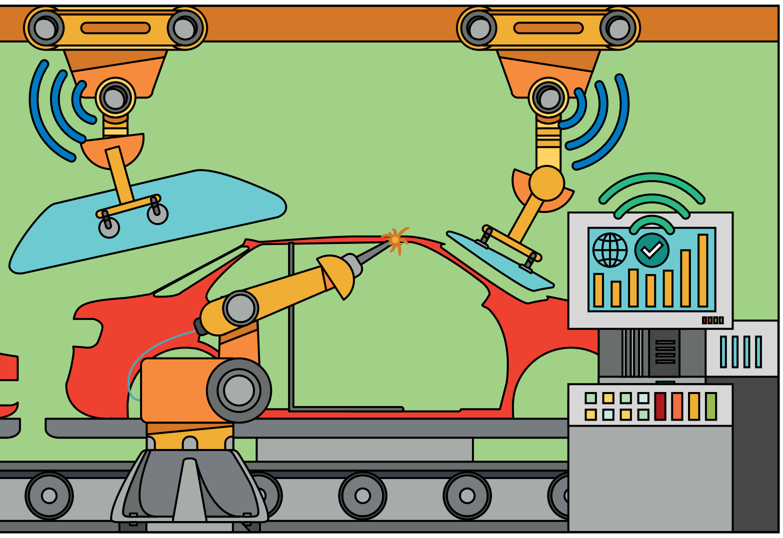
2 DIGITAL INFRASTRUCTURE AND FIRMS' PERFORMANCE



Internet connectivity affects how markets and firms function. The accessibility of fixed broadband and mobile internet has increased substantially in the EBRD regions over the last 15 years. Economies with higher income per capita and greater population density generally provide mobile internet to larger percentages of their populations. However, many economies in the EBRD regions still lag behind western European peers, especially when it comes to faster 4G technologies. Internet connectivity can boost firms' productivity: following the roll-out of high-speed broadband in Turkey, smaller manufacturing firms (especially those in ICT-intensive industries) increased exports of goods to distant markets. Similarly, the roll-out of 4G in Russia led to higher revenues and increased employment for the smallest firms in the service sector.

Introduction

The digitalisation of information and its dissemination via the internet can bring substantial benefits. In some industries, such as ICT services, the impact of improvements in digital infrastructure is direct and obvious. However, the economic impact of the internet extends much further than that. Internet connectivity can make it easier to find new products, improve the matching of workers to firms, reduce the time and effort required to learn new skills, and expand firms' market reach to encompass more remote locations. Far-reaching changes such as these affect firms of all sizes in all sectors and locations.

This chapter examines the impact that digitalisation and internet connectivity exert on firms in the EBRD regions. Internet coverage, access and speeds have all risen rapidly in the EBRD regions over the last two decades, as discussed in Chapter 1. However, people connect to the internet using a variety of technologies, and there are important differences between them: fixed broadband, for example, remains relatively limited in the EBRD regions, despite offering some of the fastest speeds, while mobile internet (which is relayed via cellular towers) offers slower data transfer rates but accounts for a much larger share of users.

By 2018, most economies in the EBRD regions had 3G networks covering more than 80 per cent of their populations (by place of residence). Many of those economies were approaching full coverage, on a par with most of western Europe, although several had coverage rates of less than 60 per cent (with some economies having rates as low as 40 per cent). The dispersion of coverage rates for 4G technology is noticeably higher. Although many economies are approaching full coverage, rates of between 20 and 80 per cent remain common. Countries with lower GDP per capita and lower population density tend to have lower levels of coverage. Like other forms of infrastructure, internet is easier to provide in more densely populated areas, as the fixed costs of installation can be spread across a larger number of consumers.

Disparities in terms of access matter, since – as this chapter shows – internet connectivity has a real impact on firms' outcomes.[1] While some effects may benefit firms, such as improvements in the pairing of workers with firms and increases in workers' productivity, other effects may prove challenging and require adaptation (for example, if the internet allows a firm's local customers to access competing firms in remote markets). Moreover, the impact on firms may differ depending on their sector and size. The data driven analysis in this chapter provides insight into these various effects in the EBRD regions.

[1] See also Hjort and Tian (2021).

IN BELARUS AND POLAND, MORE THAN 20% OF THE POPULATION HAVE FIXED BROADBAND

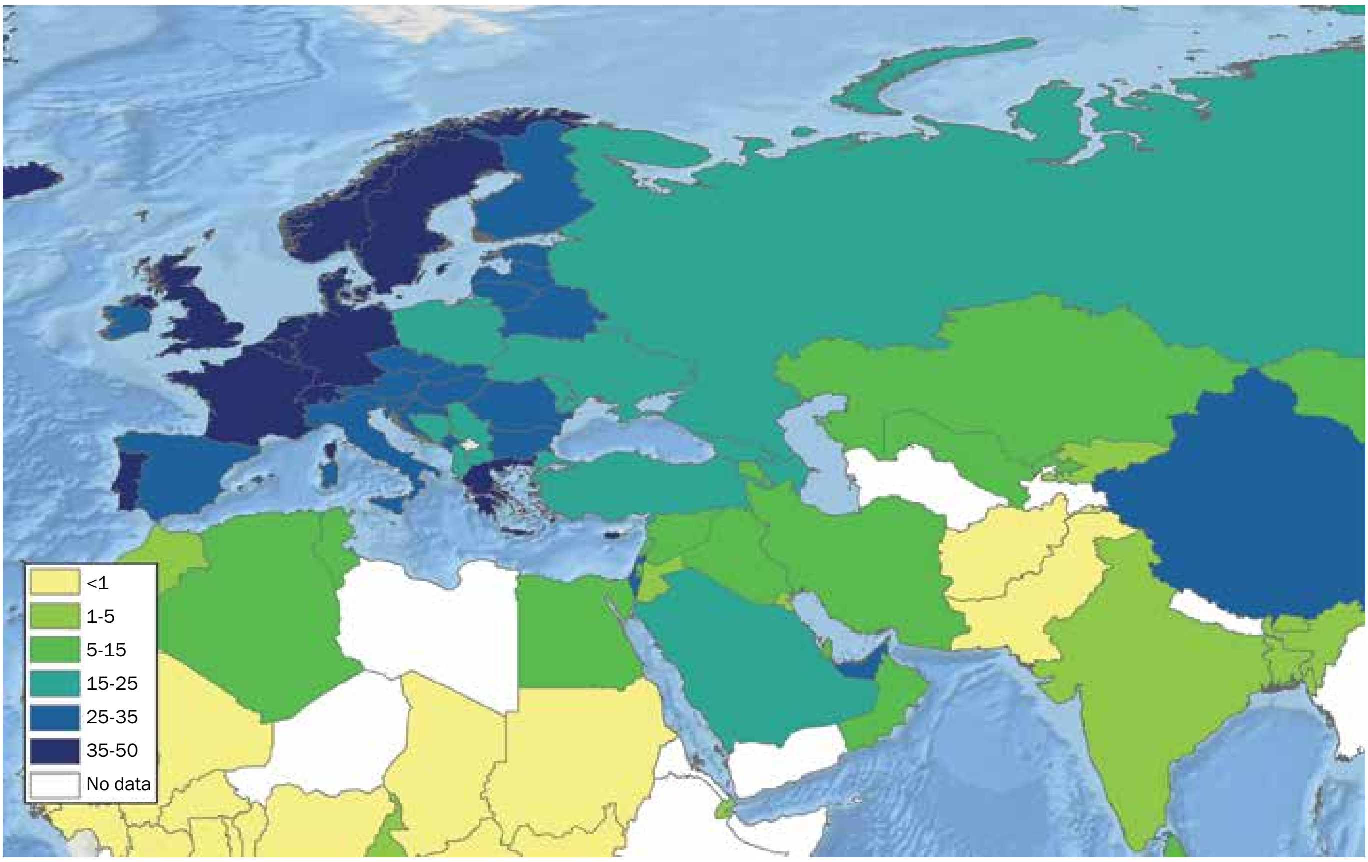
JUST 4% OF MOROCCANS HAVE FIXED BROADBAND

This chapter also looks at access to high-speed broadband in Turkey, showing that firms with better connectivity are more likely to export and introduce new products. Small firms in the manufacturing sector are estimated to have benefited most from improvements in the country's broadband infrastructure, having started selling to new foreign markets.

Meanwhile, in Russia (the largest economy in the EBRD regions) smaller firms have, on average, increased their staff numbers by about 19 per cent on the back of the roll-out of 4G. The effect on hiring has proved to be especially strong for the smallest firms in the service sector. Those firms have also been more likely to introduce new products or processes on the back of their increased use of digital technologies.

Overall, empirical evidence suggests that improvements in digital infrastructure may be particularly beneficial for small firms and their workers, partially offsetting the negative impact that digitalisation may have on economic inclusion through other channels.

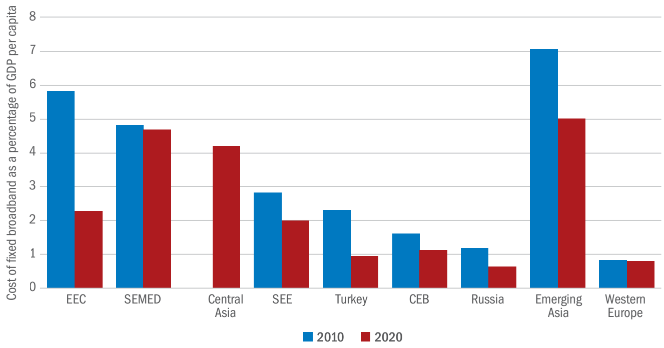
CHART 2.1. Fixed broadband penetration in the EBRD regions remains lower than in advanced European economies



Source: World Development Indicators[2] and Esri's World Ocean Basemap.[3]
Note: Colours indicate the number of fixed broadband subscriptions per 100 individuals in 2019. This map is used for data visualisation purposes only and does not imply any position on the legal status of any territory.

[2] See World Bank (2021).
[3] See Esri (2019).

CHART 2.2. The relative cost of fixed broadband has declined since 2010



Source: ITU, World Development Indicators and authors' calculations.
Note: This chart shows the cost of accessing 5 GB per month via fixed broadband relative to GDP per capita (based on constant 2010 US dollars).

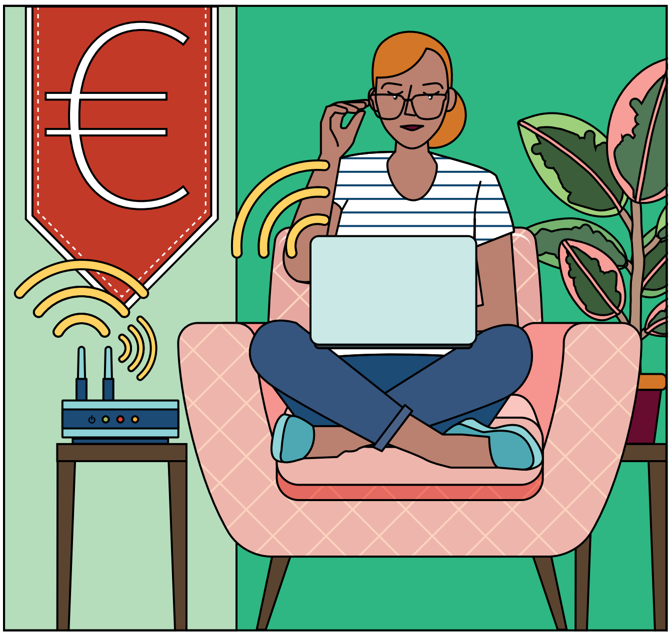
This chapter is structured as follows. The first section looks at internet connectivity across different technologies in the EBRD regions. That is followed by a short section discussing the channels through which connectivity may impact firms. The chapter then presents case studies focusing on Turkey and Russia, two of the largest economies in the EBRD regions, before ending with a number of concluding remarks.

Internet connectivity in the EBRD regions

Fixed broadband

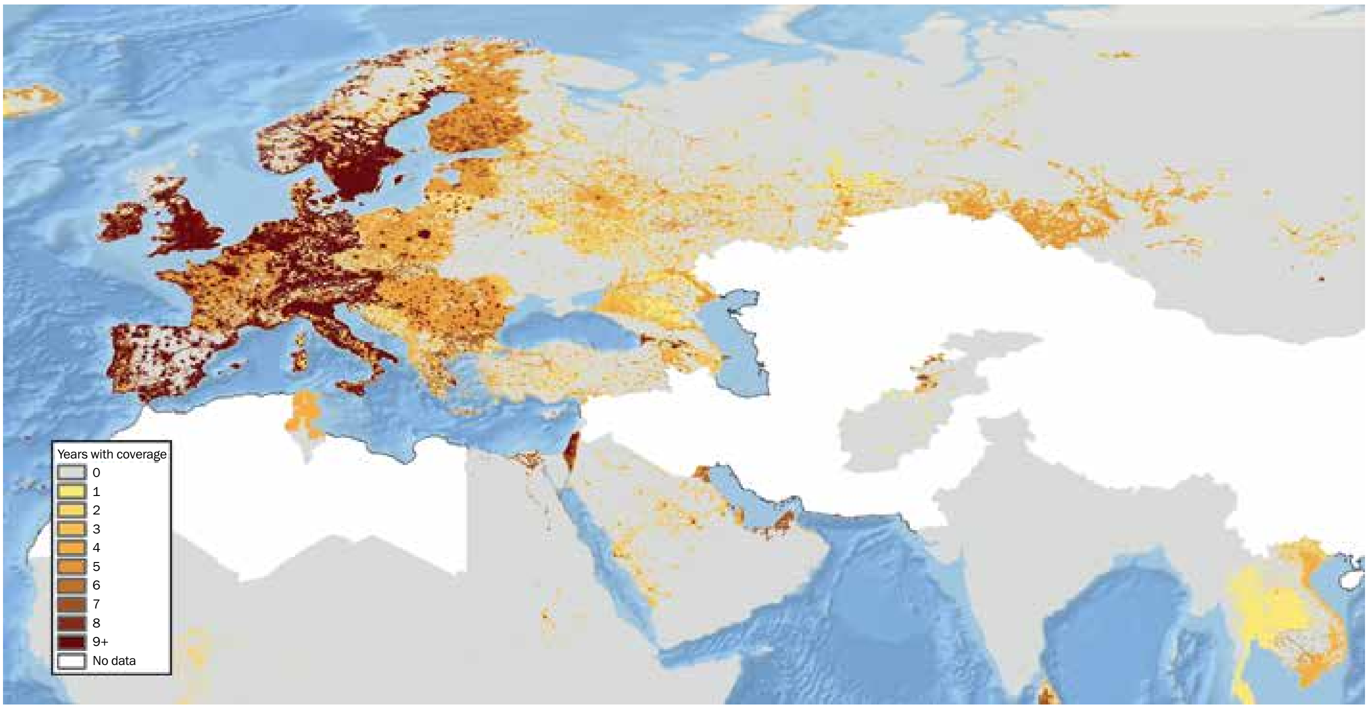
Households and firms can access the internet via fixed broadband cables or mobile networks. Adoption rates for fixed broadband remain relatively low in the EBRD regions compared with western Europe (see Chart 2.1). In 2019, the percentage of the population with fixed broadband ranged from 4 per cent in Morocco to more than 20 per cent in Belarus and Poland.

The lower adoption rates for fixed broadband in the EBRD regions may, in part, be explained by its higher cost (relative to average household income) compared with western Europe, notwithstanding the considerable decline seen in the relative cost of broadband in the period 2010-20 (see Chart 2.2). For example, while the relative cost of broadband services in eastern Europe and the Caucasus (EEC) fell by more than 50 per cent over that period, the cost of internet access remains about twice the level seen in western Europe. In the southern and eastern Mediterranean (SEMED) region, by contrast, the relative cost of broadband services declined only slightly.



THE RELATIVE COST OF BROADBAND HAS FALLEN BY MORE THAN 50% IN THE EEC REGION

CHART 2.3. Coverage by 3G and 4G networks has expanded over time



Source: Collins Bartholomew's Mobile Coverage Explorer, Esri's World Ocean Basemap and authors' calculations.
Note: Colours indicate the number of years with coverage by 3G, 4G or both in the period 2007-18. Areas with no data are shown in white. Data are not reported for every economy in every year, and all economies are missing data for 2010. The introduction years for 3G and 4G technologies have been confirmed using external sources. Where there are disparities regarding introduction years, economies have been dropped from this analysis. This map is used for data visualisation purposes only and does not imply any position on the legal status of any territory.

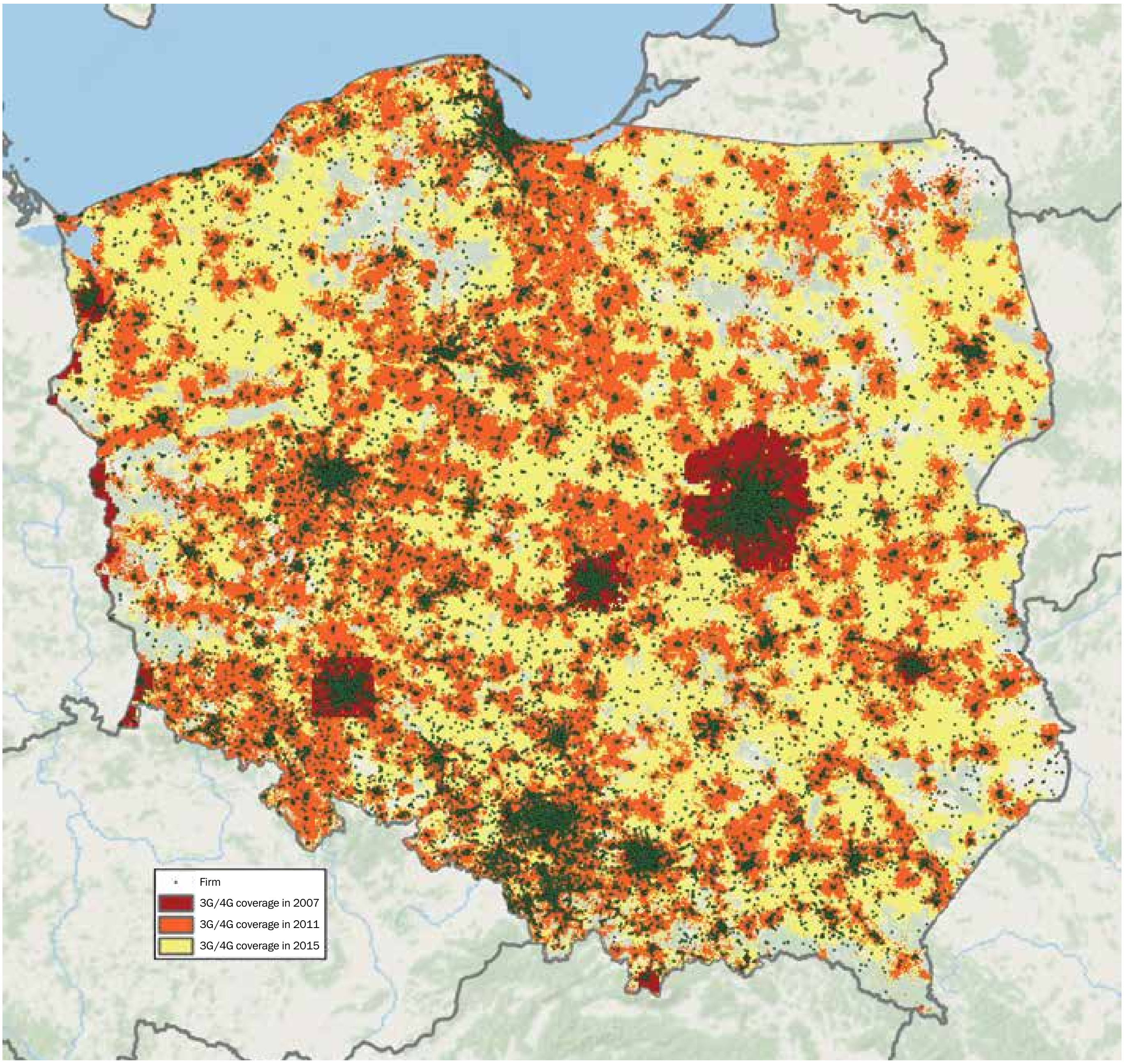
Mobile internet

Internet access via mobile devices on 3G and 4G networks offers a popular alternative to fixed broadband. The analysis below combines detailed data on mobile internet and economies' populations at 1 km^2 level, with data on mobile internet taken from Collins Bartholomew's Mobile Coverage Explorer and detailed population data obtained from the Gridded Population of the World dataset (version 4) managed by the Center for International Earth Science Information Network (CIESIN).[4] The resulting estimates of effective mobile internet coverage tend to be lower than the country-level statistics reported in Chapter 1. For instance, an individual may make extensive use of mobile data, but not have a stable connection at home. In that case, they may be recorded as being an active user of mobile internet in the country-level statistics, but be regarded as lacking effective coverage in the following analysis.

The vast majority of people living in the EBRD regions are now covered by 3G or 4G technology, albeit people in most geographical areas have had to wait longer than their counterparts in western Europe (see Chart 2.3). Urban centres such as Moscow, St Petersburg, Ulaanbaatar and Warsaw received coverage earlier than smaller cities and less densely populated areas (see Chart 2.4, for example, which shows the situation in Poland). Coverage in sparsely populated areas still varies, however. In Mongolia (the world's least densely populated country), for instance, there is still relatively little coverage outside Ulaanbaatar.

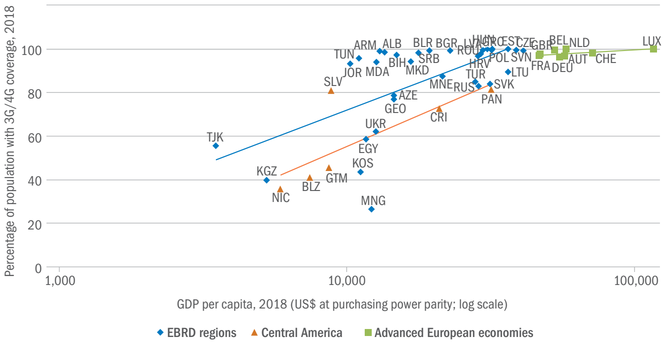
[4] See CIESIN (2020).

CHART 2.4. In Poland, urban centres received coverage earlier than smaller cities and less densely populated areas



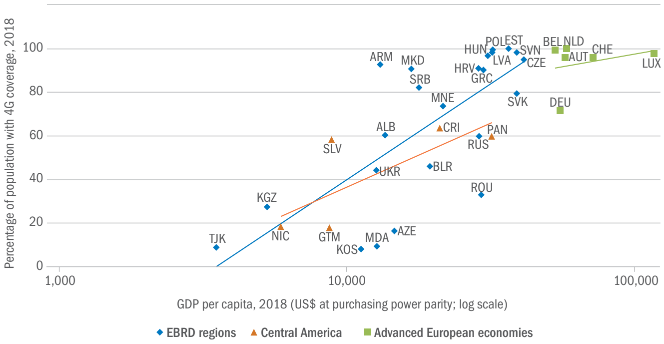
Source: Collins Bartholomew's Mobile Coverage Explorer, Orbis, Esri's World Ocean Basemap and authors' calculations.
Note: Dots indicate firms that were active in any year in the period 2007-15.

CHART 2.5. In economies with higher GDP per capita, larger percentages of the population tend to be covered by mobile internet



Source: Collins Bartholomew's Mobile Coverage Explorer, World Development Indicators, CIESIN's Gridded Population of the World dataset (version 4) and authors' calculations.

CHART 2.6. Many economies in the EBRD regions continue to lag behind advanced European comparators in terms of 4G coverage



Source: Collins Bartholomew's Mobile Coverage Explorer, World Development Indicators, CIESIN's Gridded Population of the World dataset (version 4) and authors' calculations.

In economies with higher GDP per capita, mobile internet networks tend to cover larger percentages of the population, both globally and within the EBRD regions (see Chart 2.5).

As with other forms of infrastructure and public goods, densely populated countries tend to have higher rates of coverage for 3G/4G. In densely populated areas, the fixed costs of infrastructure can be spread across more people, lowering the overall cost. For instance, Mongolia – which has the lowest population density in the world – also had the lowest coverage rate in the EBRD regions in 2018, at just 26 per cent. Meanwhile, Egypt, Kosovo, the Kyrgyz Republic and Tajikistan also had coverage rates of less than 60 per cent in that year.

Many economies in the EBRD regions continue to lag behind advanced European comparators in terms of 4G coverage (see Chart 2.6). 4G provides faster internet connections, enabling the use of more data intensive applications and websites. While many economies in the EBRD regions have coverage rates similar to those of richer western European comparators, there are several economies where more than 50 per cent of the population do not have coverage (see Chart 2.7). Indeed, there are four economies where less than 20 per cent of the population have 4G coverage.

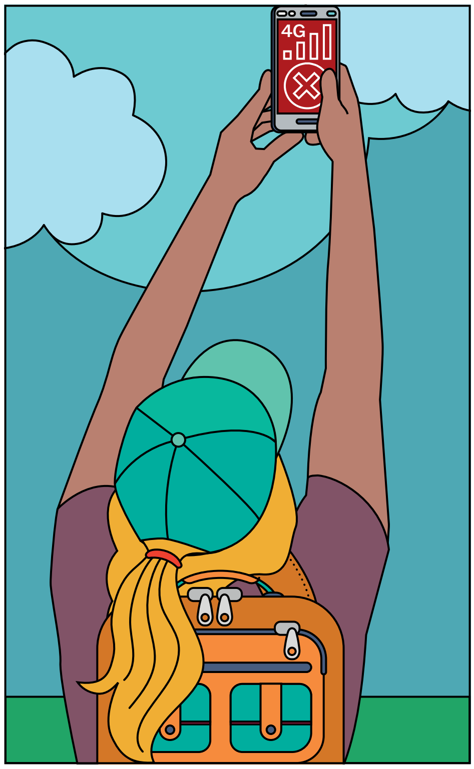
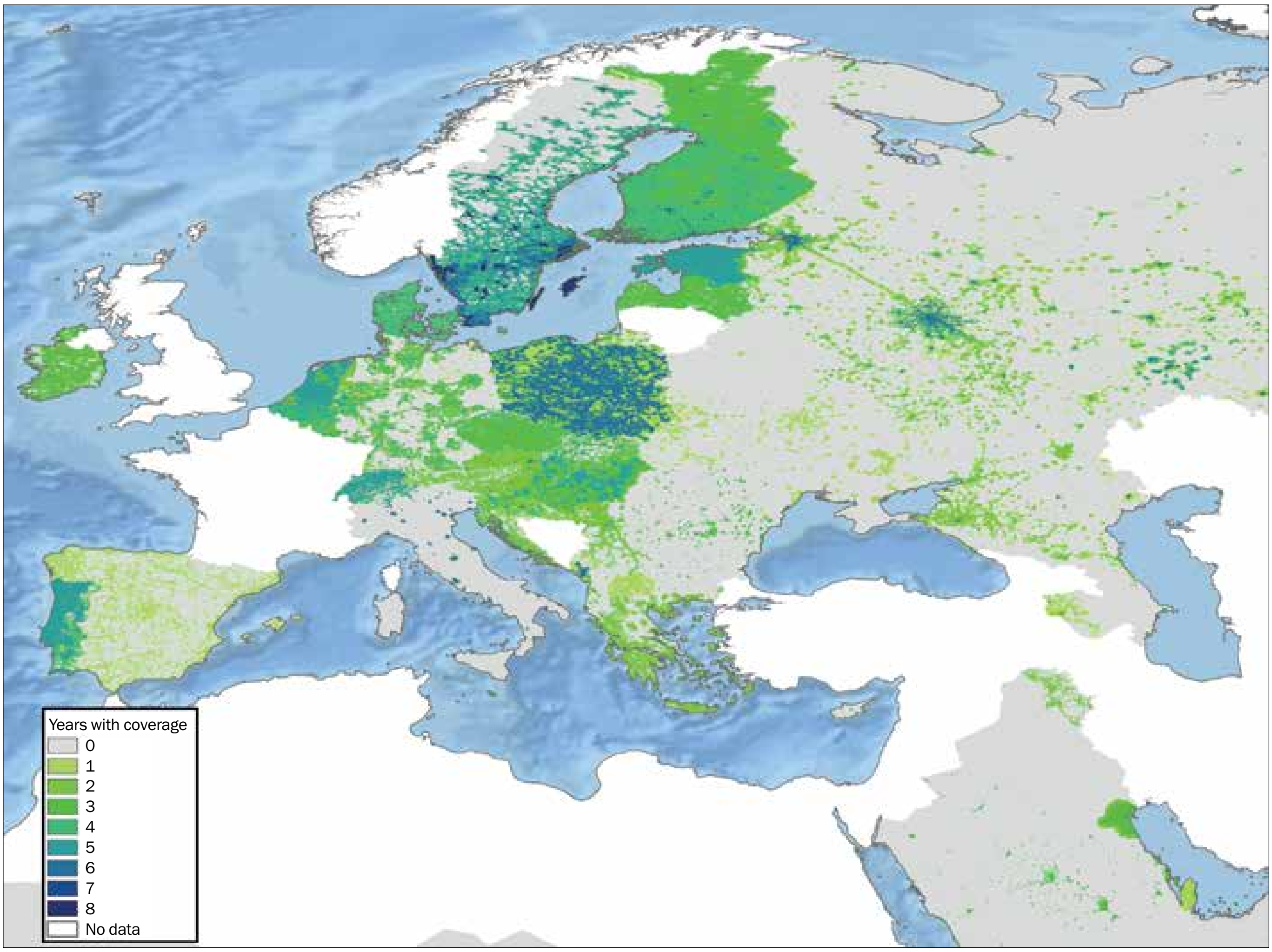


CHART 2.7. Urban centres were the first areas to be covered by 4G networks



Source: Collins Bartholomew's Mobile Coverage Explorer, Esri's World Ocean Basemap and authors' calculations.
Note: Colours indicate the number of years with 4G coverage in the period 2011-18. Areas with no data on 4G coverage are shown in white. This map is used for data visualisation purposes only and does not imply any position on the legal status of any territory.

ONLY 26%
OF MONGOLIA'S POPULATION HAVE MOBILE INTERNET COVERAGE

EGYPT, KOSOVO, THE KYRGYZ REPUBLIC AND TAJIKISTAN ALSO HAVE COVERAGE RATES OF
LESS THAN 60%

The impact of internet connectivity on firms

The digitalisation of information and its dissemination via the internet can bring substantial benefits. ICT intensive industries are particularly well placed to benefit from improved internet access. However, the economic impact of the internet extends much further than that, as illustrated by the roll-out of fixed broadband in Turkey, which is examined in detail below. Internet connectivity affects deep-seated features of markets that are common across all sectors, and it can impact firms through multiple channels.

How might internet access impact firms?

Internet connectivity affects both the demand for goods and services and firms' ability to supply them efficiently, as it results in more egalitarian access to the production and consumption of information.[5] On the supply side, for example, firms with high-quality internet may be better able to adopt new technologies. The firms' managers or owners could use the internet to learn about new production methods, ways of installing new machinery, or methods of improving coordination and communication across production lines or with customers.[6] The firms' workers, in turn, could see their productivity increase if internet access helps them to perform certain tasks more efficiently.

Increased posting of job vacancies online, greater opportunities to submit digital job applications and other information-sharing features can all make it easier to match workers to firms on the basis of workers' strengths and the skill requirements of jobs. For instance, access to online job boards could allow firms to reach applicants from across town (or beyond) who would not otherwise learn of their vacancies.

On the demand side, firms with internet connectivity are better able to access consumer markets in other geographical areas, and vice versa. What is more, they may gain access to new markets altogether. For example, without internet access it is virtually impossible to bid for public procurement projects. Meanwhile, introducing online sales might enable a firm to serve customers in other neighbourhoods. The internet also improves the quality of the information that is available to firms and their customers. For instance, the ability to read and share reviews of products or services online might increase consumers' confidence in an unfamiliar product.

We can see, therefore, that improvements in internet connectivity have the potential to affect firms' performance in a variety of different ways. Some new technologies may encourage firms to take on more workers (with multiple studies in sub-Saharan Africa finding that the roll-out of high-speed internet infrastructure fosters increases in employment),[7] while other technologies may result in human labour being replaced with software. The overall impact may depend on the size of the firm, the sector and the economy in question.

The availability of internet access across society as a whole may also matter when it comes to firms' performance, as consumers will presumably gain access at the same time as local firms. This may increase demand for local services (such as delivery of takeaway meals). On the other hand, just as firms will be able to reach new consumer markets thanks to their improved connectivity, they may face competition for their local customers from distant firms that are now able to reach their local markets. For example, in a randomised experiment looking at the expansion of e-commerce to rural households in China, Couture et al. (2021) found no effect on production or income. Instead, they found wealthier households benefiting from improved connectivity through reduced consumption costs. Firms may also face greater exposure to international competition. As internet coverage expands, firms may find their virtual market places becoming increasingly crowded. Such congestion can, ultimately, make it more difficult for consumers to search for firms.[8]

With that in mind, the next subsection examines the impact that the roll-out of fibre internet in Turkey has had on firms' performance using detailed data on firms' employment, balance sheets, income statements and customs records (which are derived, in part, from an ICT survey conducted by the Turkish Statistical Institute; see also Box 2.1).

[5] See Falck et al. (2014) and Hjort and Tian (2021).
[6] See DeStefano et al. (2018) and Akerman et al. (2015).
[7] See Hjort and Poulsen (2019).
[8] See Bai et al. (2020).

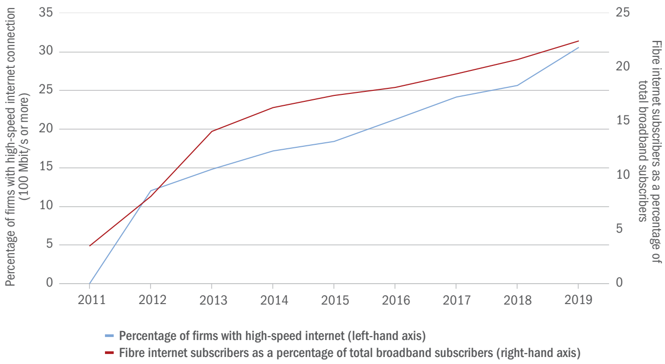
The roll-out of high-speed fixed broadband in Turkey

Until fairly recently, Turkey's internet infrastructure was large but had limited speed. Since the early 2010s, however, Turkey has been investing heavily in fibre internet, with a relatively high take-up rate. Both (i) the percentage of firms with a high-speed internet connection (defined as a download speed of 100 Mbit per second or more) and (ii) fibre internet subscribers as a percentage of total broadband subscribers have increased dramatically since 2011 (see Chart 2.8). In 2018, fibre internet connections accounted for 21 per cent of all fixed broadband connections in Turkey, close to the OECD average (26 per cent) and above the rates seen in France, Germany and the United States of America. The evidence from Turkey provides fresh insight into the considerable benefits that improvements in internet infrastructure can have for firms' growth and trade-related activities.

Analysis indicates that a 1 standard deviation increase in the density of high-speed internet cables (measured as cable length relative to the size of the local area) is associated with a 1.4 percentage point increase in the percentage of Turkish firms with high-speed internet access (see Box 2.1 for more details). That rise corresponds to a 7 per cent increase relative to average use of high-speed connections. Across sectors – that is to say, both in industries that use a lot of ICT services and in less ICT-intensive industries – Turkish firms of all sizes have made increased use of high-speed internet as high-speed broadband infrastructure has improved in the local area.

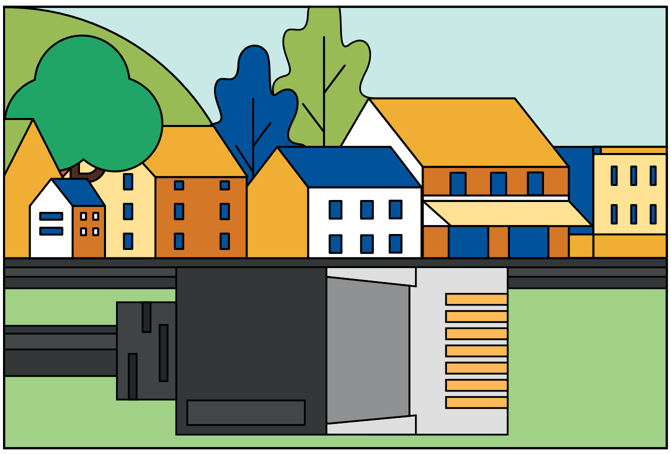
The increased availability of high-speed internet in a particular Turkish province is also associated with greater employment of ICT personnel. That effect is economically and statistically significant for firms employing at least 20 workers and is stronger for larger firms. The increase in ICT personnel in response to a 1 standard deviation increase in the availability of broadband is around 1 percentage point greater for ICT-intensive industries (such as publishing, programming and broadcasting activities, which are in the 95th percentile of the distribution of ICT intensity) than it is for less ICT-intensive industries (such as food, beverages and tobacco, which are in the 5th percentile of that distribution).

CHART 2.8. Turkey has been investing heavily in fibre internet, with a relatively high take-up rate



Source: Turkish Information and Communication Technologies Authority, Turkish Statistical Institute and authors' calculations.

IN 2018, FIBRE INTERNET ACCOUNTED FOR
21%
OF ALL FIXED BROADBAND CONNECTIONS IN TURKEY



High-speed internet benefits small manufacturing firms in ICT-intensive industries

The results also suggest that small manufacturing firms are big beneficiaries of the availability of high speed internet (see Chart 2.9). Small Turkish firms operating in more ICT-intensive manufacturing industries have increased employment and boosted their market shares as high-speed internet has been rolled out in their provinces. They have also started to pay higher average wages to their workers and have seen a decline in their marketing and distribution costs. These effects are sizeable. For instance, for small firms in a highly ICT-intensive industry, a 1 standard deviation increase in the density of high-speed internet cables is associated with a 2.7 percentage point increase in employment and a 0.7 percentage point increase in average wages. For small firms in industries with low levels of ICT intensity, the equivalent effects total 1.2 and 0.3 percentage points respectively.[9] While large firms have also benefited in terms of employment and sales, there are no statistically significant effects on other measures of their performance.

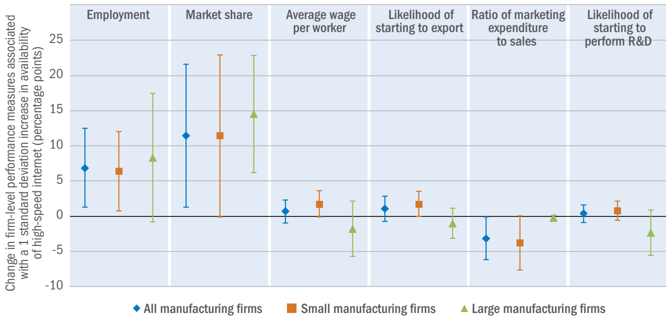
Firms that have benefited from the improvements in broadband infrastructure are also more likely to have started exporting by the end of the review period. In general, small manufacturing firms are less likely to export than large firms. Where they do export, they tend to export a smaller number of products to a smaller number of destination countries.

Following the roll-out of high-speed broadband, small Turkish manufacturing firms in more ICT-intensive industries have increased their exports, added more products and started exporting to new markets (particularly distant ones; see Chart 2.10). Indeed, for such firms, a 1 standard deviation increase in the industry-adjusted density of high-speed cables is associated with a 20 percentage point increase in the value of exports. This suggests that the impact of internet access in terms of lowering the fixed cost of acquiring information about new markets and ways of serving them has been particularly beneficial for small firms (which may have experienced prohibitively high costs in the past).

At the same time, the prioritisation of areas for the roll-out of broadband internet may not be random, giving rise to concerns that related factors may have influenced the improvements in firms' performance that have been attributed to better digital infrastructure. With that in mind, additional analysis has been carried out, examining potential determinants of the annual roll-out of fibre internet across provinces over the period 2012-19. Only population density has significant predictive power when it comes to explaining the sequencing of broadband upgrades, unlike gross regional product (GRP) per capita, the ratio of public expenditure to GRP, the percentage of firms operating in highly ICT-intensive industries or other indicators of the level or composition of business activity. Additional robustness checks included adding interaction terms combining the ICT intensity of industries with (i) changes in province-level public spending relative to GRP, (ii) bank loans per person and (iii) the quality of road infrastructure (as measured in terms of travel times between provinces).[10] These checks suggest that the reported differences in firms' performance are not driven by improvements in road infrastructure or other areas of public spending.

The next subsection turns to the link between mobile internet coverage (whether 3G or 4G) and the performance of firms.

CHART 2.9. Small manufacturing firms are big beneficiaries of the availability of high-speed internet



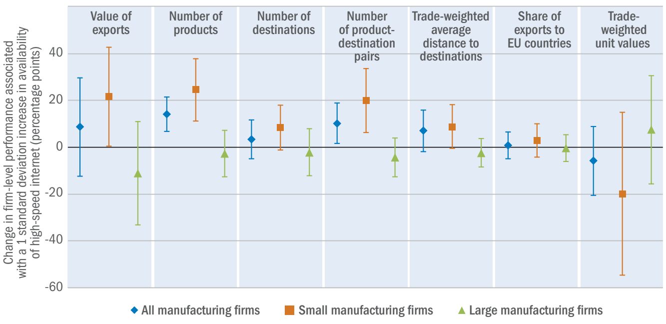
Source: Turkish Statistical Institute, EU KLEMS database and authors' calculations.
Note: These estimates are based on models regressing changes in measures of firms' performance in the period 2011-19 on the availability of high-speed internet at province level and various controls (see Box 2.1). They represent standardised coefficients, with data on all measures of performance being normalised such that estimates report percentage point changes for the purposes of comparison. 90 per cent confidence intervals are shown.

FOR SMALL FIRMS IN A HIGHLY ICT-INTENSIVE INDUSTRY, A
1 STANDARD DEVIATION
INCREASE IN THE DENSITY OF HIGH-SPEED INTERNET CABLES IS ASSOCIATED WITH A
2.7 PERCENTAGE POINT
INCREASE IN EMPLOYMENT

[9] Industries with high and low levels of ICT intensity are defined here as industries in the 90th and 10th percentiles of the distribution of the ratio of ICT capital to total capital across German manufacturing industries in 2011.

[10] See Cosar et al. (2021).

CHART 2.10. Small manufacturing firms in more ICT-intensive industries increase exports, add more products and start exporting to new markets when the availability of high-speed internet improves



Source: Turkish Statistical Institute, EU KLEMS database and authors' calculations.
Note: These firm-level estimates show long differences and relate to the period 2011-19. They represent standardised coefficients, with data on all measures of performance being normalised such that estimates report percentage point changes for the purposes of comparison. 90 per cent confidence intervals are shown.

A 1 STANDARD DEVIATION INCREASE IN THE INDUSTRY-ADJUSTED DENSITY OF HIGH-SPEED CABLES IS ALSO ASSOCIATED WITH A 20 PERCENTAGE POINT INCREASE IN THE VALUE OF EXPORTS

Mobile internet coverage and firms' performance

Identifying the effect that mobile internet has on firms' performance is challenging, as telecommunication firms tend to expand coverage on the basis of the location of potential customers and the strength of local economic activity – factors that also affect businesses directly. Indeed, 4G has (as was the case with 3G) generally tended to be rolled out in urban centres first of all (see Charts 2.3 and 2.7). In order to break the confounding links between the causal impact of internet coverage and other underlying advantages of firms and locations that might determine coverage, the analysis described below leverages differences in coverage across locations and over time.

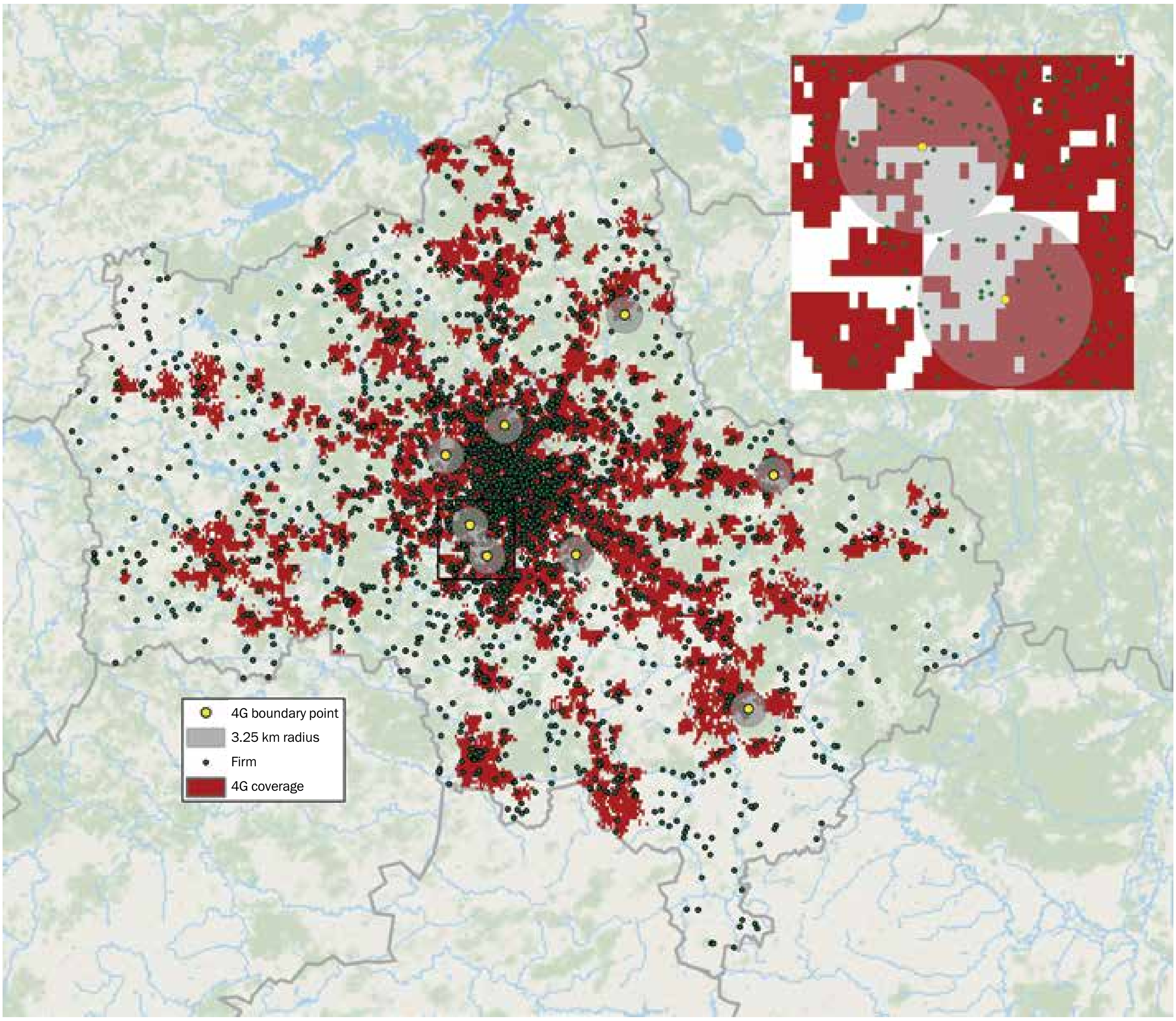
As before, the analysis draws on data from Collins Bartholomew's Mobile Coverage Explorer on 3G and 4G network coverage at 1 km^2 level, with data covering the period 2007-15.[11] The data reflect coverage reported to the GSMA by mobile operators. Firm-level data on capital, numbers of workers and revenue by year are taken from Bureau van Dijk's Orbis dataset. Geographical coordinates for firms' locations have been scraped using the OpenStreetMap API.[12] Combining firms' locations with annual coverage data provides the basis for the spatial regression discontinuity design analysis discussed in the following section.

Spatial regression discontinuity design analysis in Russia

In order to isolate the causal impact that internet coverage has on firms' performance, this analysis compares the performance of firms located either side of specific boundary lines in terms of mobile internet coverage (see also Box 2.2). Those boundary lines are determined by the reach of signals from mobile phone towers – which, in turn, is determined by many different factors, including the surrounding topography, the height of the towers and the strength of the boxes mounted on those towers. While core areas of coverage can be targeted by telecommunication firms, the exact reach of that coverage is determined by a number of factors that are not entirely within those firms' control. Thus, whether an individual firm falls just within or just outside an area of coverage can be regarded as being as good as random.

[11] See Guriev et al. (2019) for a detailed discussion of these data.
[12] Coordinates are assigned to blocks, with the typical block length being 400-800 metres. That level of precision is accurate enough in practice for the purposes of this analysis, although misclassification is possible at the outer edges of a network's coverage area.

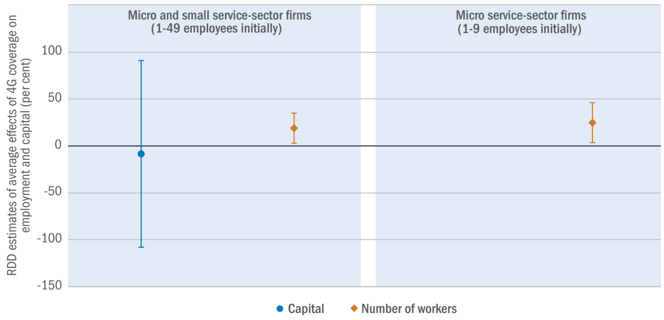
CHART 2.11. When 4G was first introduced in Russia in 2013, coverage around Moscow was limited



Source: Collins Bartholomew's Mobile Coverage Explorer, Orbis, Esri's World Ocean Basemap and authors' calculations.
Note: The window in the top-right corner provides a magnified view of two points on the 4G boundary.

IN RUSSIA, SERVICE-SECTOR FIRMS INCREASED STAFF NUMBERS BY AN AVERAGE OF
18%
ON GAINING ACCESS TO 4G, RELATIVE TO SIMILAR FIRMS WITHOUT 4G

CHART 2.12. Micro-firms in the service sector increased employment most following the roll-out of 4G



Source: Collins Bartholomew's Mobile Coverage Explorer, Orbis and authors' calculations.
Note: Estimates are based on RDD analysis. The 95 per cent confidence intervals shown are based on standard errors clustered by boundary point. Controls include the log of the population of the 1 km^2 area around the firm and fixed effects for boundary points.

An empirical methodology known as a regression discontinuity design (RDD) can be used to estimate the average causal effect of 4G internet. It leverages the fact that only a limited set of locations in Russia received 4G coverage when the technology was first introduced in 2013, leaving many firms without coverage (see Chart 2.11). Restricting the set of firms in the sample to those located close to the coverage boundary reduces the likelihood that other unobserved factors could be driving any differences between the performances of firms located within and outside the area of coverage (see the magnified window in the top-right corner of the chart, which zooms in on two points on the 4G boundary and firms falling within a 3.25 km radius of those points).

Micro-firms and small firms in Russia

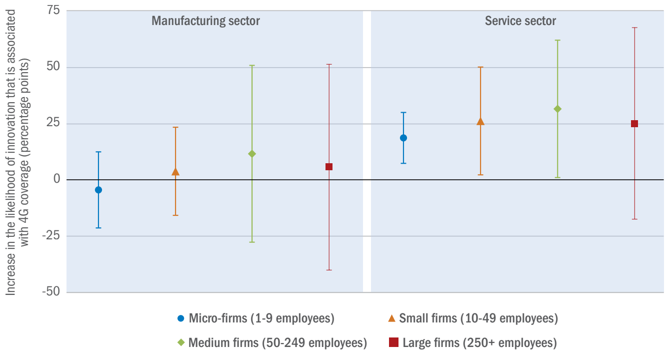
This analysis focuses on smaller firms. Although firms of all sizes are located around the coverage boundaries, relatively few of them have 50 workers or more. For smaller firms in the service sector, the benefits of internet coverage can be expected to be particularly large when it comes to matching potential workers with firms. 4G coverage might also extend the market reach of firms providing services that can be performed remotely (such as delivery services). In addition, the service sector relies more on labour and less on machinery, so it can mobilise additional workers particularly quickly. At the same time, the numbers of larger firms in the vicinity of network coverage boundaries are not sufficient to run a robust RDD analysis for those firms alone.

Analysis suggests that the arrival of 4G internet coverage was associated with a 19 per cent increase in the number of people employed by service-sector firms with fewer than 50 employees (which comprise "micro-firms" with 1-9 workers and "small firms" with 10-49 workers; see Chart 2.12).[13] The greatest benefits were enjoyed by micro-firms, which hired, on average, two additional employees each relative to similar firms that fell just outside the coverage area (representing an average increase of 24 per cent in those firms' workforces).

IN RUSSIA, SERVICE-SECTOR FIRMS WITH FEWER THAN
50 EMPLOYEES
INCREASED STAFF NUMBERS BY AN AVERAGE OF
19%
ON GAINING ACCESS TO 4G, RELATIVE TO SIMILAR FIRMS WITHOUT 4G

[13] Considering firms of all sizes yields a very similar estimate of 18 per cent.

CHART 2.13. Firms in the service sector have become more innovative following the roll-out of 4G



Source: Collins Bartholomew's Mobile Coverage Explorer, Enterprise Surveys, CIESIN's Gridded Population of the World dataset (version 4) and authors' calculations.
Note: "Innovation" refers to the introduction of a product or service that is either entirely new or represents a significant improvement on an existing product or service. Estimates are based on regression analysis linking innovation to 4G coverage at a firm's location. The 95 per cent confidence intervals shown are based on robust standard errors. All specifications include country-year, sector-year, subnational region and industry fixed effects.

Access to mobile internet is associated with increased innovation by micro-firms

Data from the Enterprise Surveys conducted by the EBRD, the World Bank and the EIB can be used to shed further light on the impact that mobile internet has on innovation. That survey focuses on small firms (with the median firm having around 20 employees) and records detailed information about firms' locations, as well as new products and processes introduced by firms in the three years preceding the survey. Data are drawn from the last three waves of the survey, which were conducted between 2008 and 2020. The sample is much smaller than the Orbis sample and does not support spatial discontinuity analysis. Instead, a difference-in-differences analysis focuses on differential trends in innovation in areas with and without 4G coverage. The analysis controls for the population density of the area around the firm, whether the firm is an exporter, whether the firm is located in an urban area, the number of bank branches within a 5 km radius of the firm, whether the firm has a female owner and whether the firm has been in business for less than five years. Fixed effects at the subnational region level and the industry level (on the basis of two-digit ISIC industry codes) are also included, as are country-year and sector-year fixed effects.

That analysis indicates that smaller firms in the service sector are significantly more likely to introduce new or improved products or services once they have been given access to 4G. Indeed, they are between 19 and 26 percentage points more likely to innovate than similar firms without 4G coverage (see Chart 2.13). The effects for manufacturing firms and larger firms in the service sector are smaller and not statistically significant.

Policy implications

Investment in ICT infrastructure may provide an opportunity to foster growth across the board and may be particularly beneficial for smaller firms and their workers (particularly in the more labour-intensive service sector). This, in turn, may have a positive impact on economic inclusion and income equality, provided that such infrastructure has a broad geographical reach. This may help to partially offset any negative effects of digitalisation in terms of widening digital divides, as discussed in other chapters of the report.

A caveat is in order, however: the analysis in this chapter has largely focused on the early effects of improved digital infrastructure. As digital infrastructure continues to improve and expand, local firms may face stronger competition from larger firms and companies located further away (even across borders).[14] While this may result in efficiencies of scale and associated benefits for consumers, increased market concentration on account of network effects will present its own policy challenges.

Competition policy, in particular, will need to evolve and become fit for the digital age.[15] This will involve new approaches to defining local markets, new tests when it comes to improved consumer welfare and longer time horizons for the analysis of competition issues.

Requirements in terms of digital infrastructure will change constantly as technology develops. For example, Box 2.3 discusses the advantages of 5G technology, which provides for faster wireless data transmission and supports the "Internet of Things" – wireless communication across a variety of devices. Digital infrastructure can also help to make other infrastructure, from electricity grids to road networks, smarter, unleashing major benefits for businesses and consumers (see Box 2.4).

However, as major parts of the economy become more reliant on digital infrastructure, cybersecurity risks will rise. As a result, cybersecurity will increasingly become a priority area for public and private investment (see Box 2.5).

IN RUSSIA, SMALLER SERVICE-SECTOR FIRMS WITH ACCESS TO 4G ARE BETWEEN
19 AND 26
PERCENTAGE POINTS
MORE LIKELY TO INNOVATE

[14] See Bai et al. (2020).
[15] See Crémer et al. (2019).

Conclusion

Despite substantial progress in terms of building internet infrastructure in the EBRD regions, high-speed fixed broadband remains expensive in many economies and adoption rates are still relatively low. Mobile internet coverage, on the other hand, has expanded significantly in the last 15 years. 3G and 4G networks tend to cover larger percentages of the population in economies with higher GDP per capita and greater population density. Several economies in the EBRD regions have relatively low levels of mobile internet coverage, with 3G networks covering less than 60 per cent of the population and 4G networks covering less than 20 per cent (on the basis of people's places of residence).

Gaps in internet coverage matter, as improvements in digital infrastructure bring benefits for firms and consumers alike. Internet connectivity assists firms with the adoption of new technologies and helps to match workers to job vacancies on the basis of the skills required. Digital connectivity can also help firms to access new, more distant markets or new suppliers. At the same time, consumers have greater product choice and find it easier to locate information about different goods and services (for example, on the basis of reviews provided by other consumers).

However, despite the advantages that the internet can provide, some firms may miss out on those benefits and face new challenges instead. Firms may become exposed to competition from firms in larger markets (including international firms), potentially concentrating market power in the hands of a small number of firms. At the same time, increased competition and congestion in the virtual marketplace may result in new information barriers for consumers.

Following the roll-out of broadband internet in Turkey, smaller manufacturing firms in ICT-intensive industries have significantly expanded their businesses. Those firms are now more likely to export and reach more distant markets than comparable firms that have not benefited from high-speed internet. Moreover, spatial regression discontinuity analysis finds that service-sector firms with fewer than 10 employees that have 4G mobile internet coverage have, on average, expanded their workforce by two to three workers more than similar firms in nearby areas without 4G coverage.

The benefits of digitalisation are far-reaching, also extending to core infrastructure such as electricity grids and road networks. However, increased digital connectivity will also come with increased risks relating to cybersecurity and the handling of sensitive personal data. This will require additional resources to be dedicated to the management of cybersecurity risks.

BOX 2.1.

Data on broadband internet in Turkey

Data on the roll-out of fibre internet in Turkey are available from the Turkish Information and Communication Technologies Authority. These are scaled by the amount of fibre cable in each province in each year.

In order to investigate whether firms located in provinces that benefit more from investment in fibre internet are more likely to use high-speed internet, the analysis in this chapter draws on an annual firm level survey on the use of ICT that is administered by the Turkish Statistical Institute. That ICT survey, which has been carried out every year since 2005, covers all firms with more than 250 employees and a representative sample of smaller firms, with a total sample of around 10,000 firms. Firms are recorded as using high-speed internet if their connection speed is 100 Mbit per second or more. The percentage of firms with high-speed internet access is calculated for each province and year.

The ICT survey is also linked to a large-scale business survey, which reports firm-level information such as employment, wages, material input purchases, industry of operation at the four-digit level of disaggregation using NACE (the Statistical Classification of Economic Activities in the European Community), the year of establishment and the province where the firm is located.

Empirical analysis investigates the effect that the availability of high-speed internet has on various firm level outcomes, such as employment, sales and exports. To this end, several firm-level administrative datasets maintained by the Turkish Statistical Institute are merged. Those data cover all formal firms in Turkey in the period 2011-19, with each dataset using the same unique firm identifiers. The firm level balance sheet and income statement data contain detailed information on annual revenue and expenditure (with a breakdown including items such as financing, marketing and taxes), as well as details of firms' assets and liabilities (including items such as bank loans, accounts receivable, accounts payable and cash holdings). Moreover, customs data provide information about the annual value and physical volumes of firms' exports, broken down by destination country and product group (at the eight-digit level of the Harmonised System).

The variable that captures the degree of reliance on ICT technologies at industry level comes from the EU KLEMS database. It is calculated as ICT-related capital's share of the total capital stock of an industry for Germany and the United States of America in 2011. Industries where this measure exceeds the median (for the manufacturing or service sector, as applicable) are categorised as ICT-intensive.

The analysis links the differences between the average outcomes for each firm (in terms of exports, for example) in 2018-19 and 2011-12 with the availability of high-speed broadband, as well as various firm level characteristics. Specifications control for the log of initial firm-level employment and an interaction term combining the province's population density in 2011 with the industry's ICT intensity. Province and industry fixed effects also capture changes in location-specific or industry-specific factors affecting demand and supply.

BOX 2.2.

Spatial regression discontinuity design analysis

The large number of firms in the Orbis dataset and the highly granular data on 4G coverage support a spatial regression discontinuity design approach based on Keele and Titiunik (2015). In this analysis, firms' locations are matched to a grid capturing network coverage at 1 km^2 level. Straight-line distances are calculated from the location of each firm to a set of points along the boundaries of network coverage.[16] The analysis focuses on the boundaries between areas with and without network coverage.

Discontinuities at the points on the coverage boundary are estimated for the primary outcomes of interest for firms: the inverse hyperbolic sine of the number of workers, the nominal value of capital, and operating revenue (expressed in euros). The differences between the outcomes of firms just inside the coverage area and those of similar firms just outside that area indicate the average impact of coverage. Specifications control for the population at the firm's location, boundary point fixed effects, the firm's industry (manufacturing or services), and the firm's size bracket (micro, small, medium or large) as determined in its first year in the sample.

Estimation and the choice of boundary points

The RDD is estimated using a local linear regression with a triangular kernel. This approach helps to estimate the discontinuity in outcomes that occur right at the boundary. The bandwidth determining how far away from boundary points firms can sit and still be included in the estimation is selected by the default optimal bandwidth algorithm in the "rdrobust" package and is typically less than 3 km. The estimated discontinuity is bias-corrected using a second-order polynomial with a separate optimal bandwidth. Robust standard errors are clustered by boundary point. This methodology leads to conservative estimates of any causal effects.

A discrete set of boundary points (211 in total for 2013) are placed along the coverage boundaries at 25 km intervals. All firms within a 50 km radius of each boundary point are included in the analysis and feed into the optimal bandwidth calculations. Boundary points are then selected on the basis of the number of firms on each side of the boundary within a 5 km radius, so many boundary points are excluded since they do not have enough firms on one side or the other for reliable discontinuity estimations. The boundary points with the most firms and the best balance between coverage and non-coverage areas (23 in this case) are retained and used in the analysis. Each boundary point essentially produces its own discontinuity estimate, with the final estimate being a weighted average of those discontinuities.

One reason to screen boundary points is the large number of firms that are needed around each point in order to run estimates with boundary point fixed effects. This ensures that outcomes are compared for firms that are all geographically close to one another, and not simply close to a boundary. Large numbers of observations are also needed in order to conduct the analysis for subgroups of firms based on industry and firm size.

RDD validity testing

The RDD analysis provides strong evidence that faster internet connections benefit smaller firms in the service sector. The validity of these results can be tested indirectly to confirm their soundness. Other factors that could conceivably influence firms' outcomes – such as population density at the start of the period, economic activity (as proxied by night light data)[17] and employment in the service sector in 2011-12 (the years prior to the roll-out of 4G mobile networks) – exhibit no obvious discontinuities around the coverage boundary.

[16] Firms located in areas without 4G coverage in 2013 are assigned a negative distance, while firms in areas with 4G coverage in that year are assigned positive values.

[17] See NOAA (2014).

BOX 2.3.

The roll-out of 5G: early lessons from Poland

5G technology aims to deliver improved connectivity, with speeds high enough to support new applications connecting not only mobile devices, but also machines, buildings and other objects. The speed of 5G is a significant benefit, with connections up to 20 times faster than 4G. 5G technology also supports 10 times more devices per square kilometre, leading to greater reliability and faster data transfer (with waiting times for transfers up to 25 times shorter than with 4G).[18]

Mobile network operators in more advanced economies in the EBRD regions have already started preparing for 5G, with auctions for spectrum rights taking place in the Czech Republic, Estonia, Greece, Hungary, the Slovak Republic and Slovenia.

Most importantly, 5G provides the backbone that is necessary to support the expansion of the Internet of Things – a network of internet-connected devices that can collect and exchange data from their respective environments. Driverless cars, for example, might be able to communicate not only with each other, but also with traffic lights and buildings, while difficult medical procedures could be carried out remotely in the future. The Internet of Things is expected to yield significant economic benefits, with a study commissioned by the European Commission estimating that an investment of €57 billion in 5G could yield benefits totalling €113 billion per year and generate 2.3 million jobs by 2025.

Within the EBRD regions, one economy where preparations for 5G are among the most advanced is Poland. Many Polish operators are upgrading their networks in preparation for 5G. Country-wide coverage in terms of 5G will be of particular importance in Poland, where more than 70 per cent of the population do not live in major cities. Consequently, fixed broadband penetration remains relatively low across much of the country, with many households heavily reliant on mobile networks. This box details some early lessons from Poland, which may provide useful insights in terms of the challenges that other economies may experience when rolling out 5G.

Uncertainty relating to spectrum auctions. In April 2020, the Polish regulator UKE (like the authorities of many other European countries) cancelled its spectrum auction on account of uncertainties relating to the Covid-19 pandemic, as well as cybersecurity concerns. UKE has decided to repeat the entire procedure for auctioning 5G spectrum bands, with the exact date of the auction yet to be announced.

Hesitant customers. Mobile subscribers in Poland have been hesitant about upgrading their plans to include 5G, given certain device-related requirements and associated costs, as well as uncertainty about the need for 5G services on a day-to-day basis. While the benefits of the Internet of Things are obvious in specialist industries, their applications have not yet reached the average mobile subscriber, so demand remains limited. Uncertainty is also being amplified by confusing messages about the availability of 5G. While the 5G spectrum auction has not yet taken place in Poland, operators are already offering 5G packages on alternative spectrum bands.

Limited pricing upsides. As a result of customer hesitancy, operators are concerned that they may not be able to significantly increase their average revenue per user by offering 5G services. However, demand for enterprise-specific 5G networks appears to be on the rise, with some firms using them to meet security needs and others using them to speed up the automation of production processes.

Significant capital expenditure. Network operators will need to spend substantial amounts of money on spectrum fees, the upgrading of their network equipment and backbones, and increasing the density and coverage of mobile towers. This is because 5G uses shorter wavelengths than 4G, which enables it to carry more data than 4G, but results in a reduced signal range. Lastly, owing to increasing security concerns/rules about suppliers of 5G equipment, operators risk potentially having to replace equipment that has already been put in place, leading to significant additional investment. Because of this capital expenditure, the operation of mobile towers is, in many European countries, increasingly being outsourced to specialist tower companies, thereby reducing the investment needs of individual mobile operators.

In light of these diverse challenges, the availability of long-term financing will be crucial in order to enable mobile operators to meet their 5G investment needs. Importantly, investing in 5G also remains central to the transition to a greener economy. 5G is categorised as “best in class” by the EU Sustainable Finance Taxonomy in terms of the environmental and energy-efficiency standards set by the European Telecommunications Standards Institute (ETSI), with significantly lower energy consumption per data unit transferred.

[18] See Ghosh (2020).

[19] See www.ebrdgreencities.com (last accessed on 3 June 2021).
[20] See Goderdzishvili et al. (2018).
[21] See OECD (2019).
[22] See City of Cape Town (2020).
[23] See https://e-estonia.com/solutions/interoperability-services/x-road (last accessed on 3 June 2021).
[24] See European Data Portal (2020).

BOX 2.4.

Building blocks for smart urban development

Digital innovations such as the Internet of Things, big data, AI and cloud computing are consistently improving our means of assessing and managing urban challenges. From water and waste management and street lighting to public transport and district heating, digital technologies are helping policymakers to address citizens' needs with much greater speed and effectiveness, thanks to information that is being collected more frequently, more accurately and more cheaply than ever before.

For many cities across the EBRD regions, digitalisation is likely to play an integral role in their future development. Several cities (such as Moscow and the Bulgarian city of Burgas) have already adopted international best practices in specific areas, such as intelligent transport.[19] Other cities, such as the Georgian capital Tbilisi, are right at the frontier in that regard. Tbilisi, for example, is on track to become one of the first cities in the world to pilot a digitised and immutable property register using blockchain technology.[20]

For the majority of the cities in the EBRD regions, however, "digital readiness" continues to lag behind that of EU comparators and other countries in the developed world. In many cases, post-socialist countries have inherited outdated and often paper-based record management systems, and some economies in the SEMED region and Central Asia are yet to make foundational investments in digital infrastructure. In such circumstances, a key policy question is how local and national decision-makers can make the most of costly investments in "smart city" technology with the ultimate aim of improving well-being. This box discusses some of the key building blocks of such investments.

Digital city strategies

A key starting point for any smart city initiative is a comprehensive digital strategy. Cities are interdependent systems, with policy actions in one area potentially having a profound impact on all others. Regular consultation across government, the private sector and civil society is thus vital in order to ensure a coordinated and viable smart city agenda. While approaches are likely to vary depending on the local context, experience from successful smart city initiatives in London, Singapore and Amsterdam suggests that strong leadership – for example, through a dedicated chief digital officer or a steering committee – is critical.

For instance, the Latvian capital Riga has been incorporating a comprehensive digital strategy into its urban planning since 2006, when the government first established its Information Society Development Guidelines (INFPO). Those guidelines are embedded in the municipality's five-year economic strategy and have been devised jointly by representatives of government, industry and academia to ensure a diverse range of viewpoints and expertise. Since those guidelines were established, Riga has achieved numerous targets relating to internet access and e-government, as well as drawing up new laws and regulations on data privacy, standards and cybersecurity.[21]

In addition to prioritising new investments, digital strategies can also help governments to identify "quick wins" in terms of improving policy management through better use of existing resources. City governments often have access to a wealth of untapped data resources, which can be hugely valuable in terms of designing and optimising the delivery of services when they are properly digitised and shared. Reforms such as government-led data inventories – which pull together information on the data that the city already has available, who controls them, and how they can be put to better use – can be carried out as part of a wider digital strategy. Over the last few years, for example, Cape Town in South Africa has made concerted efforts to digitise and share all water-related data records, having recently experienced some of the worst droughts in the city's history. In so doing, the city has vastly improved its water management and leak detection, reducing total water consumption by 45 per cent in just three years.[22]

More and better data

Thus, gathering more data is just one part of the answer. Ensuring that data are well governed, standardised and interoperable for multiple stakeholders is just as important for any smart city development. Establishing interoperability frameworks requires both regulatory oversight and the support of digital infrastructure. For instance, the Estonian capital Tallinn introduced a data exchange platform named X-Road in 2011 to allow various different information systems to communicate and exchange data. Today, X-Road is used at national level, connecting more than 900 organisations, public registries and databases across Estonia.[23]

Open data initiatives

Having large amounts of standardised data will not create value unless those data can be used, reused and redistributed without restrictions. With that in mind, open data initiatives have been adopted by a growing number of city governments around the world. Open data helps to improve public services, ensure transparency and stimulate innovation by enabling citizens, businesses and governments to collaborate in new ways. Warsaw, for example, has an open data portal containing more than 200 databases on subjects as diverse as ecology, transport and social projects. The portal, which was established in 2014, can be easily accessed by anyone, and it processes around 1 million queries a day. Importantly, dozens of applications have been developed by start-ups and other companies using Warsaw's open data, some of which have already achieved commercial success.[24]

Lastly, effective implementation of digital strategies also requires sound change management and sufficient digital skills. The introduction of a data-driven approach may change organisations' operational procedures, while interpreting and utilising large amounts of data requires additional skills and human resources. To facilitate that transition, cities could start with widespread capacity-building and awareness raising campaigns on the value of data and how to navigate the switch to a "smart city".

BOX 2.5.

Sustainable infrastructure and cybersecurity

Cybersecurity is an essential part of the digitalisation process, as it helps to prevent malicious or accidental data loss and manipulation. Such data loss can reduce the functionality of digital infrastructure and may involve significant financial losses for individuals and corporations. The digitalisation of infrastructure increases the potential for attacks, which may be motivated by a desire for financial gain (as in the case of ransomware attacks on water and energy systems) or a simple desire to incapacitate critical infrastructure (as in the case of terrorist attacks). It is for this reason that many infrastructure and energy projects are often considered to be "critical national infrastructure" in terms of cybersecurity. The interconnectedness of systems across institutions and firms with subsidiaries – even across international borders – amplifies the threat from cyberattacks. Indeed, successful cyberattacks can affect millions of people.[25]

Many public and private-sector organisations successfully defend themselves against cyberattacks by implementing encryption-based cybersecurity and firewalls and keeping up to date with the latest malicious threats. The concept of "cyberhygiene" (which includes raising awareness, securely configuring equipment and networks, updating software, not giving unnecessary system privileges or data access rights to staff and users, and training) is also critical in this regard. A third element of cybersecurity is "security by design" – the incorporation of security objectives and standards as a core part of the technology design process.

Infrastructure projects need to consider cybersecurity risks from the very start, as part of their preparatory phase. A risk assessment will need to be carried out at an early stage, while national data protection rules (such as the General Data Protection Regulations in the case of EU member states) will need to be looked at in detail. Where national standards are outdated, of poor quality or non-existent, countries will need to decide which international standards are most appropriate. Before launching operations, organisations should simulate cyberattack scenarios to check for vulnerabilities and then address any weaknesses.

In recent years, digital technologies across the infrastructure and energy sectors have benefited from internet connectivity. However, such connectivity opens up many more pathways for cyberattacks. Multi-factor authentication, authorisation protocols and data integrity checks can all mitigate the risk of malicious attacks. Commercial off-the-shelf proprietary digital platform solutions can also expose operating systems to increased risk, and pairing such systems with widely available and low-cost internet protocol-based communications can be especially risky. Where there is a high risk of cyberattacks, bespoke digital solutions armed with fit-for-purpose cyber-resilience measures should be applied.

Ideally, cybersecurity should be integrated into broader infrastructure investments and upgrades. Such projects may involve a review of the organisation's current IT security infrastructure, including gap analysis against best practices in information security in the given sector. On the basis of those assessments, phased work plans can be prepared, detailing step-by-step measures to enhance IT security systems. Those recommendations can be accompanied by tender specifications, helping the organisation to procure the services it needs to implement the measures identified. Lastly, penetration tests should be conducted in order to ascertain the reliability of the new or upgraded IT security infrastructure.

[25] See Crosignani et al. (2021).

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