working facilities have been bundled together with the NBP to "encourage digital innovation and development at the local level" (Department of the Environment, Climate and Communications, 2020a). Ireland has also responded by publishing a National Remote Work Strategy in January 2021 which sought to "to ensure that remote working is a permanent feature in the Irish workplace in a way that maximises economic, social and environmental benefits" (Department of Enterprise, Trade and Employment, 2021). While the COVID-19 pandemic has heightened recognition of the need for greater connectivity, it has also presented challenges. Due to operational challenges related to the pandemic, National Broadband Ireland was forced to halve its target of reaching 60,000 homes by the end of 2021. By mid-August only 12,000 new homes were "available for connection" (Department of the Environment, Climate and Communications, 2021).

The NBP has not been without its critics, however. The Department of Public Expenditure and Reform said the justification for spending €3 billion "on broadband has not been presented and we believe that this involves excessive costs and risks for the Irish taxpayer with questionable benefits" and recommended instead "incremental improvements in broadband" (McConnell & Laughlin, 2019). Criticism from non-government entities and the public included the tender process, the decision to use fibre rather than satellite connectivity, and the alleged absence of independent studies investigating whether the tender provided value for money.

Echoing this sentiment, some experts believed that the provision of ultrafast speeds to other parts of Ireland are less motivated by economics and the desire to unleash greater growth and efficiency but are instead motivated by ethical concerns about equity. For these areas, experts expressed scepticism about whether broadband would cause a measurable increase in companies' growth or productivity or whether increasing speeds from 10 Mbps, for example, to 100 Mbps or 1 Gbps would have any discernible effect. The issue, one interviewee said, is that laying broadband across a country tends to benefit those areas where highly skilled people predominate, while those areas where industries like food-processing are the major employer will find little use for it. Providing broadband, he said, may need to be paired with some complementary policy to develop the skills and job opportunities which could take advantage of that ultrafast connectivity. However, existing studies from other geographic contexts provide econometric evidence that subsea cable arrivals increase employment in skilled occupations in areas with terrestrial fibre by either increasing skilled employment as a share of total employment or by increasing the number of jobs overall (Hjort and Poulsen, 2019; O'Connor et al., 2020).

Regardless of the potential for accelerated growth in areas that are currently poorly connected, the NBP may help to reduce a perception that Dublin is overly focused on the part of the tech economy built around foreign investment. There has long been criticism that the government will go to great lengths to provide the major foreign tech companies with the infrastructure they need, which some interviewees said had created animosity. When residents see roads being dug up to lay cables between a tech company's offices, one interviewee said, there is some resentment: "None of these pieces of work were utilised to extend the facilities or improve any network connectivity for the general public", he said. There may be some truth to this, at least in the fact that since regulations allow only telecoms providers to lay fibre under some public infrastructure like roads, several large tech companies have registered as telecoms providers, allowing them to connect their own disparate offices in Dublin with their own cable.

8.3 PUBLIC POLICY AND REGULATORY ISSUES

Despite the economic and political tensions surrounding broadband access and benefits, the challenge for Ireland may lie less in ensuring it is building for infrastructure for both of its economies but to ensure internal blockages and other issues do not leave it uncompetitive. Experts were clear that the present challenge is to ensure that both overseas and domestic terrestrial connectivity keep pace with the times.

Irish policymakers are keenly aware of the importance of broadband infrastructure for Ireland's growth, including its role in supporting strategies aimed at attracting FDI. The importance of international connectivity was underscored in a public consultation on international connectivity for telecommunications published in October 2020 (Department of the Environment, Climate and Communications, 2020b) to inform policy development and decision making. The paper began,

> *High quality access to international telecommunications networks is a key driver in the growth of social, economic and industrial development of regions and countries. In recent times, Ireland has experienced growth in demand for international connectivity with capacity demand on the Atlantic running at a compound annual growth rate of 26% between 2015–2019. The overall growth is primarily driven by foreign direct investment, the large number of SMEs and new cloud-based applications.*

The paper highlighted the importance of Havfrue/AEC-2, which provides connectivity from North America to Denmark with spurs to Norway and Ireland with a landing point in County Mayo. It also noted that several subsea cable service providers have plans to provide additional direct connections from Ireland to the Continent.

While the government concluded its consultation paper by saying there was sufficient transatlantic connectivity, not everyone agrees. The Irish Communication Research Group, an industry group, said capacity was insufficient for future demand on international cables. The group wrote in a submission to the consultation that "new cable networks need to be provided to supply a fully utilised service with redundancy of services".

The public consultation paper also acknowledged an absence of cables connecting Ireland directly to continental Europe, which the paper identified as "an area for potential development". IDA Ireland also noted in a submission, dated 27 November 2020, that "one specific risk is direct connectivity of Ireland to Continental Europe, which is a primary market for Irish-based FDI enterprise. This is particularly the case now with Brexit, as connectivity from Ireland to the Continent is via the UK. In light of this, IDA Ireland believes that there is a need to have direct telecommunications' connectivity between Ireland and Continental Europe" (IDA Ireland, 2020b).

A key objective of new legislation noted in the public consultation paper will be to ensure that Ireland "remains an attractive location for providers of international connectivity." The government has followed up with the Maritime Area Planning Bill, designed to update antiquated legislation about managing marine development (Department of Housing, Local Government and Heritage, 2021). The bill is intended to update the Foreshore Act of 1933, under which previous cables were regulated and which has faced criticism as an obstacle to the provision of new subsea cables. The draft National Marine Planning Framework stated that a "robust and coherent marine and foreshore planning system is expected to encourage and support future investment in subsea telecommunications" (Department of Housing, Local Government and Heritage, 2018).

The new regulations would replace existing Foreshore Consents "by a more focused and streamlined Maritime Area Consent regime. The planning permission system will be extended into the entire maritime area with development subject to a single comprehensive environmental assessment" (Department of Housing, Local Government and Heritage, 2021). This may address criticism that, among other issues, the process and timeline to acquire a new foreshore license is "viewed as a significant barrier to new systems being developed on time to meet demand and also affects areas such as booking of scarce cable deployment ships, driving cost and risk to projects", in the words of an IDA Ireland submission to the public consultation on international connectivity for telecommunications in late 2020 (IDA Ireland, 2020b).

The government has also moved to reduce paperwork and fees for laying cables across the country, another source of criticism, removing broadband and telecommunications cables from a license fee when laying above-ground cables. Ensuring competitive international and intranational connectivity means in making it easy to develop the infrastructure at either end of it—from international connections to the final few metres across a field or up a garden path. Several interviewees pointed to anachronistic regulations that stymied regional projects and made running cables unjustifiably expensive. In a submission to the government, Microsoft said that its main issue was "limited backhaul options from Cork or Galway back to Dublin" and called on the government to "create [an] open and fair access policy in accessing public duct infrastructures across public infrastructure, ensuring cables can land without difficult or long lead time to [obtaining a] permit".

Dublin's city council has been quick to follow the example of some cities in the UK to set up specialised telecoms units to better handle the explosion of cables and access points that is beginning to happen with the arrival of 5G and greater connectivity demand. This, one interviewee said, is part of a deeper shift by local governments partly driven by an EU directive which in part requires them to not unduly restrict the deployment of wireless access points and to not seek revenue from such networks beyond covering any administrative charges (Directive (EU) 2018/1972, 2018).

However, concerns that regulations have not caught up with the market remain. Ireland's neighbours like France and the UK offer bigger markets unit-wise, so in some ways Ireland is already less economically attractive for providers. Addressing issues such as the absence of a fixed time limit on public enquiries into getting planning permission for landing or running a cable will be key for Ireland going forward. Without policy adaptations that lower the costs of subsea and terrestrial fibre projects by decreasing turnaround times, legal expenses, costs of permitting, and overall uncertainty, Ireland risks being unable to meet connectivity demand, thus becoming uncompetitive and unattractive for some of the industries and companies that have contributed to its impressive growth. However, by recognising and addressing these issues, Ireland can maintain its competitiveness and more fully unlock the benefits of subsea cables for future growth.

8.4 INSIGHTS FROM IRELAND

The analysis of subsea cable landings in Ireland makes clear that subsea cable investments can have outsized economic impacts for the countries where the cables land. For Ireland, subsea cables have supported the growth of tech hubs and ICT-intensive industries as well as induced FDI. Meta's past subsea cable investments in Ireland generated an impact of about €1.20 billion (about 0.39% of Ireland's GDP) annually, and a possible 2024 cable landing is estimated to catalyse an additional €1.14 billion (about 0.29% of Ireland's 2024 GDP) annually. As compared with the impact of a similar cable in 2024 for all of Europe, the percentage impact on Ireland's GDP is about 85% larger (0.29% of Ireland's GDP compared with 0.16% of Europe's GDP).

Ireland's policy and regulatory context provides a rich case study that highlights issues that may hamper infrastructure development and attenuate the potential impact of subsea cables. Ireland has achieved impressive growth since the global financial crisis of 2008, much of which is attributable to FDI. Ireland is also beginning to see signs for increased growth potential outside of FDI and its tech hub in Dublin, spurred by trends in remote work as a consequence of the COVID-19 pandemic.

To continue its impressive economic trajectory and to maximise the potential for the whole of the Irish population, Ireland will need to remain competitive in terms of its connectivity. Demand for connectivity has already been outpacing supply in terms of international and domestic bandwidth. To address the supply side to meet projected increases in demand, Ireland will need to consider regulatory measures to reduce the total expense and uncertainty related to fibre projects, especially given that subsea and terrestrial fibre planning takes place on the timescale of many years or even decades. A more streamlined set of regulations might also be combined with a set of complementary policies, for example around workforce skills and development, to not only maximise aggregate growth but to ensure that the gains from that growth are distributed equitably across Ireland.

9. Concluding Remarks

Subsea cables are critical infrastructure for growth in the modern global economy. Appropriately, they are considered by policymakers as a tool to drive economic development. Meta's investments in subsea cable landings in Europe demonstrate the potential for such investments to catalyse growth.

We estimate that Meta's investment in the MAREA cable generates an impact of approximately €16.7 billion (about 0.09% of Europe's GDP) annually. Based on Europe's GDP forecast for 2024–2027, we expect the impact of two possible cable landings consisting of 24 fibre pairs to catalyse an additional €59.6 billion (about 0.29% of Europe's 2027 GDP) annually. Together, the three cables constitute an economic impact of about 25% of a typical year's GDP growth (based on Europe's 1.5% GDP per capita CAGR since 2015).

However, several complementary policy issues should be considered to unlock the full potential of subsea cables for economic growth and to maximise the potential of subsea cable investments. Policies affecting subsea cables can either incentivise or disincentivise subsea cable investment and likewise either accentuate or attenuate their economic impact.

Foremost, international bandwidth capacity must keep up with the steeply increasing demand, otherwise industrial applications requiring ultrafast, reliable Internet will be infeasible, rendering some companies' products or services uncompetitive. Secondarily, a diversity and redundancy of routes is needed to minimise latency and maximise reliability. To support planning for additional subsea cables and international capacity to meet those objectives, policymakers should adopt clear, streamlined, and robust processes and procedures for maritime development that for investors enables planning by reducing uncertainty and excessive time or monetary costs surrounding the project. This can be done, for example, by placing time limits on planning permissions and consolidating licensing requirements and costs.

Policymakers should also keep in mind the importance of terrestrial infrastructure as complementary to subsea cables. More robust terrestrial fibre infrastructure accentuates the impact of subsea cables (because of network effects as discussed in Section 5). Therefore, as with subsea cables, regulations surrounding terrestrial fibre should be clear, streamlined, and non-prohibitive for development to the extent possible. Diverse backhaul options are particularly important to deliver international bandwidth to underserved areas and to reduce latency for cities along these routes. In addition to adding to the total economic impact of subsea cables, this helps address equity issues and prevent existing gaps from widening, particularly along urban-rural divides. However, to meet the demands of more users more international bandwidth is required. Therefore, it is important to consider the dynamic effects of increasing broadband penetration rates on average broadband speeds and ensure that both terrestrial and subsea fibre development are planned in concert.

Europe's growth has been modest over the past decade and has taken a hit with the COVID-19 pandemic. While most forecasters predict a relatively quick recovery from the pandemic in 2021 and 2022, Europe must confront its technological and strategic positioning to improve and sustain its macroeconomic growth trajectory. To do this, Europe will need to find ways to ensure its demands for increased international and domestic connectivity are met through measures that incentivise and streamline the development of new infrastructure. Europe has many major cities that are international hubs for data, finance, technology, and other economic activity at the technological frontier. These cities and many others in the future will increasingly rely on subsea cables and complementary infrastructure to remain competitive at this frontier.

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