Box 4. The post-pandemic economy and the new technological paradigm

A historical perspective on the advances in technology shows they come in waves, being triggered largely by a series of revolutionary inventions which, while opening up new avenues for research, radically altered the operation of production processes, with significant effects on productivity and society's welfare in general. At present, an increasingly large number of views expressed by academics and government authorities alike suggest that humanity is in the early stages of the fourth industrial revolution that has artificial intelligence at its core. In this context, this box aims to provide an overview of the transformational processes unleashed worldwide by the new technological revolution, while also presenting some aspects that refer to its stage of implementation in the domestic economy.

The fourth industrial revolution and its effects on economic activity

A number of elements that foreshadow a new technological revolution have recently moved to the centre of public debate (Schwab, 2016). In this sense, the significant increase in digital processing power has led to the development and the improvement in artificial intelligence, which is a major component of the process of creating and refining new innovating technologies such as cloud processing, autonomous industrial robots, high-speed communication, big data, virtual reality, 3D printing and other aspects related to nanotechnology and biotechnology. The vast multitude of complementary innovations spurred by the use of artificial intelligence and its ability to be improved upon over time have caused it to be referred to as a General Purpose Technology, similarly to the steam engine, electricity or the transistor (Brynjolfsson *et al.*, 2018).

In comparison with the technologies of the previous wave, which were also based on digitalisation (as the systems were programmed, step by step, to perform various tasks), artificial intelligence uses multiple instruments to create its own representation of reality, thus acquiring implicit knowledge (i.e. information whose collection cannot be identified and therefore transmitted further, such as intuition, empathy, wisdom or wit). The concept of artificial intelligence refers to the ability of a man-made system to adequately observe the external environment and to learn from the analysis of these data to subsequently fulfil complex tasks, machine learning and, further, deep learning being merely ways of achieving this goal (Mitchell, 1997).

Technology leaps irreversibly alter production processes, with significant effects on society as a whole. As a rule, the full adoption of new technologies takes longer, which implies a period of sluggish productivity. In a theoretical model, total factor productivity (TFP) can be decomposed into two components linked to the state of the economy (endogenous components): knowledge accumulation and technology utilisation rate, i.e. rate of introducing new technology in production processes (Bianchi *et al.*, 2019). In a first stage, the elements of the new industrial revolution impact TFP via knowledge, which basically aims to spawn complementary innovations, the speed at which they are developed being correlated with the efficiency of research and development and the financial

resources allocated to it. Once this step is complete, the next stage begins, implying the actual incorporation of new technologies into production processes, the first effects on productivity being noticeable in a relatively short period of time (in general, the best performing firms integrate the new technologies faster). Subsequently, substantial leaps in productivity occur as the technology matures and becomes available to most companies in the economy. This process may take quite long, spanning a period of over 25 years in the case of the third industrial revolution (Brynjolfsson *et al.*, 2018). Mention should be made that the cycle of innovation and implementation of new technologies is largely influenced by economic conditions, an increase in demand for certain goods, for instance, acting as a catalyst, with firms raising, on the one hand, R&D expenditure and, on the other hand, the substitution of capital (machines) for labour (Anzoategui *et al.*, 2019). An illustrative example is the need for digitalisation of the economies in the context of the pandemic, which involves both components of productivity.

Nonetheless, the integration of new technologies in the production process also impacts labour. The production of goods and services in an economy may be seen as a process that uses both capital and a collection of tasks performed by several workers with different education levels, which confer them a number of skills and which subsequently translate into certain comparative advantages (Acemoglu and Autor, 2011). Technological advance, which more than often concerns solely an area of the vast array of production-related tasks, impacts only those employees who have a lower comparative advantage. For instance, industrial robots can perform repetitive tasks more efficiently (Brynjolfsson and Mitchell, 2017). Conversely, the employees with a higher education level who can perform activities involving higher cognitive processes (analysis, abstract reasoning, anticipation) complement the new types of technologies and, thus, labour demand sees a significant upturn in this case. In a similar vein, the demand for workers performing tasks that require little technical education, but a high degree of implicit knowledge (activities in the services sector) is on the rise, as the advance in productivity gives a boost to household income, given that these workers cannot be efficiently replaced with digital systems. Hence, technological progress tends to support a polarisation of the labour market (i.e. growth of jobs at the top and bottom of the occupational spectrum, concurrently with a decline in middle-skill employment), Autor, Katz and Kearney (2006) identifying such a trend in advanced economies.

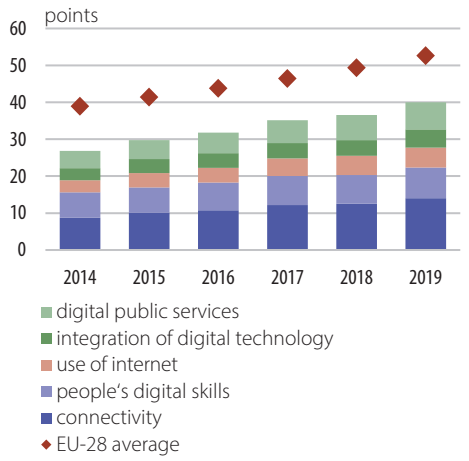
The position of the Romanian economy

The large-scale adoption of new technologies hinges decisively on the degree of technological penetration in the previous wave. At a European level, a measure of digitalisation calculated by the European Commission is the Digital Economy and Society Index (DESI[1]), which summarises five dimensions of digitalisation: connectivity, people's digital skills (human capital), use of internet, integration of digital technology and digital public services. From this perspective, Romania

[1] https://ec.europa.eu/digital-single-market/en/digital-economy-and-society-index-desi

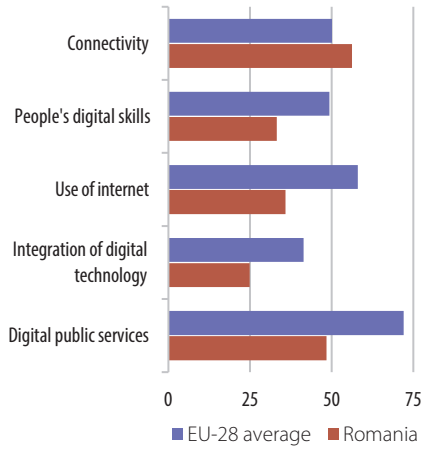
made progress in the past five years, DESI[2] rising, on average, by about 2.6 points, to approximately 40 points in 2019 (Chart A). Despite these positive developments, the gap to the EU average (around 12 points) did not narrow, Romania further ranking 26th, ahead of Greece and Bulgaria and about 3.6 points below Italy; Nordic countries lead the way in digitalisation.

Chart A
The Digital Economy and Society Index (DESI)



Source: European Commission

Looking at the dimensions of digitalisation covered by DESI (Chart B), Romania ranks above the EU average solely in terms of connectivity, with wide availability of fixed very high capacity networks for households (for example, the share of households that may have access to ultrafast broadband subscriptions of at least 100 Mbps is 23 percentage point higher than the EU average) and/or high mobile broadband take-up. This performance can be mainly attributed to the sector's dynamism in the pre-accession period (favoured also by less stringent legislation), which triggered investment in fixed assets (expressed as a share of GDP) significantly larger than in the other EU economies. Subsequently, the stronger competition underpinned firms' interest in maintaining and expanding their networks, a process that was also fostered by government support, as a result of EU-funded projects targeting particularly the rural area. Specifically, in 2019 approximately 40 percent of rural areas had very high capacity network coverage, double the EU average, according to Digital Economy and Society Index (DESI) 2020 Romania. This share continued to increase in 2020, in the context of the pandemic, according to the ANCOM data. The tough competition also had an impact on the path of telecommunication service prices that are the lowest in the EU at least as early as 2014[3].



Source: European Commission

Chart B
DESI components in 2019

As far as the other dimensions of digitalisation are concerned, Romania ranks last among EU Member States on digital public services and the use of internet services. In the latter case, the available data for 2020 show, however, a substantial decline in the share of people who have never used the internet (to 14 percent, down by about 4 percentage points from 2019), driven by the stronger need to use digital resources amid mobility restrictions. Nevertheless, the share of people who have never used the internet is further significantly higher than the EU average. In a similar vein, Romania also ranks last among EU countries on the share of individuals who use the internet for activities with certain economic characteristics such as online banking (12 percent), online shopping or selling online (38 percent and 4 percent, respectively) or who attend online courses or access electronic educational resources (8 percent). The poor penetration of internet services may

2 The DESI index may range between 0 and 100 and is published by the European Commission in its annual DESI reports. The latest Report (DESI 2020) mainly contains statistical data available until 2019.

3 Ever since comparable data have been available.

be ascribed to individuals' low digital skills, the share of people with at least basic digital skills being 31 percent in 2019 versus the EU average of 59 percent. At the same time, the sole human capital indicator in terms of which the domestic economy performs well (ranking among the top three EU countries, after Malta and Ireland) refers to the share of ICT graduates (bachelor's degree or equivalent); Chart C.

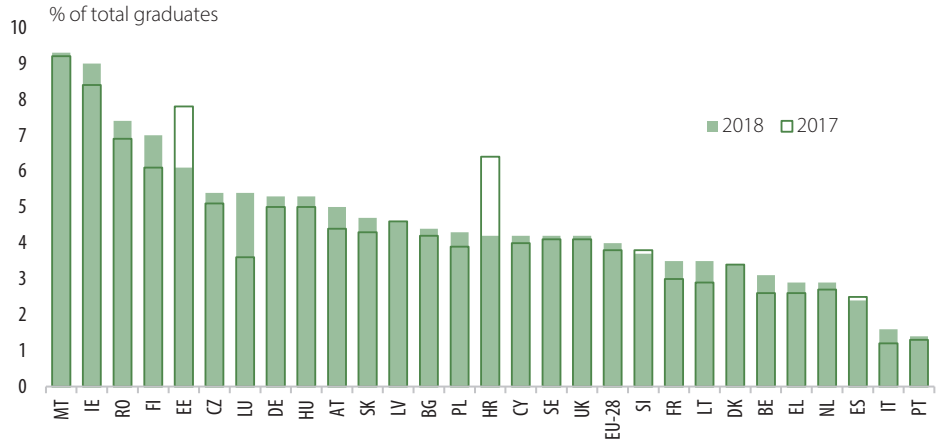


Chart C
ICT graduates

Source: Eurostat

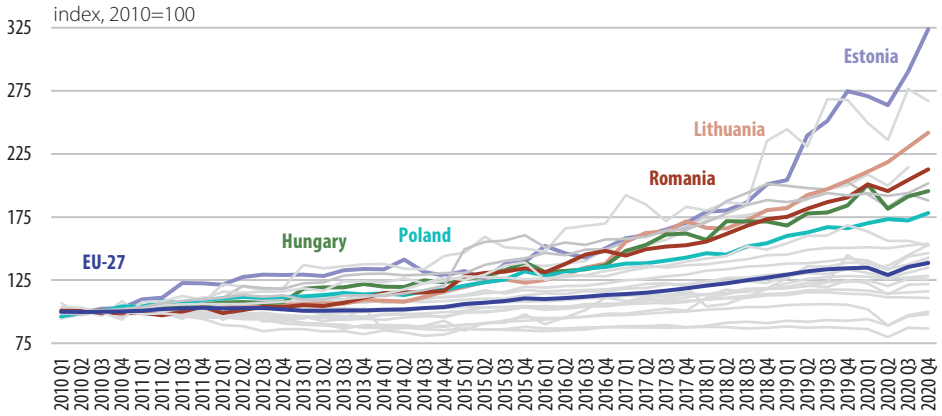


Chart D
ICT turnover in EU countries

Note:The ICT sector is broadly defined (section J of NACE). Ireland, Greece and Luxembourg are not represented.

Source: Eurostat

The large pool of ICT specialists and the possibility to find potential employees with deep technical skills on the domestic front (the outstanding results achieved by the Romanian students in the international mathematics and informatics olympiads are a point of interest in the domestic economy) act as a catalyst for foreign ICT companies. Fast broadband coverage plays a key role as well, as it enables, among others, remote working, an important factor in attracting and retaining employees[4]. In this context, the ICT sector in Romania has expanded markedly over the past years (Chart D), outperforming the EU average in terms of its contribution to value

[4] According to Brainspotting's *IT Talent Map, Romania 2019-2020.*

added economy-wide[5] and the share of workers in this activity. At the same time, the ratio of the number of ICT companies to the total population is broadly similar to the EU average (Table A). As far as some firm characteristics are concerned, an ICT service provider operating in Romania usually generates a turnover lower than the EU average, in spite of employing a larger number of workers, which apparently suggests certain weaknesses in the competitive position. Productivity measured as value added per employee indicates that local companies rank close to the lowest level reported in the EU. A possible explanation lies in the fact that the domestic economy is an important destination for international ICT firms aiming to relocate part of their activity that is less complex. Taking into consideration companies' expenditure for the compensation of employees (assuming that international competitive pressures prompt firms to uniformly pay workers for the tasks needed to produce the final good), labour productivity certainly shifts to a substantially more favourable level as compared to the EU average. The trend in the domestic ICT sector to engage in less complex activities (which frequently target solely components of a more sophisticated product) is also highlighted by the findings of a survey conducted by Brainspotting and Codecool[6], which show that a potential improvement in this direction is hindered by employees' limited experience in delivering high complexity projects and the lack of seniors to mentor juniors.

Table A
Position of the ICT sector in 2018

Position of the sector in national economies

	EU-28*			Romania
	min.	average	max.	
No. of companies, % of total economy	1.8	4.9	8.7	4.9
Value added, % of total economy	5.1	7.6	13.5	8.7
No. of employees**, % of total economy	2.6	4.4	6.9	4.7
Personnel costs, % of turnover	9.1	20.4	26.7	25.4
Average turnover (EUR million)	0.4	1.4	6.6	0.6
Average no. of employees**, employees/company	2.9	5.9	11.6	7.9
Operating profit ratio, %	8.5	15.4	24.0	16.5
Labour productivity**, EUR thousand/employee	30.6	71.0	184.4	33.9
Labour productivity adjusted for personnel costs**, %	118.9	154.1	232.0	157.8
Personnel growth rate**, %	-2.3	5.4	13.9	6.9
Personnel growth rate**, 5-year average, %	-6.5	27.7	60.4	37.1
Investment in fixed assets**, % VA	9.1	14.6	24.9	15.0
Investment in fixed assets**, % VA, 5-year average	10.7	14.8	24.4	18.5

*) excluding Ireland, Cyprus and Malta

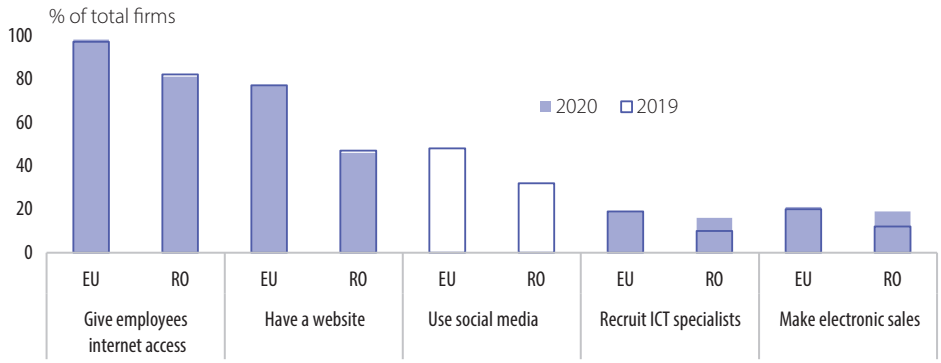
**) excluding Ireland, Cyprus, Malta, Netherlands, United Kingdom

Note: The ICT services sector is defined at NACE division level (G46.5, J58.2, J61, J62, J63.1, S95.1). Data refer to the companies operating in the economic sectors referred to under sections B to N and section S division 95 of NACE. Firms in financial and insurance activities (section K of NACE) are excluded.

Source: Eurostat, SBS

5 Value added created by the companies operating in the economic sectors referred to under sections B to N and section S division 95 of NACE. Firms in financial and insurance activities (section K of NACE) are excluded.

6 The survey is included in the report entitled *How Can Romania Become the Strongest Technology Hub in Europe*.



Note: Data refer to the companies with over 10 employees operating in the economic sectors referred to under sections B to N and section S division 95 of NACE. Firms in financial and insurance activities (section K of NACE) are excluded.

Chart E
Digitalisation of companies

Source: Eurostat

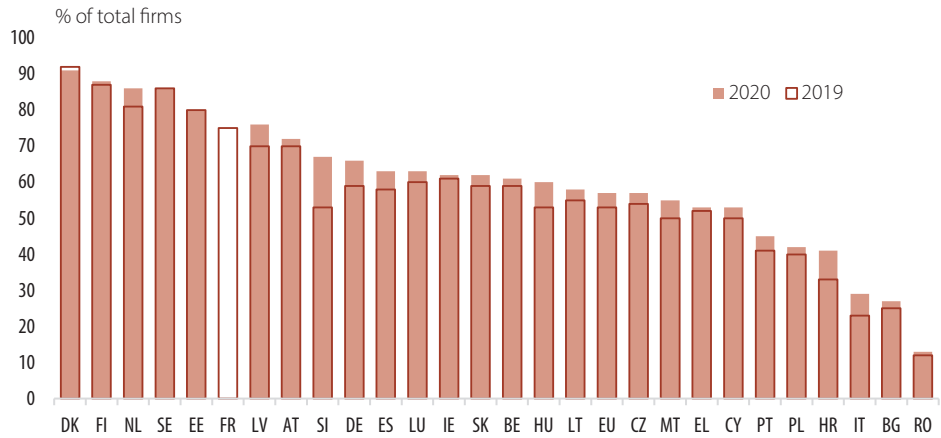


Chart F
Degree of online interaction with the public authorities

Source: Eurostat

The ICT sector in Romania is in a favourable position to benefit from the increased demand for digitalisation, as well as from the integration of the fourth industrial revolution technologies, both trends being significantly amplified by the pandemic. As far as the former issue is concerned, great opportunities for the development of the ICT services industry in Romania arise not only from the substantial demand from international markets, but also from the lower penetration of digital technologies in the other domestic firms and the general government. In this vein, the companies[7] with over 10 employees operating in Romania rank last among EU countries in terms of numerous key aspects of digitalisation such as the share of firms that give employees internet access, have a website or use social media for various activities, including product marketing and recruitment of employees (Chart E). At the same time, 2020 saw considerable increases in the share of businesses recruiting ICT specialists (up to 16 percent) or using the online environment for commercial activities (up to 19 percent). In both cases the growth pace was among the highest in the EU (up by 6 and 7 percentage

7 Data refer to the companies operating in the economic sectors referred to under sections B to N and section S division 95 of NACE. Firms in financial and insurance activities (section K of NACE) are excluded.

points, respectively). The fast access of domestic companies to online services, in a context in which the restrictions on people's mobility led to reduced physical shopping, was also facilitated by the innovations in the area delivered by eMag, the second unicorn company in Romania in terms of the funds attracted, after UiPath (according to the ranking suggested by McKinsey, 2020). At the same time, an important driving force for the activity of the domestic ICT sector and economy-wide productivity may be the digitalisation of public administration; in 2020, merely 13 percent of households (versus an EU average of 57 percent) had an online interaction with the public authorities at least once over the past 12 months (Chart F). The low penetration of e-government services may be ascribed to the acute lack of investment in this field, as the public authorities have neither implemented a uniform digital architecture for government service management nor hired enough skilled staff in public structures so far (ADR, 2021). In this context, a report prepared by Employers' Association of the Software and Services Industry and Ernst&Young[8] estimates that the expansion of digitalisation of public administration (to a level similar to that gauged for the local government, which is around 30 percent) would result in an approximately 2 percent increase in GDP.

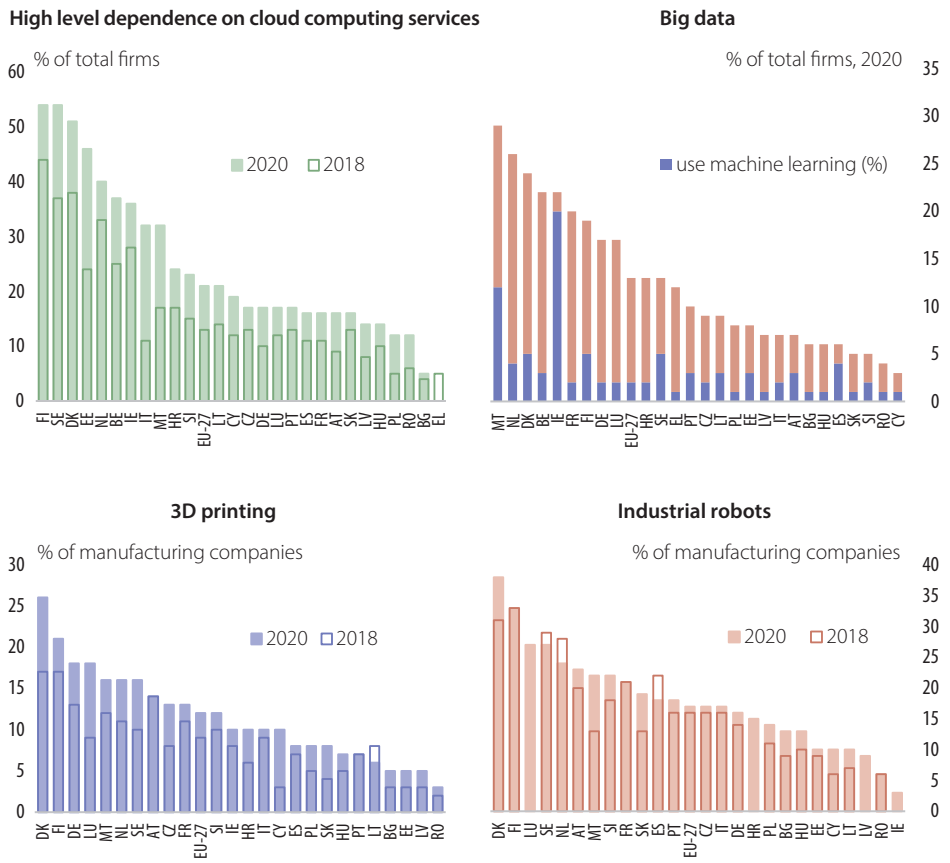


Chart G
Elements of the new industrial revolution

Note: Data refer to the companies with over 10 employees operating in the economic sectors referred to under sections B to N and section S division 95 of NACE. Firms in financial and insurance activities (section K of NACE) are excluded.

Source: Eurostat

8 *Studiu asupra economiei digitale din România* (2021), a report prepared by the Employers' Association of the Software and Services Industry and EY (Romanian only).

European companies have gradually started to integrate the elements of the fourth industrial revolution into production processes. The new wave technologies that boast a high level of penetration include cloud computing services (which have numerous advantages in terms of operating costs and employee access), the demand for these services rising substantially as firms' need for teleworking increased amid the pandemic. At the European level, the share of companies that purchased such services[9] widened to 21 percent in 2020, the trend being observable in all European countries. On the domestic front, the number of firms using cloud computing services doubled in 2020 (to 12 percent) as compared with 2018 (Chart G). At the same time, 13 percent of European companies use big data to analyse and substantiate business decisions, the share narrowing to 2 percent in the case of firms that rely on machine learning in this endeavour. Another important area, where progress in the adoption of new technologies is still modest (near standstill in 2018-2020) for the moment, refers to the use of industrial robots. Specifically, 17 percent of the manufacturing companies in Europe (6 percent in the case of Romania) employ such robots, the level being markedly lower than in other advanced economies such as Japan or the US (Anderton *et al.*, 2020). In a similar vein, 3D printing is used by 12 percent of firms, up however by 4 percentage points from 2018.

The further development and implementation of complementary technologies of the new industrial revolution will certainly act towards increasing long-term productivity, with major implications for household welfare and social equity. Equally, the domestic government sector can improve the institutional framework and hence enable, on the one hand, the efficient reallocation of labour affected by technological changes (e.g. via retraining programmes) and, on the other hand, the creation of an economic environment conducive[10] to the establishment and development of new ICT companies. This can support the domestic economy in matching or even surpassing, in some ways, the performance of countries in Western Europe.

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9 Namely the high level dependence on cloud computing services, according to the Eurostat classification.

10 According to the *Startup Ecosystem Ranking 2020*, a report prepared by StartupBlink, Romania ranks 45th worldwide (dropping seven places from 2019) on the number and quality of startup ecosystems, as well as on the features of the business environment, lagging behind most EU economies.

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