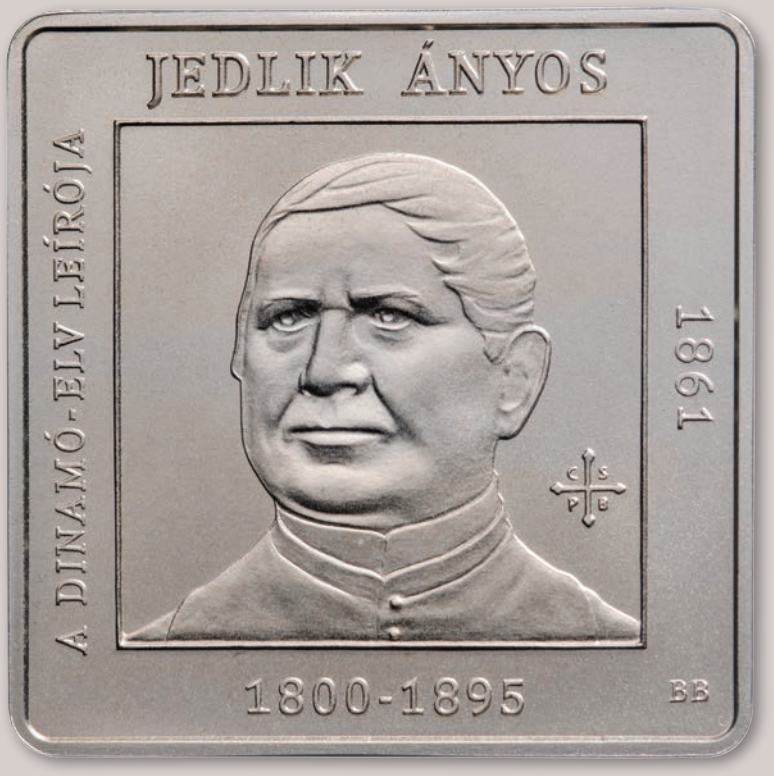
PRODUCTIVITY REPORT



2022

JULY

"Where would we be
if God deprived us of the ability to work?"

Ányos Jedlik, 1895

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Pursuant to Act CXXXIX of 2013 on the Magyar Nemzeti Bank, the primary objective of Hungary's central bank is to achieve and maintain price stability. Low inflation ensures higher long-term economic growth and a more predictable economic environment, and moderates the cyclical fluctuations that impact both households and companies. Without prejudice to its primary objective, the MNB supports the maintenance of the stability of the financial intermediary system, the enhancement of its resilience and its sustainable contribution to economic growth, as well as the economic policy of the government using the instruments at its disposal.

The Productivity Report provides support for the central bank in fulfilling its statutory duties, by facilitating an understanding of the drivers, breakdown and dynamics of economic growth and the key factors of convergence, which helps us to formulate and implement reforms aimed at improving productivity. The Productivity Reports does this in a complex manner, examining a wide range of efficiency indicators, including labour productivity as well as innovation, digitalisation and ecological productivity.

The analysis was prepared by the Directorate Economic Forecast and Analysis, under the general guidance of Gergely Baksay, Executive Director for Economic Analysis and Competitiveness.

For the compilation of our Report, we used data available until May 13, 2022.

Introduction

The Productivity Report helps the central bank fulfil its statutory duties. The primary objective of Hungary's central bank is to achieve and maintain price stability. The relation between productivity and inflation has been known for a long time in economics, i.e. the examination and analysis of productivity and efficiency help us better understand inflationary trends, and thus the report fosters the achievement of the central bank's objectives. On the other hand, its mandates also include supporting the economic policy of the government without prejudice to its primary objective. The Productivity Report facilitates this by promoting an understanding of the drivers, distribution, breakdown and dynamics of economic growth and the key factor of convergence, which helps us formulate and implement reforms to boost productivity.

Productivity serves as a basis for long-term growth and sustainable convergence. During the acute phase of the COVID-19 crisis, the most important duties included supporting employment and demand, as well as helping families, companies and economic sectors which were facing difficulties. Due to the successful crisis management, the economy has recovered much faster than at any time after World War II. However, the imbalances developing as result of the fast recovery have also highlighted the fact that the sources of extensive growth are about to exhaust. Economic growth (both in Hungary and globally) is restrained, facing – among other things – the limits of environmental sustainability, labour supply and indebtedness. Under such circumstance productivity and efficiency become even more important as they serve as a basis for long-term growth and sustainable convergence.

This publication examines, in addition to labour productivity, the efficiency of the innovation system, digitalisation and the utilisation of environmental resources. Our analysis attaches special importance to the efficiency of the traditional economy, i.e. labour productivity, but also includes three additional aspects. Economic research in recent years has highlighted the fact that the efficiency of innovation systems can also vary over time and space, and thus our analysis covers the efficiency of innovation as well. Thirdly, we extend the analysis to look at data, "the oil of our age", which is becoming an increasingly important factor of production. The efficiency of processing and utilising continuously increasing data assets is a key factor for modern economies; in line with this aspect, this report examines the efficiency of digitalisation. Fourthly, as also discussed in the work 'Long-term Sustainable Econo-mix ' published by the MNB, it is not possible to achieve sustainable growth without detriment to the ecological system, and thus we also deal with the ecological productivity of the economy in detail.

In economic terms, productivity is very closely related to the notion of efficiency. Welfare can grow continuously in an economy if the efficiency of production/service processes increases tangibly over longer periods. Accordingly, the continuous, broad-based measurement and analysis of productivity is essential for monitoring changes in welfare. Productivity usually means efficiency ratios that show the value produced by one unit of resource absorbed. This report refers to the value created as output and the expenditures as input. In contrast to the general practice, productivity is used in a broader sense, extending it to other areas as well, in addition to labour productivity.

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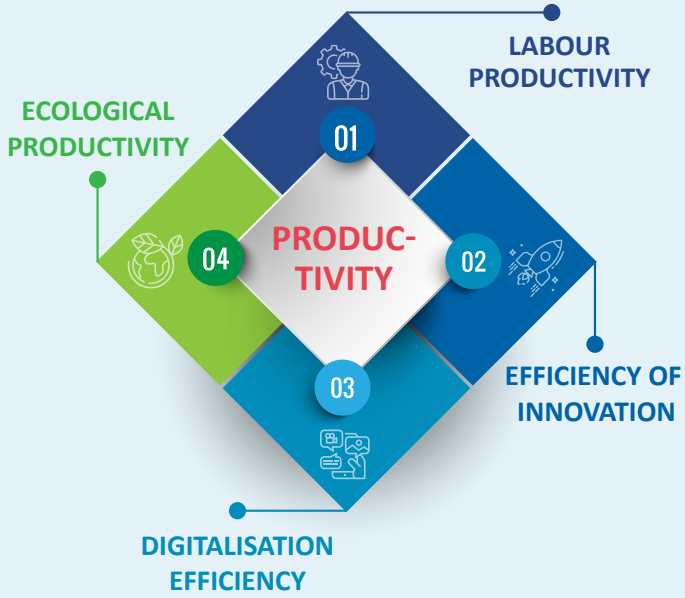
Executive Summary

To achieve sustainable convergence after the successful extensive growth period, Hungary shall switch to an intensive growth regime, where productivity and increasing efficiency are key factors. Thus, we are examining the four pillars of productivity, which consists of the productivity of labour, innovation, digitalization, and ecological productivity. The domestic productivity and efficiency indicators lag behind the EU average, which provides growth reserve for the economy. The advanced economies represent a high technological level and are well-supplied with goods and services. Therefore, it is worth examining Hungary's position regarding efficiency indicators compared to the EU countries. In the cross-sectional analysis, the comparison is made to the EU average and the other Visegrád countries, as well as to the TOP5 countries in the respective indicator. The productivity and efficiency differences also represent a growth reserve for Hungary, which is worth highlighting in terms of competitiveness. The unprecedented growth and convergence path between 2013 and 2019 which also maintained economic balance was based on targeted economic policy measures that successfully addressed the shortcomings of the economy and mobilised its resources. In our publication we examine, in addition to labour productivity, the efficiency of the innovation system, digitalisation and the utilisation of environmental resources. (Chart 1).

The Hungarian productivity indicators typically reach two-thirds of the EU average, and 40-50 percent of the TOP5 EU countries, but in the last few years there have been improvements in multiple areas. Since 2017, labour productivity has improved significantly. Headcount-based labour productivity rose annually by an average of 2 percent between 2017 and 2021, while the EU average only increased by 0.4 percent. The labour productivity of SMEs significantly increased over the past decade, but the efficiency still lags considerably behind large corporations. The R&D expenditures also increased significantly, however the efficiency in terms of returns is low when compared internationally. There is great growth potential in the number of patents, since Hungary currently sits at 30 percent of the EU average. The coronavirus crisis accelerated the digitalization processes in 2020. In Hungary, the coverage of the digital infrastructure is high, however there is great growth potential in the utilization. Hungary performs best in ecological productivity among the four pillars of productivity, reaching 80 percent of the EU average. In this field there is room for improvement by increasing the ratio of renewable energy sources (at present it is only roughly half of the EU average).

Chart 1: Productivity pillars



Source: MNB.

Despite the significant improvement experienced in recent years, domestic labour productivity is in the bottom third of the EU ranking and is somewhat behind the V3 average. Improvement of productivity represents the largest growth reserve during the next decade. Based on the average of the variety of indices measuring labour productivity, Hungary's

labour productivity stands at 62 percent of the EU level and at 45 percent of that of the TOP5 Member States. Labour productivity in the SME sector has significantly increased since 2012, but the lag compared to large enterprises is still considerable (55.7 percent). The COVID crisis also temporarily created a special situation in labour productivity: value declined in 2020, which was due to the fact that corporations reduced their numbers of employees proportionally to a much smaller degree than production. However, this strategy facilitated a faster recovery in 2021, as the labour force was available immediately when production and services activity could be restarted. This labour management facilitated a fast recovery from the crisis. Overall, in Hungary, headcount-based labour productivity rose in total by 1.3 percent between 2019 and 2021, while the V3 average growth was merely 0.5 percent and the EU average declined by 0.4 percent.

Innovation expenditures in Hungary are gradually increasing, however the efficiency of the innovation system is still low when compared internationally. Hungary's innovation efficiency is 57 percent of the EU average, and 37 percent compared to the TOP5 EU countries. Innovation is one of the main drivers of labour productivity. Significant room for improvement can be identified particularly by increasing the number of patents as well as in trademark and design patents. Using these indicators, the Hungarian indicator is merely 30 percent of the EU average. Looking ahead, the major growth in knowledge-intensive employment in recent years is a positive development, as in the future the registration and utilisation of innovation achievements may rise faster.

In Hungary the coverage of the digital infrastructure is high, and exceeds the EU average, however the utilization is low in an international comparison. Amongst all four productivity pillars, it is in digitalisation efficiency that hungary lags the most behind the V3 average. Hungary's digitalisation efficiency is 63 percent on average compared to the EU average, and 46 percent compared to the TOP5 EU countries. In 2020, Hungary was ranked 23rd in the European Union's aggregate digitalisation index. Corporate digitalisation improved in certain areas. One example of this is the ratio of Hungarian corporations using e-invoicing, and significant improvement also was observed in the use of cloud-based services; nevertheless, there is still significant room for further development. The coronavirus pandemic accelerated the digitalisation processes: in the case of the best performing countries, it typically brought forward the penetration of digitalisation by 2-5 years, while in Hungary only by 1–1.5 years. Despite the recent major developments in Hungarian public administration, there is still considerable room for increasing the efficiency of digitalisation in public administration.

Among the four pillars of productivity, Hungary is performing best in ecological productivity. However, there is still room for improvement: for example, by increasing the ratio of renewable energy sources. Hungary's ecological productivity is 79 percent of the EU average, and 50 percent compared to the TOP5 EU countries. The basis of the ecological pillar is the proper use of natural resources and their potential. The preservation and liberation of these assets ensures the ecological sustainability for the long-term path of economic growth. One of the key indicators of ecological productivity is the value added per one unit of environmental pollution. With less environmental pollution, the same, or higher volume of goods and services that can be produced, the higher the ecological productivity of a given economy is. Within the pillars under review, Hungary achieved the best result in ecological productivity. However, there is still major room for improvement in this area as well, particularly by increasing the ratio of renewable energy sources (at present it is only roughly half of the EU average) and more efficient raw material consumption (72.2 percent of the EU average).

Summary of Hungary's main achievements

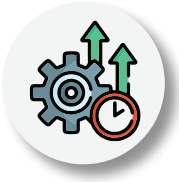
DESPITE THE SIGNIFICANT IMPROVEMENT EXPERIENCED IN RECENT YEARS, DOMESTIC LABOUR PRODUCTIVITY IS IN THE BOTTOM THIRD OF THE EU RANKING AND IS SOMEWHAT BEHIND THE V3 AVERAGE. IMPROVEMENT OF PRODUCTIVITY REPRESENTS THE LARGEST GROWTH RESERVE DURING THE NEXT DECADE.

Based on the average of the variety of indices measuring labour productivity, Hungary's labour productivity stands at 62 percent of the EU level and at 45 percent of that of the TOP5 member states.

In 2021, the value added per employee in Hungary was 72.3 percent of the EU average, representing an improvement of 1.7 percentage points compared to 70.6 percent registered in 2019. Accordingly, Hungary ranked 24th in the EU ranking last year. Hungary's labour productivity was 47.6 percent of the average of the 5 most productive European countries (the same ratio in 2019 was 49.8 percent). It is essential to improve labour productivity in order to increase Hungary's economic development.

In Hungary, value added per working hour was about two thirds (65.9 percent) of the EU average in 2021 and amounted to 65.3 percent of the EU27 average in 2019.

The labour productivity of SMEs is significantly lower than the national average. In the calculation of the average pillar value, we determined the relative Hungarian SME productivity rate, which is 48.2 percent, in relation to the average labour productivity of the EU. The productivity gap between SMEs and large corporations remains large: in 2020, productivity of micro, small and medium-sized enterprises relative to large corporations was 43 percent, 64 percent and 73 percent, respectively. There is still significant duality between corporations under domestic and foreign control, while productivity-driven duality somewhat decreased between 2017-2019. During the period of 2009-2016, the productivity of corporations under foreign control was on average 3.1 times higher, which declined to 2.6 times by 2019. Foreign-owned enterprises are more productive than those under Hungarian ownership, as the average size of the former is much larger. The combined result of the 7 percent fall in productivity of the whole SME segment and the stagnation experienced by large corporations is a growth in the productivity gap relative to large corporations in 2020 when compared to 2019 (the figures for 2021 were not yet available when compiling the report).



In Hungary, headcount-based labour productivity rose in total by 1.3 percent between 2019 and 2021, while the V3 average growth was merely 0.5 percent and the EU average declined by 0.4 percent. Despite the economic downturn in 2020, employment declined only moderately owing to job protection programmes. Accordingly, during the period of recession, labour productivity fell temporarily by 3.7 percent, followed by a rise of 5.0 percent in 2021, in parallel with the recovery. Similar trends were observed also internationally: in 2020, average labour productivity in the CEE region and across the EU fell by 3.1 percent and 4.6 percent, respectively, while in 2021 it improved by 3.6 percent in the V3 countries and by 4.1 percent in EU Member States.

These cyclical movements are inseparable from the fluctuations in economic activity; accordingly, it is worth examining the recession in 2020 and the fast growth in 2021 together. In 2020, the decline in productivity was due to the fact that compared to previous crises, this time corporations reduced the number of their employees by a much smaller degree. This had a negative impact on productivity in 2020 (as production declined to a larger degree than the number of employees). However, this strategy allowed for a faster recovery in 2021 due to the immediate availability of labour, when after the uncertain pandemic period production and services activity could be restarted. This labour management facilitated a fast recovery from the crisis. In the absence of this (assuming larger scale dismissals) the restart could have taken much longer as corporations would have needed to find an appropriate labour force necessary to re-launch their activities.

During 2020–2021, corporations active in the manufacturing and market services sectors on average improved their labour productivity. In 2021, all productive industries made a positive contribution to the aggregate growth in productivity. Market services accounted for almost two-thirds of the growth observed during the period of 2017–2019, and for more than half of the change in the period 2020-2021. In 2021, market services

improved Hungary's labour productivity by 5.4 percent on average, which is mostly the correction of the fall experienced the previous year. Labour productivity of market services deteriorated on average by 3.2 percent in 2020, with the exception of the infocommunication sector and the financial intermediation sector, which improved their productivity between 2019 and 2021 by 4.5 and 13.8 percent, respectively. In 2021, productivity improved in all sectors other than agriculture. When examining the productivity of each sector relative to each other, the highest labour productivity was achieved in the financial sector at HUF 20.6 million/person, followed by the infocommunication sector (HUF 13.1 million/person) and manufacturing (HUF 11.6 million/person).

THE INNOVATION EXPENDITURES IN HUNGARY ARE GRADUALLY INCREASING, HOWEVER THE EFFICIENCY OF THE INNOVATION SYSTEM IS STILL LOW WHEN COMPARED INTERNATIONALLY.

Hungary's innovation efficiency is 57 percent of the EU average, and 37 percent when compared to the TOP5 EU countries.

Innovation is one of the main drivers of labour productivity. Hungary's innovation performance has continued to materialise under steadily rising expenditures with low return, although efficiency improved between 2018 and 2020 at several sub-indicators. Efficiency of the innovation system is still low in an international comparison.

In Hungary, R&D expenditure as a percentage of GDP rose between 2018 and 2020. However, the increment registered in 2020 was partly attributable to the decline in real GDP caused by the coronavirus. The impact of the rising dynamics in R&D and innovation expenditures over the past 4-5 years can already be felt in several output indicators.

When making an international comparison, Hungary's innovation efficiency has not improved significantly in recent years. Data related to science citation remain favourable; nevertheless, in the light of the trend of growth in R&D&I expenditures it should be possible to achieve further improvement in the registration of intellectual property rights. Looking ahead, the major increase in knowledge-intensive employment in 2020 is a positive development, as in the future registration and utilisation of innovation achievements may rise faster assuming steady innovation efficiency.

With a view to improving Hungary's position, maintaining the present high ratio of state subsidies is justified. However, state subsidies alone do not guarantee the long-term sustainability of the rise in productivity. Such an objective may only be achieved by the development of the innovation ecosystem, and corresponding measures were included in the government's R&D strategy adopted in 2021. As regards to recent years, it is a positive development that the willingness of the innovation system's actors to cooperate increased, and the R&D expenditures of Hungarian-owned enterprises grew faster than those of foreign-owned companies.

IN HUNGARY THE COVERAGE OF THE DIGITAL INFRASTRUCTURE IS HIGH, AND EXCEEDS THE EU AVERAGE, HOWEVER THE UTILIZATION IS LOW IN AN INTERNATIONAL COMPARISON. AMONGST ALL FOUR PRODUCTIVITY PILLARS, IT IS IN DIGITALISATION EFFICIENCY THAT HUNGARY LAGS THE MOST BEHIND THE V3-AVERAGE.

Hungary's digitalisation efficiency is 63 percent on average compared to the EU average, and 46 percent when compared to the TOP5 EU countries.

In 2020, Hungary scored 41 in the European Union's aggregate digitalisation index, placing it in 23rd place in the ranking of EU countries. Hungary preceded Poland, Greece, Bulgaria and Romania in the ranking, while Denmark, Finland, Sweden, the Netherlands and Ireland achieved the highest scores.

In 2020, the year of the COVID crisis, the penetration of digitalisation in Hungary improved by 2.7 points compared to 2019, which falls short of the EU average improvement of 4.4 points. Although the coronavirus pandemic fostered digitalisation, the degree to which fell short of the EU average.

Hungary's digital efficiency is determined by the fact that it gives an average performance concerning input indicators but falls below the average regarding output indicators. For example, when looking at input indicators, it

is ranked 12th in the EU in the area of network infrastructure. However, for output indicators, its best ranking of 22nd was achieved in digital human resources. Accordingly, in the productivity and efficiency ratios obtained as a quotient of the below average output and more favourable input indicators, Hungary is at the bottom of the EU rankings.

In 2020, the efficient utilisation of Hungarian households' digital skills was 83 percent of the EU average, while compared to the average of the TOP5 EU countries, it was 66 percent. In 2020, Hungary took 26th place in the EU ranking, which represents no progress compared to the performance of 2019. Although the development level of the digital infrastructure in Hungary is still adequate, the utilisation of this remains low, and thus there is significant room for improvement in this area as well.

In 2020, the corporate efficiency of digital technologies in Hungary was 60 percent of the EU average and 44 percent of that of the TOP5 EU countries. In 2020, Hungary was ranked 26th among EU countries, moving up one place in the ranking compared to 2019, and thereby preceding Romania. According to the enterprise digitalisation sub-index, only a small part of Hungarian corporations invests in digital technologies. The digital intensity index shows that 53 percent of the enterprises only have minimal digital technology, which is a significantly less favourable ratio compared to the EU average of 39 percent.

Corporate digitalisation significantly improved in certain areas. Between 2018 and 2020 the ratio of Hungarian corporations using e-invoicing rose from 10 to 13 percent. In addition, a major improvement was observed also in the use of cloud-based services. In 2018, only 17 percent of corporations used such technology, while this ratio rose to 25 percent in 2020.

Hungary exhibits a major lag in the efficiency of digital specialists: In 2020, it was 40 percent of the EU average and 21 percent of the average of the TOP5 countries. In Hungary, 80 percent of large enterprises and 26 percent of SMEs employed ICT specialists in recent years, which exceeds the EU average of 75 and 18 percent, respectively. However, Hungarian specialists are able to digitalise enterprise processes to a relatively small degree compared to the V3 and EU countries, since domestic enterprises employing ICT specialist tend to use modern enterprise resource planning and customer relation management software more sparingly than Western European enterprises.

In 2020, the efficiency of e-governance in Hungary was 70 percent of the EU average and 55 percent of that of the TOP5 EU countries. In 2020, Hungary's second to last place in the ranking remained unchanged compared to 2019. Despite the recent major developments in Hungarian public administration, there is still considerable room for increasing the efficiency of digitalisation in public administration.

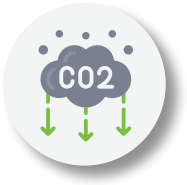
AMONG THE FOUR PILLARS OF PRODUCTIVITY, HUNGARY IS PERFORMING BEST IN ECOLOGICAL PRODUCTIVITY. HOWEVER, THERE IS STILL ROOM FOR IMPROVEMENT: FOR EXAMPLE, INCREASING THE RATIO OF RENEWABLE ENERGY SOURCES.

Hungary's ecological productivity is 79 percent of the EU average, and 50 percent when compared to the TOP5 EU countries.

In our analysis, the basis of the 4th pillar, i.e. ecological productivity, is the proper use of natural resources and potentials. The preservation and liberation of these assets ensures the ecological sustainability for the long-term path of economic growth. The current magnitude of environmental pollution and the current rate of environmental degradation are two of the most important obstacles to long-term sustainable growth. One of the key indicators of ecological productivity is the value added per one unit of environmental pollution. With less environmental pollution, the same, or higher volume of goods and services can be produced, and the higher the ecological productivity of a given economy becomes.

Hungary's ecological productivity is 79 percent of the EU average, and 50 percent compared to the TOP5 EU countries. Compared to the EU average and the average of the TOP5 countries Hungary's ecological productivity indicator has not changed materially in the past two years, and still stands at 79 percent and at 50 percent, respectively.)[1]

1 Figures from two years ago, underlying the comparison, may differ from those shown in the Productivity Report published in November 2020. The difference is attributable to the data revision, and – in the case of the EU average – the changeover from the previous EU28 to EU27.



Hungary's ecological productivity is in line with the regional pattern. Recently, there has been a positive change in ecological terms, but there is still room for improvement, in an EU comparison. The value added per unit of carbon dioxide emissions has improved significantly lately. Despite a significant improvement in the indicator, the Hungarian figure is still below the EU average, but has improved at the same rate in recent years. In this respect, Hungary stands at 88 percent of the EU average, and while compared to the average of the TOP5 countries this value is 58 percent. Compared to the EU average, no significant change can be identified between 2018 and 2019, and the same also applies to the average of the prevailing TOP5 EU countries.

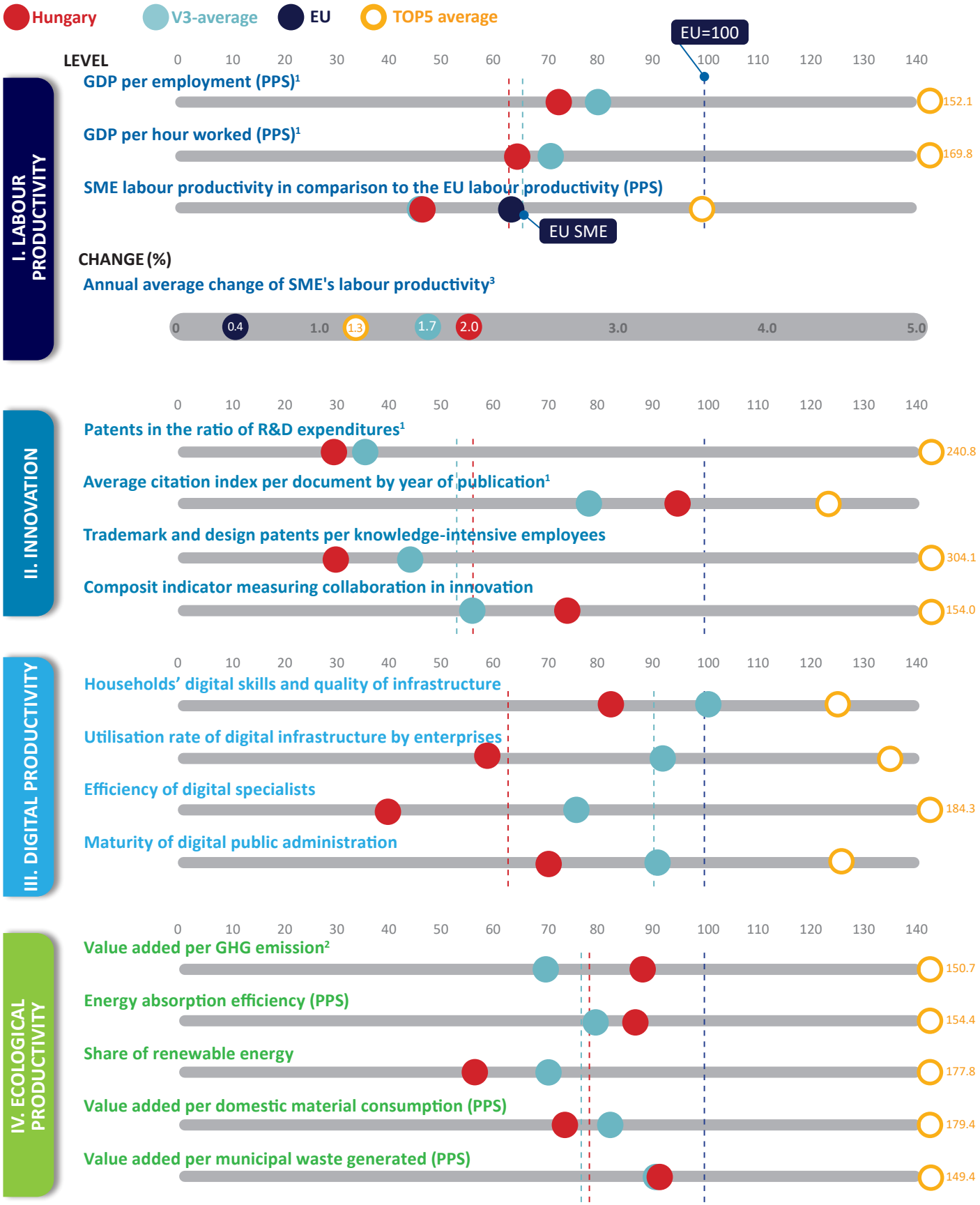
As regards to material use efficiency, a significant improvement was registered between 2019 and 2020, but the Hungarian economy still lags behind the developed Western European countries. In material use efficiency, Hungary's efficiency reached 72 percent of the EU average, and 40 percent of the average of the TOP5 countries.

In an international comparison, Hungary falls behind in regards to the recycling of municipal waste and renewable energy resources. The recycling ratio of municipal waste was 33 percent in 2020, which puts Hungary not only below the EU average, but also below the average of the region. In 2020, the average of the TOP5 EU member states was close to 60 percent. Due to the penetration of renewable energy, dependence on fossil fuel has declined significantly over the past one and a half decades. During this period, the ratio of electricity from renewable resources (produced from biomass, water, solar and wind energy) has trebled in Hungary, and as a result of this 11 percent of the total power generation comes from such sources. In 2020, 17 percent of the EU average and around 40 percent of the average of the TOP5 EU Member States came from renewable energy sources. On the consumption side, renewable energy in Hungary accounted for 14 percent of energy consumption in 2020, compared to the EU average of 24 percent and an average of over 43 percent for the EU TOP5 countries.

There is an improving trend in the green productivity ratios across a wide range of sectors. Over the past two decades, value added per unit of carbon dioxide emissions has almost doubled in manufacturing and services. A moderate improvement was observed in agriculture. However, ecological productivity deteriorated in construction, stabilising in recent years at around 60 percent of the 2000 figure.

In line with the emergence of the decarbonisation process, Hungary may gradually change over to the low carbon-dioxide emission economic model. The economy's improving energy absorption efficiency, material use efficiency and waste management contribute to this favourable trend.

Chart 2: Value of the indicators in Productivity pillars (EU average = 100)



[1] Based on 2021 data; [2] Based on 2019 data; [3] Average annual change for the period 2017-2021.

Note: Data for 2020, except for: calculations marked with [1], [2] and [3] in the figure.
Source: MNB-calculations based on Eurostat, European Commission, DIW, WIPO, ScimagoJr, IEA databases.

1 Labour productivity

DESPITE THE SIGNIFICANT IMPROVEMENT EXPERIENCED IN RECENT YEARS, DOMESTIC LABOUR PRODUCTIVITY IS IN THE BOTTOM THIRD OF THE EU RANKING AND IS SOMEWHAT BEHIND THE V3 AVERAGE. IMPROVEMENT OF PRODUCTIVITY REPRESENTS THE LARGEST GROWTH RESERVE DURING THE NEXT DECADE.

Based on the average of the variety of indices measuring labour productivity, Hungary's labour productivity stands at 62 percent of the EU level and at 45 percent of that of the TOP5 member states.

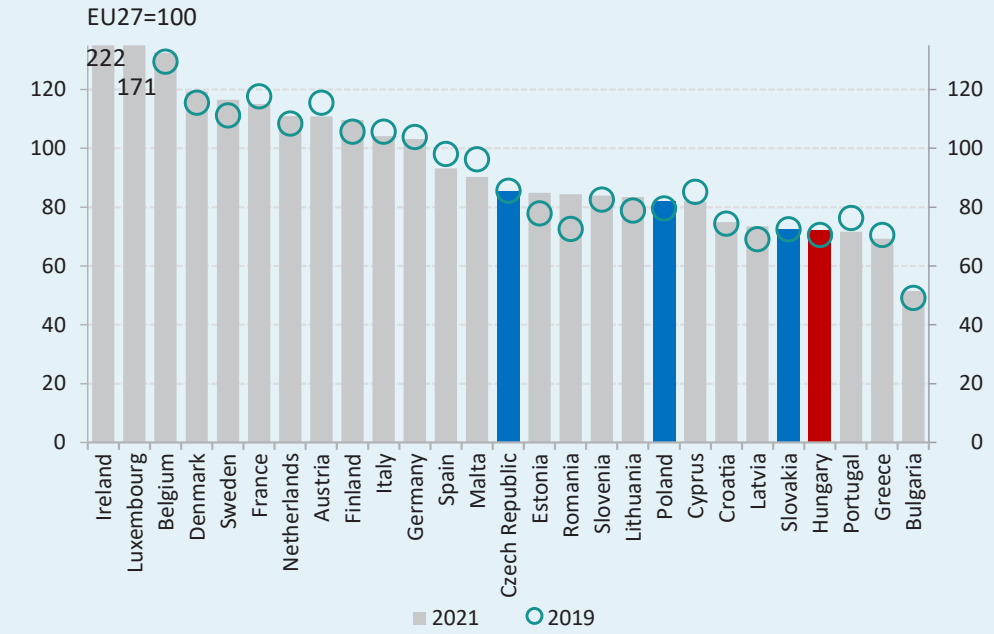
1.1 Hungary's productivity in an international comparison

Productivity quantifies the value (added) that an economic unit – be it an enterprise, industry or country – is able to produce using one unit of input. Labour productivity is the most frequently used efficiency indicator, which indicates the output/value added per employee or working hour.

The value of the pillar obtained from Hungary's labour productivity indicators for 2021 stands at 62.1 percent of EU countries and 45 percent of the TOP5 EU countries. This indicator is based on the average of the relative productivity per headcounts and hours worked, as well as labour productivity of the SME sector.

There is significant growth potential in headcount-based domestic labour productivity (GDP per employee), since in 2021 it stood at 72.3 percent of the EU average. This is 1.7 percentage points higher than 70.6 percent recorded in 2019. Accordingly, in 2021 Hungary ranked 24th in the EU ranking. Apart from the EU average, Hungary's labour productivity can be also compared to that of the leading countries of Europe. The five most productive countries in terms of value added per employee are: Ireland, Luxembourg, Belgium, Denmark and Sweden. Compared to the average of these EU countries, domestic labour productivity stood at 47.6 percent in 2021, while it was 49.6 percent in 2019[1]. It is essential to improve labour productivity in order to increase Hungary's economic development (Chart 1-1, Baksay–Matolcsy–Virág, 2022).

Chart 1-1: Labour productivity level in European Union (2021)

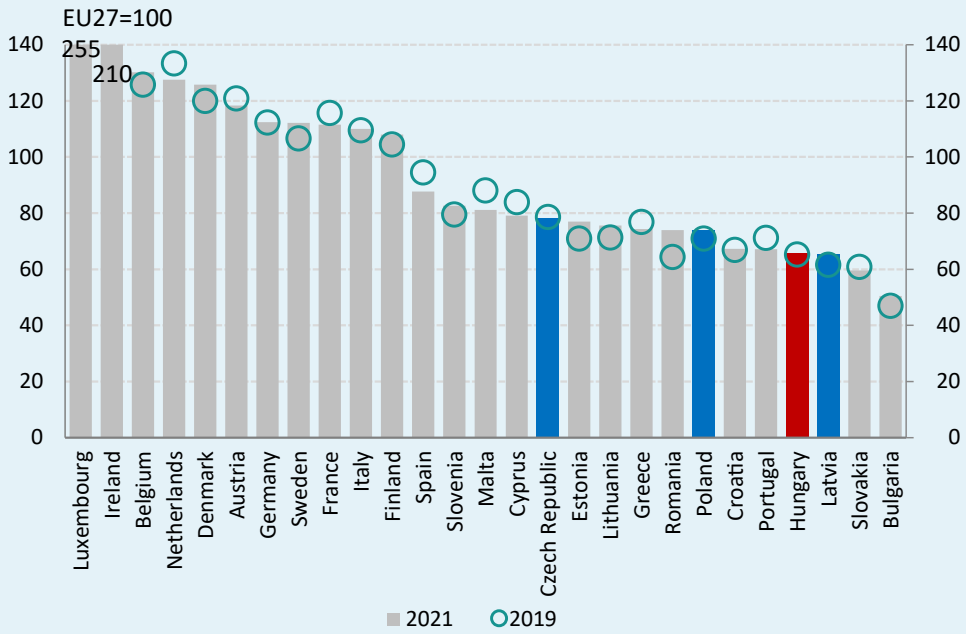


Note: GDP per employee.
Source: MNB calculation based on Eurostat data.

1 When one wishes to compare the levels of GDP (labour productivity) per employed person between countries, it should be based on GDP measured at purchasing power parity. The use of purchasing power parity is necessary because it is expected to filter out the effect of the difference in prices from the comparison. This way we are to examine the economy's output from a welfare point of view.

Productivity per hour worked in Hungary exceeded its 2019 level, expressed as an EU average, by 0.6 percentage point in 2021. (Chart 1-2). This statistic takes into consideration not only the number of employees, but also the average number of hours that employees work in the respective country. Domestic labour productivity per hour worked in 2021, the productivity index per hour worked, rose to 65.9 percent of the EU average, from 65.3 percent registered in 2019. In this EU ranking, Hungary was 24th in 2021, ahead of Slovakia among the Visegrád countries. In terms of value added per working hour, the group of leaders in the EU consists of the same countries as for the ratios per employee, with the exception of one place (the Netherlands instead of Sweden). The value of the Hungarian indicator was 38.8 percent compared to that of the five most productive European countries.

Chart 1-2: Working hour-based labour productivity level in the European Union (2021)



Note: GDP per full-time equivalent.
Source: MNB calculation based on Eurostat data.

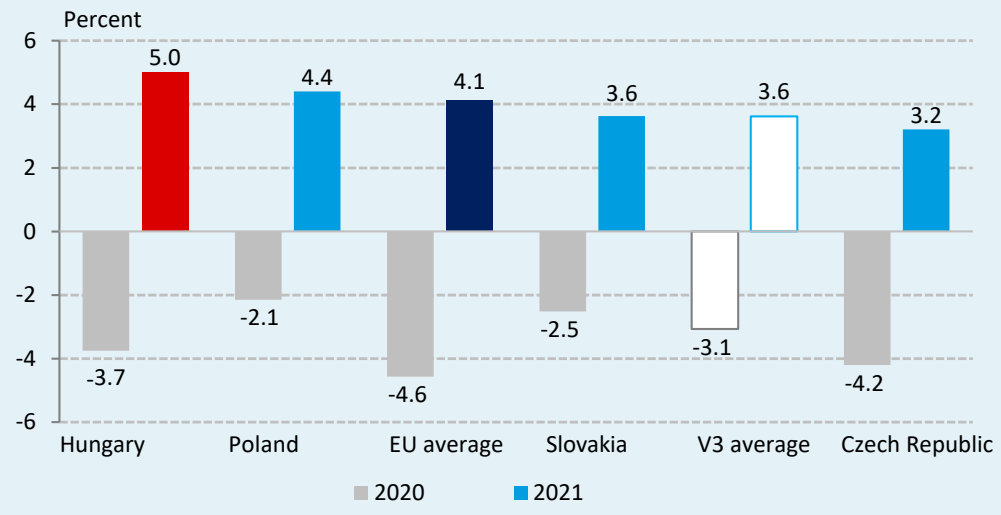
The strong growth in labour productivity since 2017 supported convergence to the EU average, but productivity improvement declined as a result of the coronavirus crisis (Chart 1-3). In the previous report (Productivity Report 2020), it was presented that the productivity cycles inspected from 1995 were in sync with the business cycles. An important criterion of growth periods is whether they improve the performance of an economy in a sustainable way or with imbalances. As a result, – due to its pro-cyclical nature – labour productivity may also improve in an overheated environment, temporarily or permanently under sustained equilibrium. The six years prior to the outbreak of the coronavirus crisis can be broken down into two shorter three-year phases: a period of expanding labour market-based growth (2013–2016), followed by a period of historically high capital- and productivity-driven growth following a constrained labour expansion (2017–2019). During the period 2017–2019, labour productivity rose by almost 3 percent on average, and thus it not only maintained but also accelerated economic growth and real economic convergence.

In Hungary, headcount-based labour productivity rose in total by 1.3 percent in the two years between 2019 and 2021, while the V3 average growth was merely 0.5 percent and the EU average declined by 0.4 percent (Chart 1-3). In 2020, productivity fell temporarily by 3.7 percent, due to the moderate effects of the crisis on the labour market. Similar trends were observed also internationally: in 2020, average labour productivity in the CEE region and in the EU fell by 3.1 percent and 4.6 percent, respectively.

The fall in employment was much smaller than the fall in total output due to the impact of certain job-retention programmes and decisions made by employers. As a combined result of the aforementioned, employment-based labour productivity decreased in 2020 which was an inevitable consequence. However, this way the labour force was available post-pandemic when production and service activities could be restarted. This measure facilitated a fast recovery from

the crisis. In the absence of this (upon larger scale dismissals) the restart could have taken much longer as corporations would have needed to find an appropriate labour force necessary for the re-launch of their activity. In 2021, GDP per employee in Hungary increased by 5 percent as a result of the recovery from the economic crisis caused by the pandemic. This increase exceeded the 3.6 percent productivity growth rate in the V3 countries and the 4.1 percent EU average.

Chart 1-3: Annual change in labour productivity in the Visegrád countries and in the Europe-an Union (2021



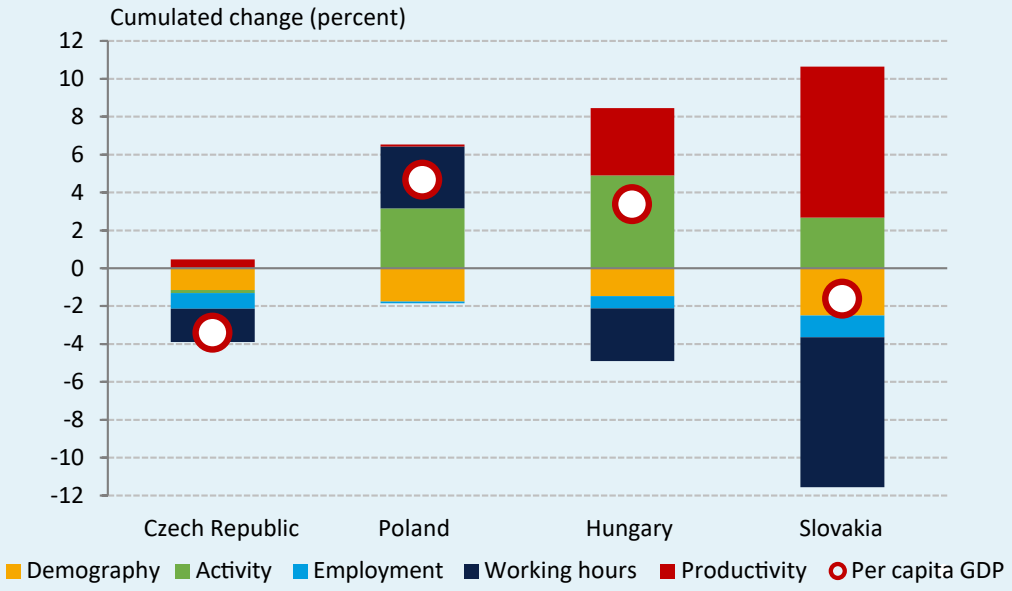
Source: MNB calculation based on Eurostat data..

In the Visegrád region, GDP per capita in Hungary (3.4 percent) and Poland (4.7 percent) increased between 2019 and 2021. In Hungary, the increase was mainly attributable to the rise in productivity per hour worked and activity growth, while in Poland it was mainly due to labour market adjustment (Chart 1-4). The relationship between GDP per capita and productivity can be described by the following formula.

$$\frac{\text{GDP}}{\text{Capita}} = \frac{\text{GDP}}{\text{Working hours}} \times \frac{\text{Working hours}}{\text{Employees}} \times \frac{\text{Employees}}{\text{Economically active persons}} \times \frac{\text{Economically active persons}}{\text{Persons of working ages}} \times \frac{\text{Persons of working ages}}{\text{Total population}}$$

With this formula, the impact of labour productivity per hour worked, the number of hours worked per employee, employment, activity and demographic change can be separated in order. The demographic impact appearing as the ratio of persons of working age to the total population. This factor essentially changes slowly, over several decades. However, the pandemic had a unique effect on the decline in population. The labour force participation rate is the percentage of the employed and unemployed persons (economically active persons) in relation to the working age population. The employment ratio here is not the same as the employment rate, which is the ratio of the total number of employees to the working-age population, but it rather presents the ratio of employees to the active population. Similar to demography, activity and employment components are able to increase GDP per inhabitant only up to a certain degree. The hours worked component measures the number of hours worked per employee. As a result of the job protection crisis management programmes, employment in 2020 fell to a lesser degree than the number of hours worked, i.e. a segment of employees started to work part-time. After 2020, the recovery of hours worked began. Hours worked per employee during the period of 2019–2021 restrained the growth in domestic GDP per capita by 2.8 percentage points and the change in GDP per capita in the Czech Republic and Slovakia by 1.7 and 7.9 percentage points, respectively. Finally, productivity growth, i.e. GDP per hour worked, contributed to a 3.6 percentage points change in GDP per capita in Hungary and an 8 percentage point change in Slovakia. In the Czech Republic and Poland, labour productivity in 2021 was almost the same as in 2019.

Chart 1-4: Breakdown of change in real GDP per capita (2019 –2021)



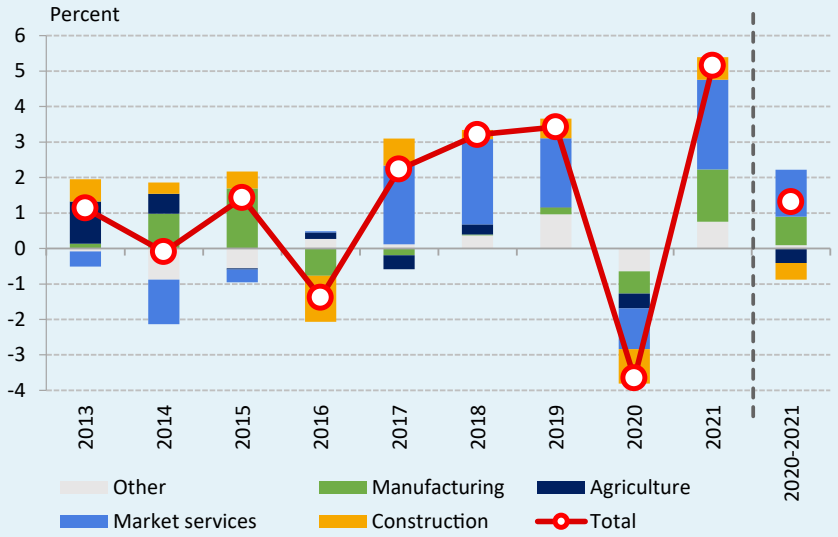
Note: the chart shows productivity per hour worked.
Source: MNB calculations based on Eurostat.

1.2 Industry analyses

In terms of value-added weight in Hungary, the most important productive industries included manufacturing (21.9 percent), trade and tourism (17.3 percent) and professional, scientific and support service activities (9.2 percent) in 2021. Companies in these three industries accounted for nearly 40 percent of gross domestic product in 2021. The productivity of these industries plays an outstanding role in the performance of the Hungarian economy.

Over the period of 2020–2021, active corporations in the manufacturing and market services industries improved their labour productivity. In 2021, all productive industries made positive contribution to the aggregate growth in productivity (Chart 1-5). During the period of 2017–2021, developments in the productivity of the national economy were mainly determined by the productivity of service industries. Market services accounted for almost two-thirds of the growth observed in the period of 2017–2019, and for more than half of the change in the period of 2020-2021. In 2021, market service companies improved their labour productivity by an average of 5.4 percent, thereby contributing 2.5 percentage points to the aggregate labour productivity growth of 5.1 percent. Manufacturing industries contributed 1.5 percentage points, the repeated pick-up in construction contributed 0.6 percentage points, and finally the remaining sectors contributed 0.8 percentage points to the 2021 performance. In the previous year (2020), the largest ratio of decrease was registered in market services. During the first year of the pandemic, the fall in labour productivity affected primarily the service sector. In 2020, labour productivity in most market services deteriorated (by 2.5 percent on average), except for info-communication and financial intermediation activities. In the crisis year of 2020, all production sectors presented experienced a deterioration.

Chart 1-5: Breakdown of the change in labour productivity bí industry across the whole economy (2013 –2021)



Note: Weighted by employment. The other group includes water and energy supply, government and mining industries.
Source: MNB calculation based on Eurostat data.

In 2021, i.e. the year of recovery, the value added ratio per number of people in employment stagnated in only the agricultural sector, while annual labour productivity improved in all other industries. The infocommunication and financial intermediation industries improved their productivity, while labour productivity in other key fields deteriorated in 2020 (Chart 1-6). In the first year of economic disturbances caused by the coronavirus pandemic, only companies in the ICT and financial industries improved their productivity. Labour productivity within these activities also increased in 2021, resulting in a 4.5 percent improvement in value creation efficiency in the information and communication industries, and 13.8 percent in the financial intermediation segment during the period of 2019-2021. The production weight of these national economy branches was 5.1 and 3.7 percent, respectively, in 2021. During these two years, manufacturing as well as trade, tourism and logistics (together), were the two industries with the largest growth in terms of value added, growing by 4.3 percent and 3.0 percent, respectively, in terms of productivity. The cumulative labour productivity of professional scientific and administrative activities decreased by 2.2 percent compared to 2019. Enterprises operating in the other services and agriculture registered a decrease of 10.4 and 10.5 percent, respectively. Agricultural production efficiency stagnated in 2021. In the primary sector, most of the decline registered between 2019 and 2021 was linked to performance in 2020.

Chart 1-6: Labour productivity characteristich of Hungarian industries (percentage, 2020 and 2021)

	Nominal labour productivity (2021)	Changes in real labour productivity (2019-2020)	Changes in real labour productivity (2020-2021)	Cumulated changes in real labour productivity (2019-2021)
Financial services (3.7%)	20.6	5.6	7.7	13.8
ICT (5.1%)	13.1	1.9	2.5	4.5
Manufacturing (21.9%)	11.6	-3.4	8.0	4.3
Agriculture (3.9%)	9.9	-10.3	-0.2	-10.5
Professional, adminstrative activties (9.2%)	7.9	-7.0	5.2	-2.2
Construction (6.5%)	7.6	-12.1	7.5	-5.5
Trade, tourism, logistics (17.3%)	7.4	-3.6	6.8	3.0
Other services (2.5%)	5.1	-12.9	2.9	-10.4
Market services, Total (48%)*	10.2	-3.2	6.4	3.0

*Note: *Market services include the following national economy branches: trade, infocommunication, finance and insurance, real estate transactions, professional, scientific and technical activities, and other services.*
Source: MNB calculation based on Eurostat data.

Labour productivity of financial intermediation also was outstanding in 2021 at HUF 20.6 million/person, followed by infocommunication activities (HUF 13.1 million/person) and manufacturing (HUF 11.6 million/person). (Chart 1-6). As a result of the shift towards a knowledge-based economy, the market penetration of the infocommunication industry may be a determinant factor for future production. As mentioned before, the productivity of manufacturing is a key factor for the generation of value added to the economy. The lowest productivity is still registered by other services (HUF 5.1 million/employee), followed by construction (HUF 7.6 million/employee).

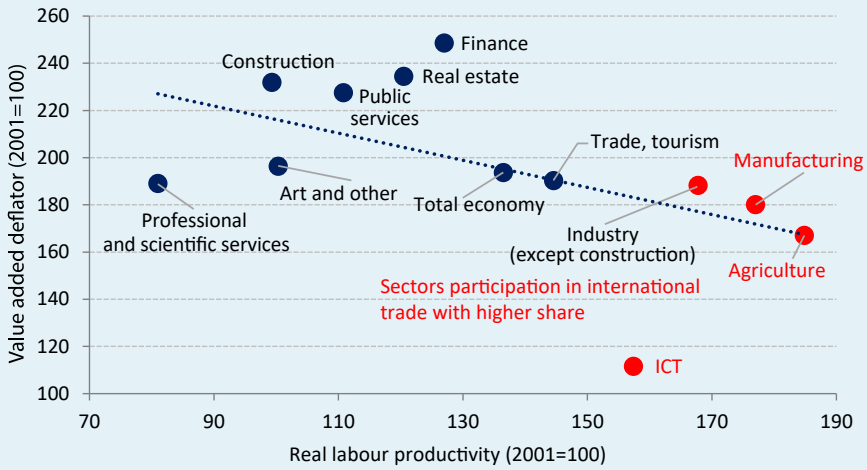
Box 1-1: Relationship between labour productivity and inflation

A long-studied correlation in economics is the relationship between productivity and inflation. Productive sectors and enterprises produce at lower costs and are able to adapt flexibly to rising deman. By contrast, less productive/ competitive firms have higher costs per unit and respond to an increase in demand mainly by raising prices.

When examining the industry level data over a longer period (2001-2019), it is clear that those industries achieving higher productivity have experienced smaller increases in the industrial level price index (Chart 1-7 and Chart 1-8). Those industries achieving the highest productivity growth (manufacturing, agriculture, information and communication) experienced only moderate changes in the value added price index, while the industries registering lower productivity growth (construction and services) observed more significant price increases. A higher ratio of the more productive industries participate in external trade, since more productive firms are capable of competing internationally to a larger degree. They are characterised by efficient technology, lower costs and continuous innovation, and their sales prices are highly dependent on global competition, as a result of which their sales prices also changed to a lesser degree in the period under review.

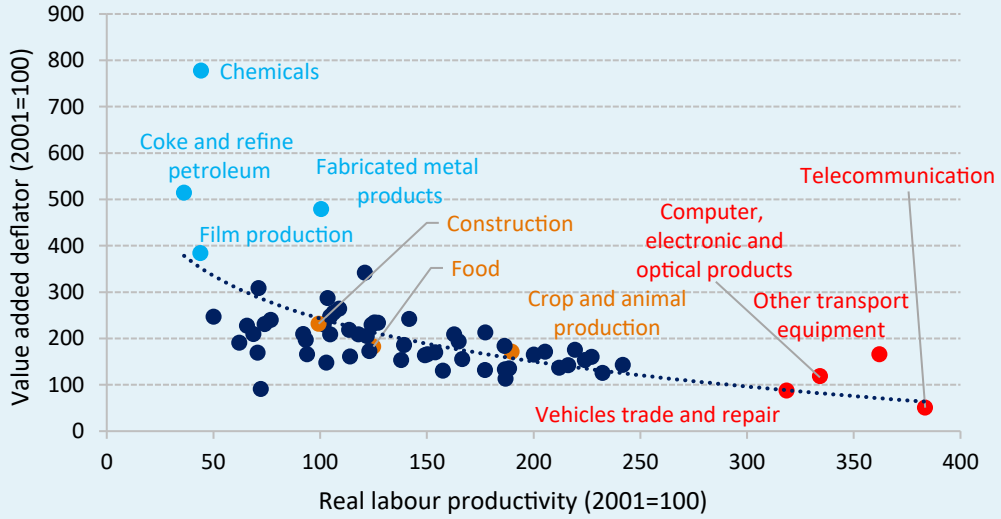
- The ICT industry is a prominent example, where technological developments have had the most direct impact. Here, under awith productivity growth of 57 percent, producer prices rose by only 11 percent over 18 years.
- Producer prices in the industrial and agricultural branches, which achieved productivity improvements of 60-80 percent between 2001 and 2019, rose by 70-90 percent.
- In construction, productivity has not increased in 19 years (in 2019 it stood at 99 percent of its 2001 level), while prices rose by 132 percent, and the same situation is only slightly more favourable in the real estate sector.
- Productivity in the trade and catering sector, a highly weighted category, improved by 45 percent between 2001 and 2019, during which time prices rose by around 90 percent.

Chart 1-7: Changes in real labour productivity and the value added deflator between 2001 and 2019



Source: MNB calculation based on Eurostat data.

Chart 1-8: Changes in real labour productivity and the value added deflator in the national economy sub-sectors between 2001 and 2019



Note: Sub-sectors with declining productivity but high price changes are shown in light blue. Sub-sectors with high productivity growth and low price changes are shown in red. Other important economic sub-sectors are highlighted in orange.
Source: MNB calculation based on Eurostat data.

In the manufacturing branch, productivity grew by around 77 percent and producer prices rose by 54 percent between 2001 and 2019. When examining the industries in more detail, the price (index) reducing effect of productivity can be identified (Chart 1-9).

- **In industries where energy consumption is a significant cost factor, productivity has declined** over the last almost two decades (chemicals, coke production and crude oil processing), while in the metal processing sector it has stagnated over the same period. The production costs of these sub-sectors increased substantially over the same period: **the average producer price increase of these three sub-sectors was four times higher than in manufacturing as a whole**

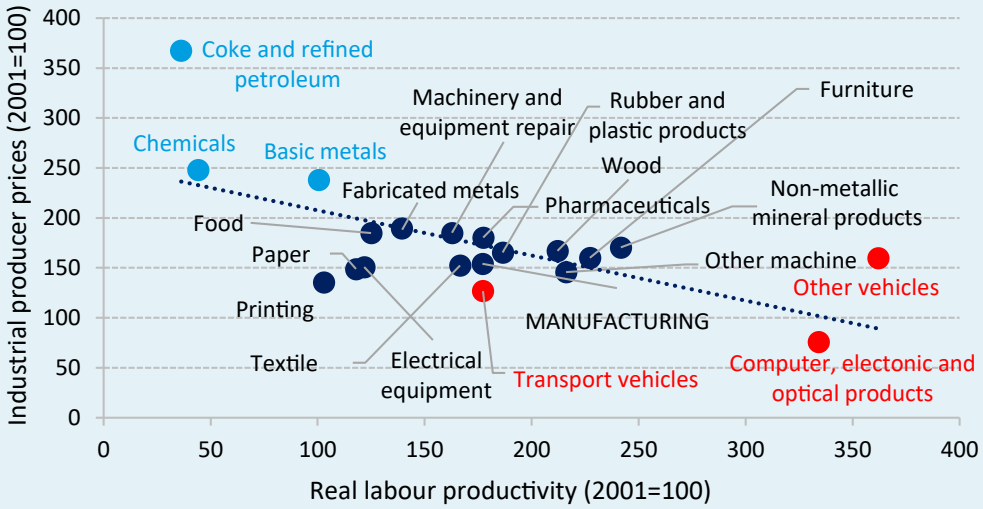
- **The most significant productivity growth was registered in the automotive and electronics sub-sectors,** where industrial producer price changes remained moderate. Productivity in these sub-sectors increased by 191 percent on average, well above the manufacturing average, while producer prices rose by only 20 percent on average over the same period.

- **The food industry, which is of particular importance due to internal demand, is one of the less productive sectors of manufacturing.** Between 2001 and 2019, productivity rose by around 25 percent, which is significantly below the manufacturing sector, while producer prices in the sector rose by 85 percent, which is higher than the manufacturing average. The recently observed high domestic food price index, even by international standards, may be partly attributable to the low productivity of the sub-sector.

- **In the manufacture of wood and wood products, furniture, and mineral production sub-sectors,** which have a low weighting, productivity improvements were 50 percent higher than the manufacturing average, while the increase in producer prices slightly exceeded it.

- In the paper industry, printing and electrical equipment production, productivity growth in the sub-sectors was significantly below the manufacturing average, while their production costs increased moderately compared to the same average.

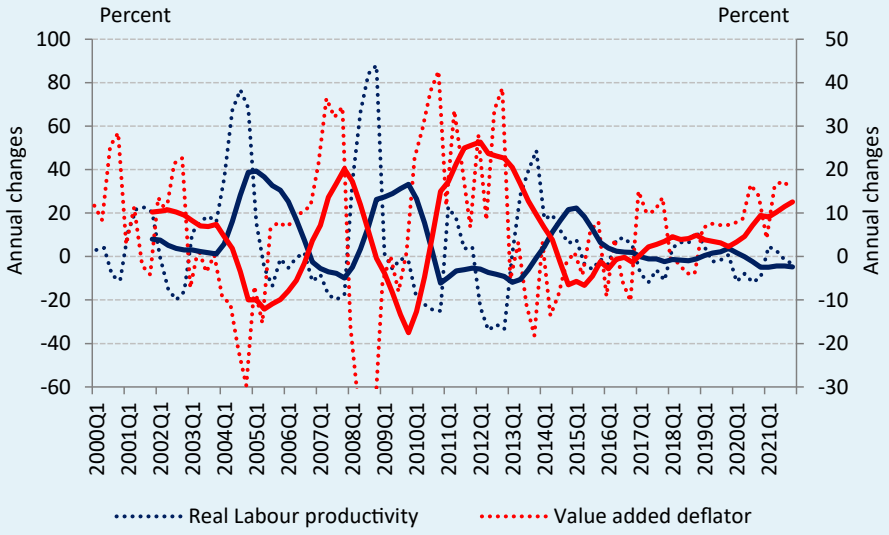
Chart 1-9: Changes in real labour productivity and industrial producer prices between 2001 and 2019 in the manufacturing sub-sectors



Note: Sectors with declining productivity but high price changes are shown in light blue. Sectors with high productivity growth and low price changes are shown in red.
Source: MNB calculations based on Eurostat

In agriculture, increasing irrigation areas would lead to sustainable productivity improvements, which would reduce food price levels and volatility. Agriculture provides a particularly graphic example of the opposite movement of productivity and price changes (Chart 1-10). Annual crop yields are significantly influenced by the weather, including the volume, temporal and territorial distribution of annual rainfall. Weather and rainfall are external factors, and typically, if the weather is unfavourable, it has a negative impact not only on domestic crop yields, but also on European or global crop yields. Falling crop yields (i.e. falling productivity) push up the prices of agricultural products. Likewise, under favourable weather conditions, higher crop yields are usually accompanied by lower prices. Thus, there is a strong negative co-movement between productivity and price levels in agriculture. This cyclical movement could be mitigated by increasing irrigation areas, which would result in higher crop yields and lower and less volatile prices even in adverse weather conditions.

Chart 1-10: Changes in real labour productivity and the value added deflator in agriculture between 2000 and 2021

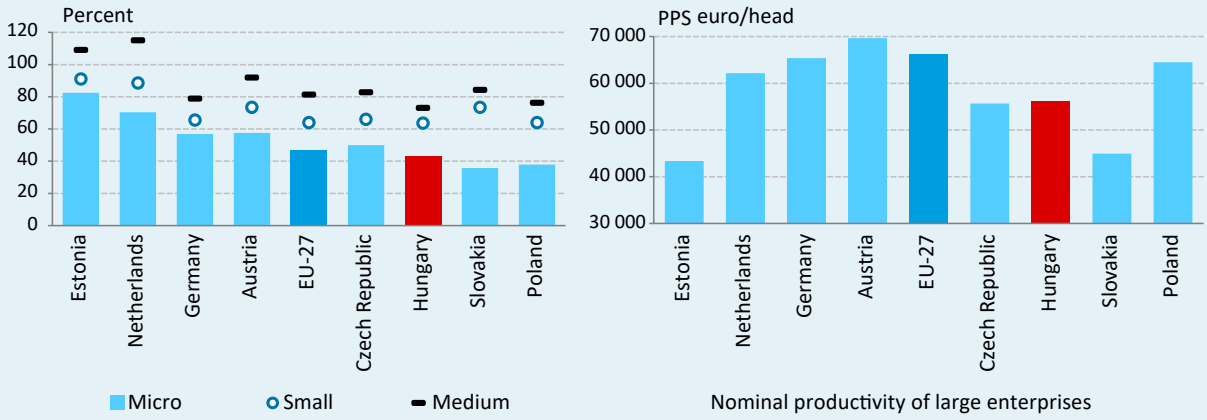


Note: Dotted lines indicate the actual data, continuous lines are smoothed data series with an 8-period moving average.
Source: Eurostat, MNB calculation.

1.3 Comparisons by enterprise size

The productivity gap between SMEs and large corporations remains large: in 2020, productivity of micro, small and medium-sized enterprises relative to large corporations was 43 percent, 64 percent and 73 percent, respectively (Chart 1-11, left pane). The degree of the duality – i.e. the productivity lag compared to large corporations – contains important additional information on the performance of corporations in the economy. In a statistical sense, economies of scale is an – unobserved – corporate metric engendering a productivity advantage, which implies that, in its own right, the productivity of large corporations exceeds the indicators of smaller enterprises. According to the 2020 indicators, the relative productivity lag of Hungarian small enterprises (the productivity of small enterprises is 63.6 percent of that of large enterprises) was the largest in the Visegrád region. However, the regional ratios in the small and medium-sized enterprise segment were within a narrow range. The productivity advantage of national large enterprises compared to the labour productivity of micro enterprises in each country is spread over ratios of a wider scale. While the productivity gap between these two groups in Slovakia and Poland are 35.8 and 37.9 percent, respectively, the gap is 43 percent in Hungary and 50 percent in the Czech Republic in 2020. Overall, the ratios of small and medium-sized enterprises in the Visegrád region have moved up to the 64-84 percent range, from the previous (in 2017) 59–80 percent range. In addition to the aforementioned, the productivity of large enterprises in Hungary is also below the EU average (Chart 1-11, right pane), mainly due to the low domestic value added ratio in production. Large enterprises mainly produce for export, and the Hungarian economy has the fourth lowest domestic value added for exports in the EU (54 percent), while the Polish economy, for example, demonstrating successful convergence, has a much higher domestic value added ratio of around 70 percent. Hungary's lower domestic value added ratio is also be attributed to the high import content of goods sold abroad (vehicles, spare parts, electronic equipment) and the low level that capital inflows are embedded in domestic production networks.

Chart 1-11: Labour productivity as a percentage of large corporations (2020) and labour productivity of large corporations (2020)

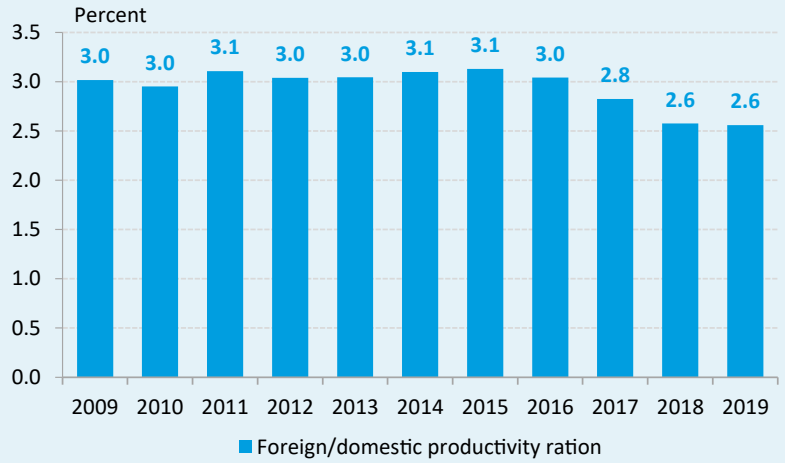


*Note: *Data for 2020 are nowcasts. The entire SME segment includes all sectors from mining and quarrying to administration (marked B to N), except financial intermediation (marked K).*
Source: MNB calculation based on DIW-ECON data.

There is still a large duality between corporations under domestic and foreign control, while productivity-driven duality somewhat decreased in the years of growth. (2017–2019) (Chart 1-12). Duality in terms of productivity can be detected not only in the case of small and large enterprises, but also in the case of foreign-owned and Hungarian-owned companies2. Foreign companies were typically three times more productive than Hungarian-owned companies from 2009 to 2016. This ratio has remained almost unchanged since 2009, but growth rates have varied more widely. It should be noted that the foreign productivity advantage outlined along ownership relations is closely related to the Hungarian corporate structure, as large manufacturing companies located in Hungary are typically foreign-owned. During the intensive growth phase from 2017, the productivity gap narrowed due to the performance of the mostly Hungarian-owned SME sector. Between 2009 and 2016, the advantage of corporations under foreign control, which were 3 times more productive, declined to 2.6 times by 2019.

2 In the Eurostat accounts the distinction between domestic and foreign ownership is based on control. Accordingly, it is established whether or not an enterprise is controlled by non-residents along multiple ownership dimensions, instead of considering only direct ownership subordination.

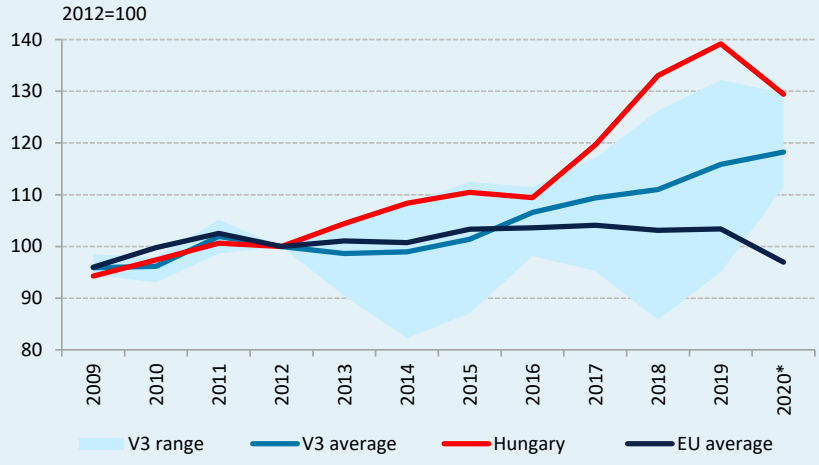
Chart 1-12: Annual change in labour productivity at enterprises in majority Hungarian and foreign ownership



Source: MNB calculation based on Eurostat data.

As a result of the crisis, labour productivity of SMEs fell by nearly 7 percent in 2020, but the 2021 data according to size category – where we could present the recovery – are not yet available (Chart 1-13). Owing to the growth registered in the period of 2012-2019, the cumulative productivity growth of Hungarian SMEs was by 24 percentage points higher in 2019 than the regional average. Productivity-driven growth in the growth phase of 2017–2019 played a key role in this. This trend faltered in 2020, when productivity of domestic SMEs fell by 7 percent (9.8 percentage points on a cumulative scale). Nevertheless, cumulative domestic productivity growth from 2012 was close to the regional maximum. At the time of compiling this report, productivity data according to size category for 2021 were not yet available to quantify recovery rates.

Chart 1-13: Labour productivity of SMEs in a regional comparison (2009–2020)

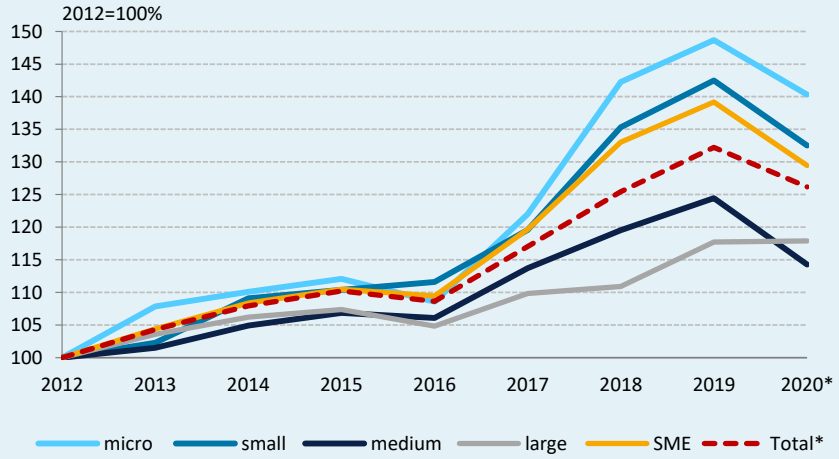


*Note: *Data for 2020 are nowcasts. The entire SME segment includes all sectors from mining and quarrying to administration (marked B to N), except financial intermediation (marked K).*
Source: MNB calculations based on European Commission, Eurostat and DIW

The combined result of a nearly 7 percent productivity decline across the entire SME segment, and the stagnating efficiency of the large enterprise sector, had led to a widening productivity gap when compared to large enterprises in 2020 (Chart 1-14). Productivity of micro enterprises deteriorated by more than 8 percentage points in 2020 on a cumulative scale, while the labour productivity decline of small and medium-sized enterprises was around 10 percentage points in the crisis year of 2020. The annual labour productivity of large enterprises actually stagnated in 2020. Cumulative SME productivity growth from 2012 fell from 139.2 percent in 2019 to 129.4 percent in one year. The same productivity indicators of large enterprises stood at 117.7 (2012-2019) and 117.9 (2012-2020) percent. The observed trends were influ-

enced by the fact that the vast majority of SMEs operate in the market services sector, which was hit harder by the 2020 pandemic and measures taken to adapt to it. By contrast, large manufacturing companies were able to adapt more quickly to the circumstances after a short stoppage.

Chart 1-14: Changes in SMEs' real labour productivity in Hungary in a breakdown by enterprise size (2012–2020)



*Note: *Data for 2020 are nowcasts. The entire SME segment includes all sectors from mining and quarrying to administration (marked B to N), except financial intermediation (marked K).*
Source: MNB calculations based on Eurostat and DIW.

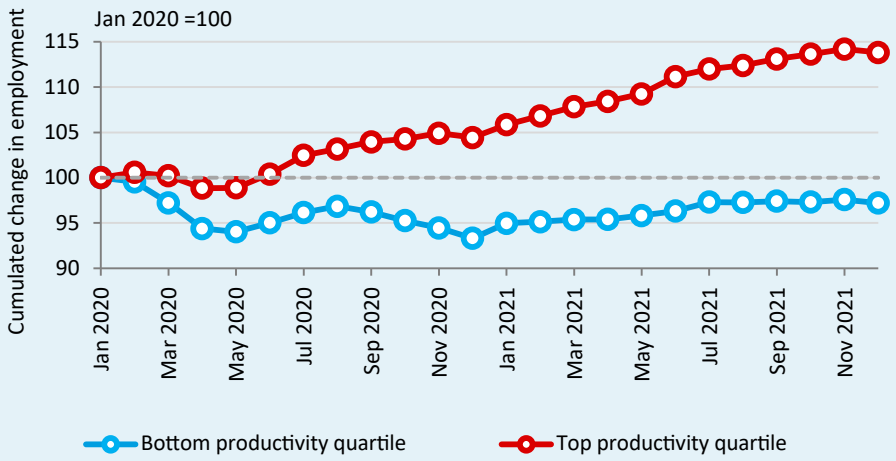
Box 1-2: Labour productivity aspect of reallocation processes

In all countries, the pandemic triggered a major economic downturn and potentially lasting structural changes. Demand fell significantly in some sectors, while it rose in others. In the event of such shocks, resources are reallocated neither immediately nor free of charge (reallocation) (OECD Interim Economic Outlook, September 2021).

The impact of the pandemic on potential output depends in part on the effect it has had on the reallocation of labour force from low to high productivity enterprises. Schumpeter (1939) assumed that recession may accelerate this process of "creative destruction", but that decline may also distort the dynamics of reallocation. If financial constraints lead to the premature disappearance of productive but underfunded enterprises, the reallocation effect of a negative economic shock also shrinks. The crisis management elements of the pandemic may have had a further special effect due to the fact that the job retention programmes delayed the restructuring of unproductive firms that otherwise would have experienced shrinkage, thereby posing a risk of "zombification".

Despite the negative economic consequences of the pandemic, the reallocation continued to boost productivity. Two recent studies (Andrews-Charlton-Moore, 2021 and Andrews-Bahar-Hambur, 2021) have examined and shown, using data from the UK, Australia and New Zealand, that although the overall rate of job reallocation declined following the pandemic, a non-negligible proportion of companies continued to hire or lay off workers, and thus the reallocation process was still connected to productivity. In other words, the trend of expansion at high productivity enterprises and contraction of low productivity firms – which drives productivity growth over the medium term – remained in place. Labour adjustments continued to have an impact on business productivity. This was particularly the case in Australia, evidenced by the large difference in employment growth between enterprises in the top and bottom productivity quartile. In a similar way to the aforementioned authors, we examine the employment ratios of enterprises in the lower and upper productivity quartile, with the only difference being that we present the changes using 24 months of employment data (Chart 1-15).

Chart 1-15: Changes in monthly headcount data in the lower and upper productivity quartiles (January 2020 – December 2021)



Source: MNB calculation based on tax registry data.

Employment in high-productivity companies increased in Hungary, while employment in low-productivity companies decreased. Under the government's job retention measures, high productivity domestic enterprises on average did not change the number of their employees until May 2020, and then started to expand their workforce in the following months. By contrast, enterprises in the bottom productivity quartile dismissed workers through layoffs or closures, a trend which turned to growth from January 2021; nevertheless the employment level in the bottom quartile did not reach the figure registered at the end of 2019. During the second wave, employment adjustment continued. The increasing gap between employment in low and high productivity enterprises implies that resource reallocation continued to increase productivity, despite the fact that in the early months of the pandemic job retention corporate policies enjoyed priority over other adjustment channels.

Finally, the potential impact of job retention programmes on redistribution should not be examined in isolation. Instead, such schemes should be assessed in terms of their broader objectives, such as support for household incomes, reducing insecurity and temporary protection of enterprise-specific capital (by maintaining the link between employees and companies). Although initial concerns3 related to zombification proved to be exaggerated, there is a thin line between the supportive and distortive effects of such policies. This underlines the need that job retention schemes should exert their impact in targeted periods and develop together with the change in economic conditions.

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3 For instance, news.com.au; www.news.com.au or Deloitte.

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2 Efficiency of innovation

THE INNOVATION EXPENDITURES IN HUNGARY ARE GRADUALLY INCREASING, HOWEVER THE EFFICIENCY OF THE INNOVATION SYSTEM IS STILL LOW WHEN COMPARED INTERNATIONALLY.

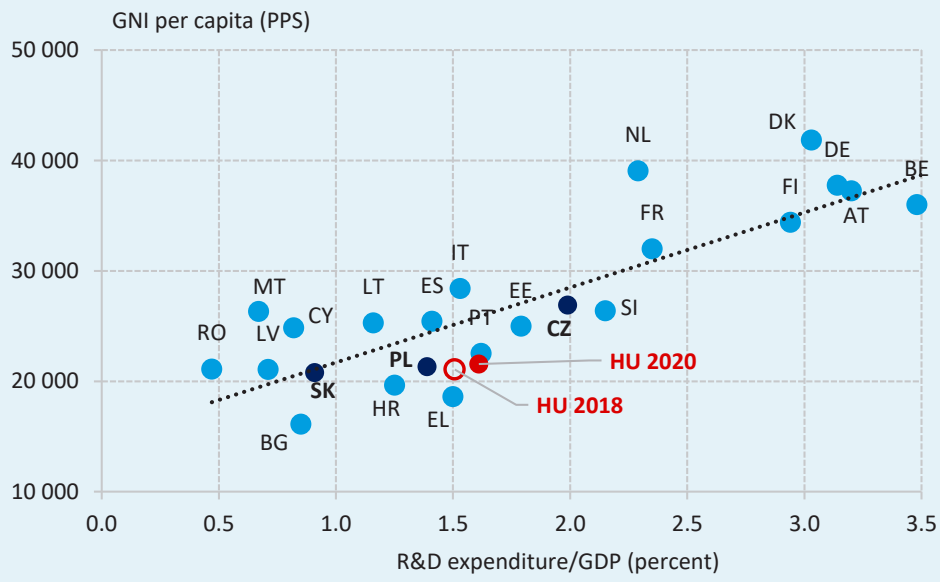
Hungary's innovation efficiency is 57 percent of the EU average, and 37 percent when compared to the TOP5 EU countries.

Introduction

Innovation is one of the main drivers of productivity. In the 2020 Productivity Report, we presented the prominent role of innovation in the economy and pointed out that the more advanced an economy is, the more innovation should lead growth. The maintenance of growth calls for more and more innovation. Countries spending more on innovation are able to maintain or improve their level of development owing to their significant expenditures[4]. The positive impact of innovation expenditures on economic performance is also confirmed by studies conducted on corporate microdata. The efficiency of research and development, i.e. the ability to turn research inputs into outputs that the economy is able to exploit (patents, trademarks, know-how, intellectual capital), is a key factor for the long-term growth prospects of the economy.

The growth in funds used for research and development in Hungary as a percentage of GDP fell short of the EU average. Hungary's R&D expenditure as a percentage of GDP rose from 1.5 percent in 2018 to 1.6 percent by 2020, while the EU average, calculated as an arithmetic mean, increased from 1.6 percent to 1.8 percent. The comparison of research and development resources with the gross national income per capita shows that Hungary did not improve its position between 2018 and 2020 (Chart 2-1). Hungary has not achieved material progress compared to its 2018 position, and compared to its R&D expenditures it is still at a lower level of development. Although compared to the data registered two years ago the gross national income (GNI) per capita rose, this was accompanied by higher R&D expenditure as a percentage of GDP. Of the Member States that joined the EU in the past twenty years, Estonia, the Czech Republic and Slovenia are in the leading group, just below the line.

Chart 2-1: Ratio of research and development expenditures and GNI per capita (2020)

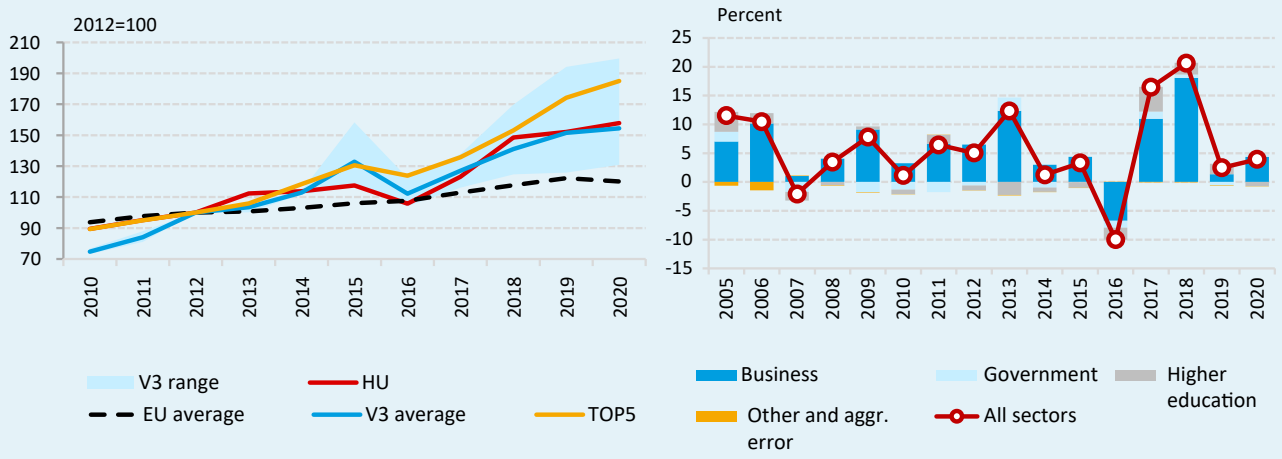


Note: Gross national income (GNI) per capita calculate on purchasing power standard (PPS). Because of their special economic structure, Ireland and Luxembourg is omitted from the graph, due to the high GNI values.
Source: MNB calculation based on Eurostat data.

4 For more details, see Griffith (2000).

In the past almost 10 years, the R&D expenditures of Hungary and all Visegrád countries exceeded the EU average (Chart 2-2, left pane).[5] Due to the economic downturn because of the coronavirus crisis, the innovation indices may distort the view on innovation trends. In 2020, the degree of the fall in GDP significantly affected the favourable Hungarian and European trends in research and development expenditures as a percentage of GDP. Accordingly, it is important to examine the R&D real expenditures, which show that growth has been limited since 2018. When examining expenditures by sectors, the largest fall was registered in the expenditures of corporations from the previously high levels. Higher education and the government also cut their expenditures, but these, compared to corporate expenditures, had been materially lower even in previous years (Chart 2-2, right pane). The moderate expenditures may be attributable to decreasing state aid (primarily financed from EU funds) compared to the previous year, and as regards the structure by size, to the fact that within the corporate sector R&D expenditures decreased in the micro and small enterprise segment in real terms.[6];[7]

Chart 2-2: Change in R&D real expenditures in the region and Europe (left pane) and annual change in hungarian R&D real expenditures by sectors (right pane)



Note: The TOP5 countries were defined based on the data available for last year, and were plotted as a simple arithmetic average of the values for the same countries retrospectively. The TOP5 countries in order: Poland, Lithuania, Cyprus, Greece and Bulgaria.
Source: MNB calculation based on Eurostat data.

In this section, first we review the performance and efficiency of the Hungarian innovation system based on times series, and then compare the Hungarian results with those of our region. In the second part of the section, we provide supplementary explanation with regard to the trend processes.

2.1 Efficiency of the innovation process in Hungary

Innovation expenditures and output results may show a significantly different picture, and thus for Hungary we examine the key indicators individually. Innovation is a manifold process, which may include many activities from creating the basic correlations of knowledge to the implementation of new organisational structures. Since such differentiation is overly wide-ranging based on too many criteria both for the purposes of analysis and policy planning, in practice research, development and innovation are usually separated and their efficiency is also interpreted separately. In the earlier, traditional approach of research and development, research work precedes or advances innovation. Research and development is one of the most important value-creating phases leading to innovation, characterised essentially by utilisable results obtained by using scientific methods.

5 In 2018, R&D expenditures in Hungary substantially increased year-on-year, which was also slightly influenced by a methodological change. Following a change in the internationally accepted Frascati Manual defining R&D expenditures, from 2018 onwards the HCSO also includes intangible assets in R&D expenditures. The ratio of intangible assets within R&D expenditures is 2-5 percent, which may have increased the ratio to GDP by 0.05-0.08 percentage point compared to the data before 2018. Although the change has no significant effect on our view of the R&D trends, the international comparison of the Hungarian figures calls for more attention due to the fact that the individual countries' practice of reconciling this revision varies.

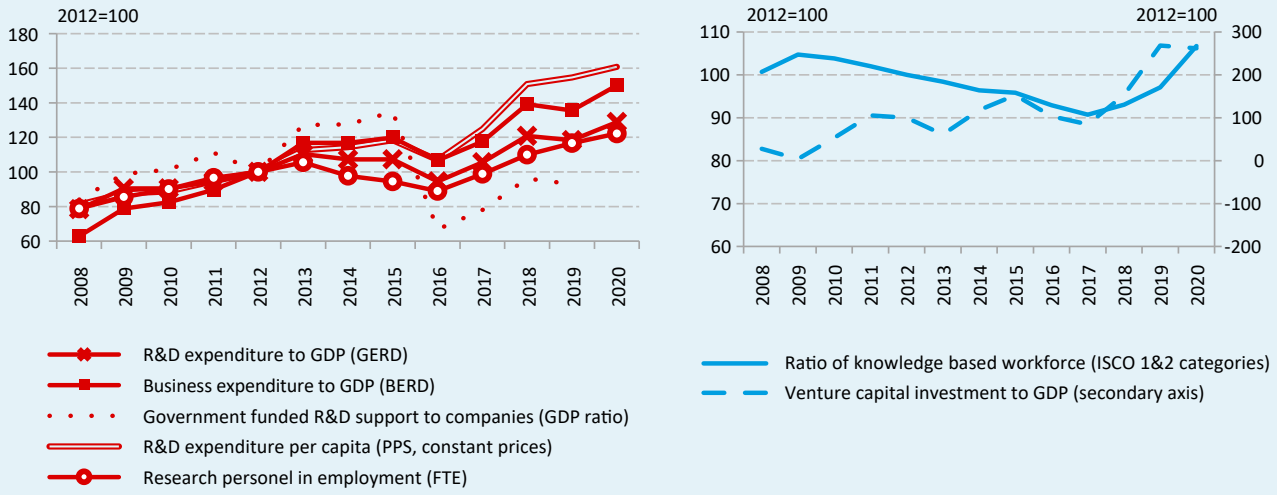
6 According to the European Commission's site presenting the aid disbursement data, there were very few new commitments for R&D expenditures after 2018. This is due to the fact that the funding needs of approved projects already reached the financial allocation in 2018. New project applications were accepted only in 2021. (source: cohesiondata.ec.europe.eu)

7 The ratio of micro-, small- and medium-sized enterprises in Hungary's R&D expenditure is 39.1 percent (2020), which is almost 3 percentage points lower than in 2018 (HCSO, 2020).

Expenditure or input variables include ratios that examine the change in human and material resources necessary for innovation, while output variables are indicators that already show the results of the research process. Chart 2-3 contains the time series of the expenditure group, while the time series of the output indicator group are included in Chart 2-5. To make it easier to follow, time series related to R&D processes are marked in red, while those related to innovation are marked in blue.[8]

On the expenditure side, the rising trend of both the R&D and market innovation indices continued in 2019 and 2020. Based on Chart 2-3, most of the input indicators registered material growth in the period after 2004, and growth in expenditures was particularly large from 2016. In 2020, the coronavirus pandemic caused no decrease in expenditures, while the stabilisation of research expenditures at a high level was not mainly attributable to the additional orders in the medical and natural sciences (biology) area as a result of the pandemic, but mainly to engineering and IT projects. R&D expenditures in the engineering fields, primarily in the machinery and automotive industry, account for about two-thirds of total R&D expenditure in Hungary.

Chart 2-3: Measures of expenditure determining research and development (red, left pane) and innovation (blue, right pane)



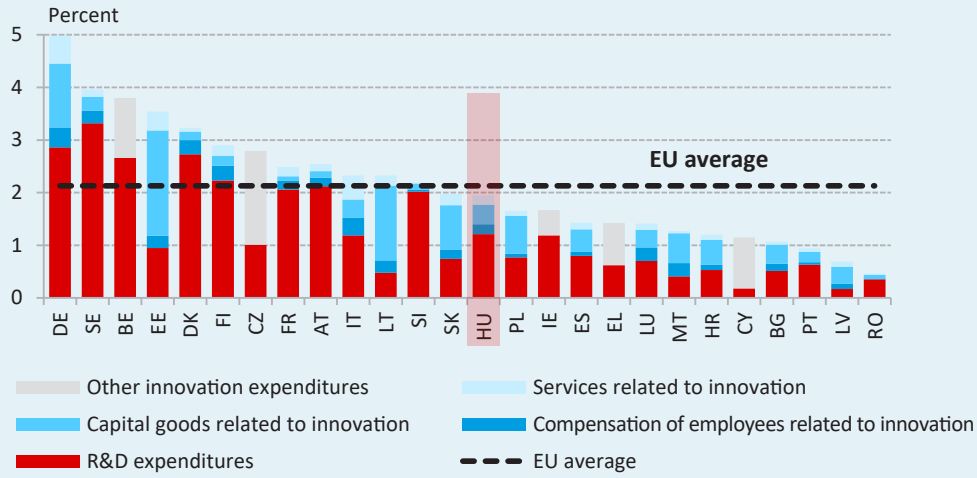
Source: MNB calculation based on HCSO, OECD and Eurostat.

The innovation expenditure indicators (in blue) also show a positive trend in recent years. The ratio of knowledge-intensive jobs declined during the period of extensive labour market growth, but this trend turned in 2017 and the indicator has been rising since then, in 2020 already exceeding the level registered before the financial crisis of 2008/2009. As employment in the national economy also increased substantially, the number of employees in knowledge-intensive jobs has increased significantly compared to the same proportion ten years ago. The coronavirus pandemic somewhat reinforced this trend by usually permitting highly skilled workers to keep their jobs, while less skilled workers were more strongly affected by the moderate labour market effects of the pandemic (mainly in services). Venture capital investments peaked in 2019,[9] and the stagnation in 2020 may have been contributed to by the uncertain economic environment due to the pandemic.

In terms of innovation-related expenditures in a broader sense, Hungary sits in the mid-range of Europe (Chart 2-4). While R&D expenditures are relatively easy to track for statistical offices, innovation expenditures, which is considered a softer category, are typically not shown in the data series of statistical offices. In response to this shortcoming, the 2018 Community Innovation Survey (CIS)[10] started to measure the costs associated with market innovation. The indicator shows that the innovation expenditure of Hungarian companies reached 2 percent of GDP, slightly falling short of the EU average. A lag can be identified particularly in capital goods linked to innovation. The latter mainly covers intangible assets, but also includes all expenditures that have a direct impact on innovation results.

8 The methodological differentiation of R&D and innovation is included in the chapter on Innovation in the 2020 Productivity Report.
9 The rise in venture capital investments observed until 2019 may have been attributable to the fact that state-owned Hiventures Zrt. is actively increasing its portfolio, and according to a regional start-up site, Hiventures was the most active investor in Eastern Europe in 2020 (Vestbee, 2022).
10 Community Innovation Survey - Access to microdata - Eurostat (europa.eu)

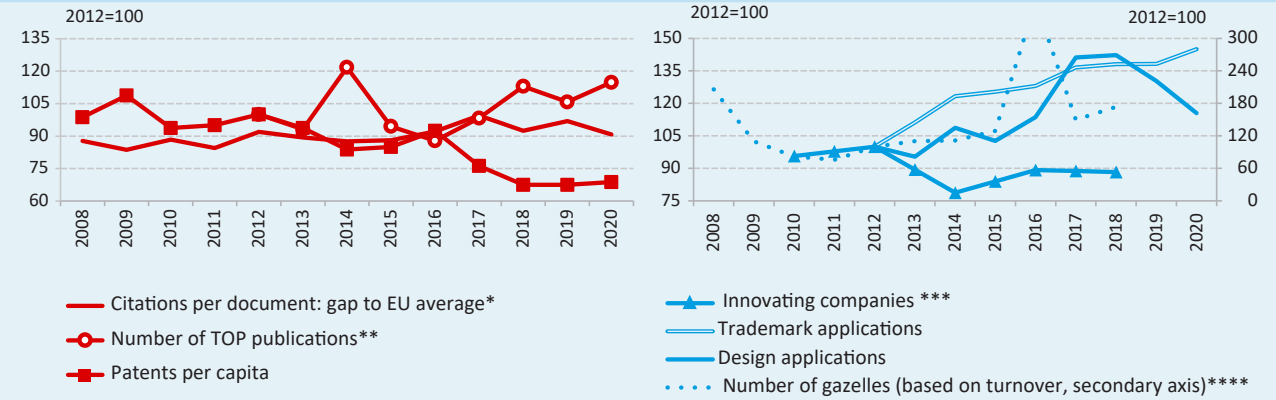
Chart 2-4: Corporate innovation expenditures as a percentage of GDP (2018)



Note: Corporate R&D expenditure is calculated on the basis of the CIS survey, which may differ from the official BERD (Business Expenditure on Research and Development) data.
Source: MNB calculations based on Eurostat (CIS).

In terms of output indices, results generally stagnated with a slight improvement (Chart 2-5). In terms of R&D figures (in red), only the number of top publications showed a significant increase, but it should be noted that despite the increase, there was still a significant lag in Hungary compared to the EU average: the Hungarian ratio is 5.5 percent, slightly higher than the V3 average of 5 percent, but below the EU average of 8.6 percent (EIS, 2020). Among the innovation output indices (in blue), a further increase was registered in the number of trademark applications, with both Hungarian and foreign applications contributing to this increase, based on national patent applications. Among the national patent applications in 2020, most new trademark applications were filed by pharmaceutical companies (Richter and EGIS). The companies with the highest number of EU trademarks are URSA Salgótarján (glass industry) and Richter. As regards the fall in design patents observed over several years, this includes both domestic and foreign design patents. The largest domestic applicant was Julius K9[11] with 233 community designs (Hungarian Intellectual Property Office, 2020). There has not been a recent survey on the ratio of innovating companies, and neither has any new data on gazelle enterprises been published since our 2020 publication.

Chart 2-5: Output measures determining research and development (red) and innovation (blue)



*Note: * Hungarian to EU average by the issuance year of the document. EU average is weighted by the number of documents. ** Publications in the top 10% of all publications in the domain (source: EC, EIS indicators). ***methodological break in 2016-2018. **** for the period between 2008 and 2012 MNB estimates based on HCSO data.*
Source: ScimagoJr, Scopus data.

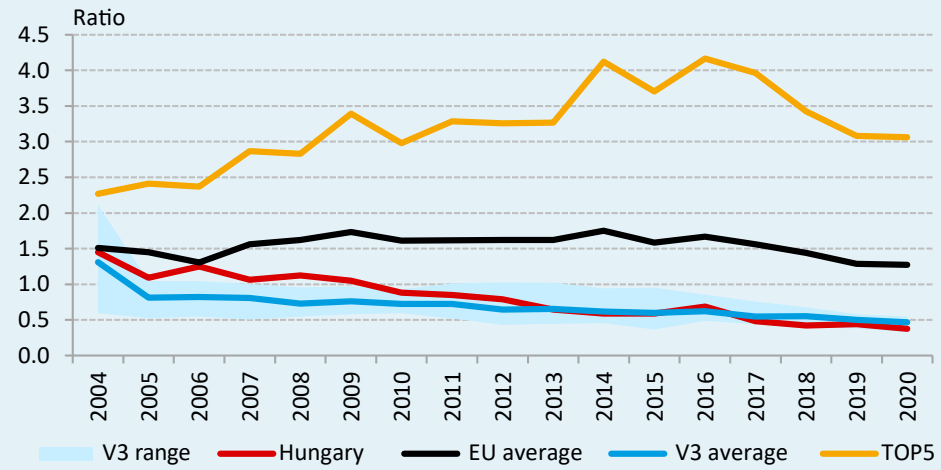
Overall, the upward dynamics of Hungarian input indicators, dating back 4-5 years, has so far had a positive impact on only a few output indicators. There is also room for further improvement in the citation indicators of works published in 2020, in the number of design patent registrations and in patent protection.

11 The main activity of the company is scientific and technical research and development.

2.2 Innovation efficiency in an international comparison

The declining efficiency of research and development expenditure is mainly linked to the fall in the number of patents (Chart 2-6)**.** The declining activity regarding patents observed across the world also exists in the region, and thus the phenomenon is present in Hungary as well. Although more international patents were registered in 2019 as a percentage of the population than a year earlier, R&D expenditures also showed a modest increase, and thus the indicator obtained as the quotient of the two values improved only slightly.

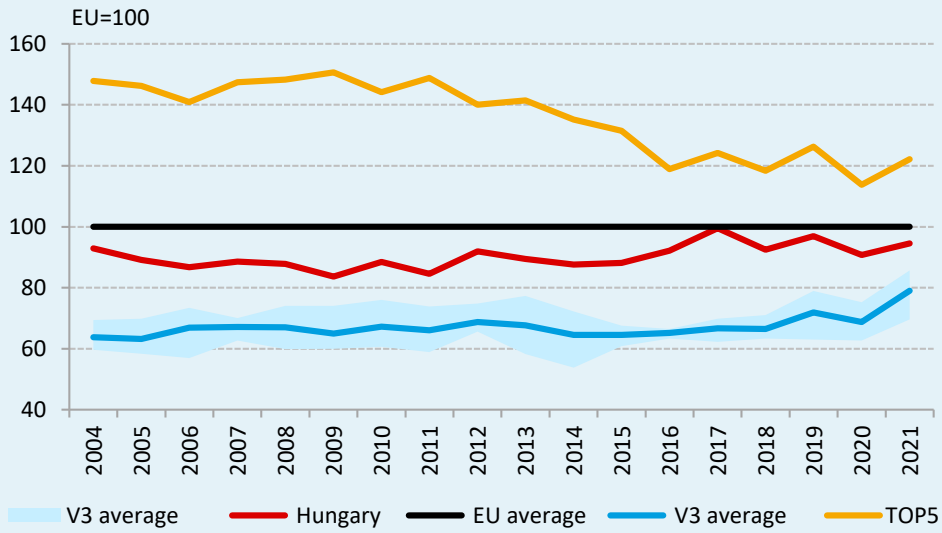
Chart 2-6: Number of patents attributable to research and development expenditures



Note: The TOP5 countries were defined based on the data available for last year and were plotted as a simple arithmetic average of the values for the same countries retrospectively. The TOP5 countries in order: Luxembourg, Malta, Finland, Netherlands, Sweden.
Source: MNB calculations based on Eurostat and WIPO.

The scientific performance of Hungarian journals exceeded the average of the other Visegrád countries in 2021 as well, while the Hungarian performance is close to the EU average, as in recent years, but still lags behind the TOP5 EU countries (Chart 2-7)**.** As in our 2020 publication, the citations per paper for each country was compared to the EU average. In 2021, the performance of Hungarian journals is almost the same as the EU average. However, there was a decline in several areas in 2021. Hungary ranked 19th in the EU in terms of the number of journals published in the field of medical sciences, which has the highest publication volume, and this is a decrease compared to the 17th place achieved in 2020. It should be also noted that despite the fact that technical sciences account for the largest share of Hungarian R&D expenditure, Hungary ranks only 23rd in engineering. However, good results were achieved in dentistry (1st place), earth sciences (7th place) and physics (10th place).

Chart 2-7: Average citation index per document by year of publication

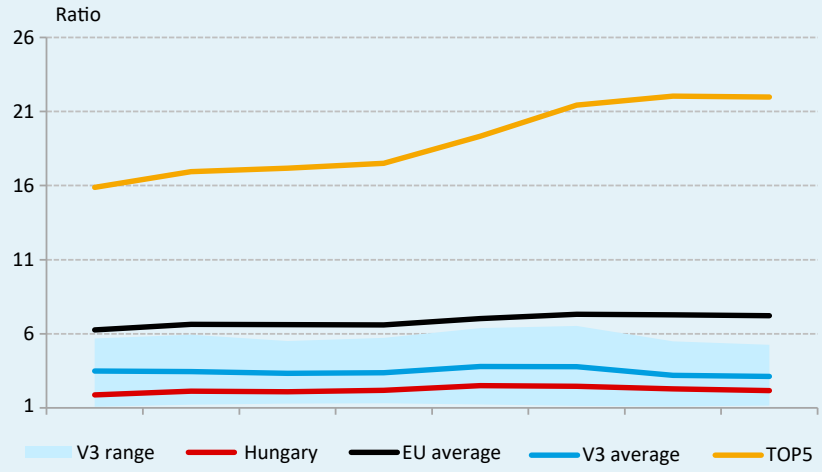


Note: The TOP5 countries were determined based on the data available for last year, and were plotted as a simple arithmetic average of the values for the same countries backwards in time. The TOP5 countries in order: Denmark, Netherlands, Belgium, Ireland, Sweden.
Source: MNB calculations based on ScimagoJr, Scopus.

Hungary lags behind both the EU and regional averages when looking at the number of trademarks and designs per knowledge-intensive employee (Chart 2-8). This indicator is able to capture innovation performance in a broader sense, together with the patent family (patent, trademark, design patent), and these two types are worth looking at because they typically affect more enterprises than the patent law.[12] In 2020, the number of people employed in knowledge-intensive jobs in Hungary increased by 80,000 compared to 2019, which is more favourable than in Poland, the population of which is four times higher than that of Hungary. All sectors of the national economy contributed to the increase, with the largest growth registered in professional services and manufacturing. The impact of this may appear later in innovation outputs.

In an international comparison, Hungary's innovation efficiency did not improve significantly in the past 1-2 years. Despite a trend of increasing expenditures, no clear improvement can be identified in the output indicators. In an international comparison, data related to science citation remain favourable; nevertheless, in the light of the expenditure it should be possible to achieve further improvement in the registration of intellectual property rights.

Chart 2-8: Trademark and design patents per knowledge-intensive employees



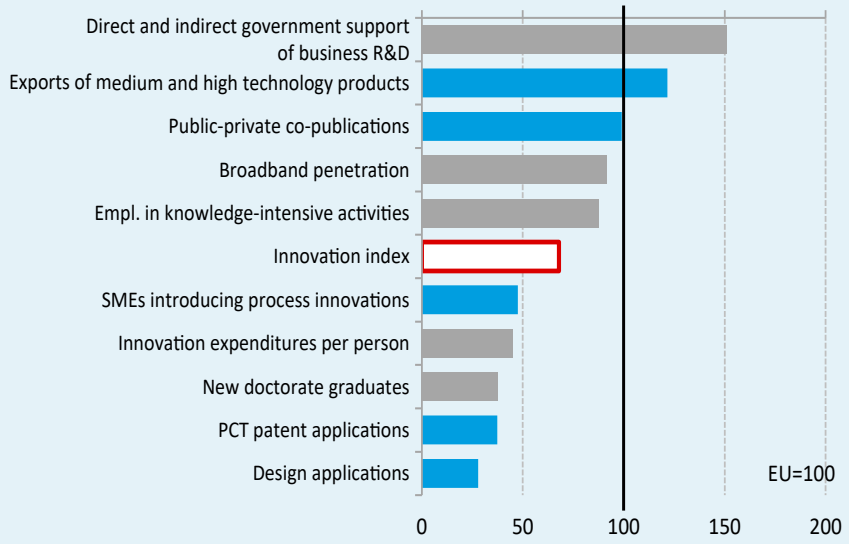
Note: Patents were compiled based on the EIS scale, while knowledge-intensive employees are expressed as a percentage of all employees. The TOP5 countries were defined based on the data available for last year, and were plotted as a simple arithmetic average of the values for the same countries retrospectively. The TOP5 countries in order: Estonia, Slovenia, Latvia, Lithuania, Denmark.
Source: MNB based on Eurostat and European Commission (EIS).

12 This year, we have changed the calculation of the indicator due to the change in the underlying data. Accordingly, Chart 2-7 cannot be compared with that in the 2020 publication.

2.3 Factors underlying Hungary's innovation performance

Innovation activity by SMEs in Hungary remains moderate, but there has been some improvement in the willingness to cooperate. As in our 2020 publication, we have highlighted 5-5 indicators from the latest European Innovation Scoreboard (EIS) ranking, in which Hungary performed best and worst. On the input (expenditure) side, Hungary performs poorly in terms of overall innovation expenditure (measured at purchasing power parity) and the number of new doctoral students, while on the output side, the number of patents and design patent protections is below the EU average, and process innovation also continues to be very little, especially among SMEs (Chart 2-9).

Chart 2-9: Measures of the European Innovation Scoreboard showing the lowest and best results in Hungary (2021)



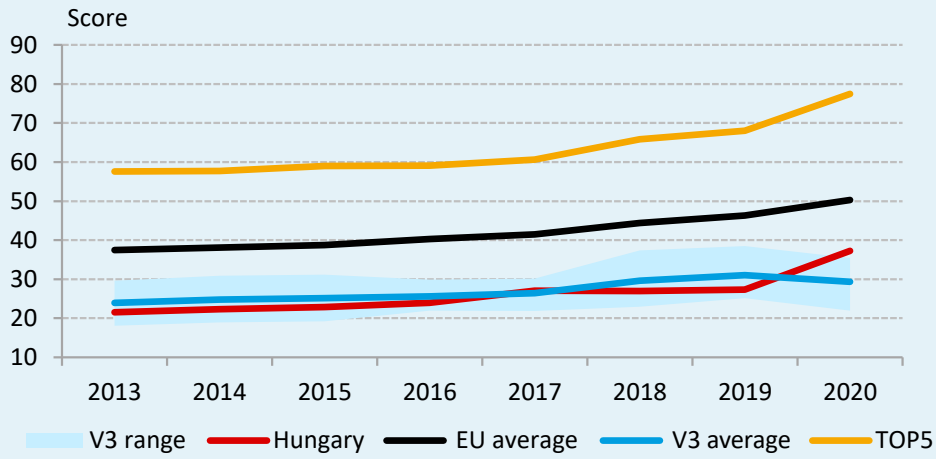
Note: Grey indicates the expenditure, while blue the output indicators. We included indicators that are directly relevant for innovation. Accordingly, we omitted a number of indicators related to the general condition of the economy.
Source: MNB calculations based on European Commission – EIS (2021).

In a European comparison, the Hungarian innovation system continues to perform best in the dimension of expenditure (Chart 2-9). As a percentage of GDP, the contribution of the Hungarian state to financing corporate R&D expenditures is above the EU average. On the one hand, this is a positive feature of the Hungarian innovation system, as the outcome of corporate R&D projects is accompanied by significant uncertainty with regard to return on investment, and thus a strong commitment by the state may encourage companies to take more risks. On the other hand, it is questionable whether sustained state involvement can stimulate the initiation and use of innovation activities in the longer term or, to the contrary, it would create a dependency relationship. Looking at the strengths of Hungary, it is also worth mentioning the high ratio of high-tech exports, primarily due to the machinery industry. However, in the machinery industry, which is organised in global chains, the work phases carried out in Hungary are typically those that do not require a highly qualified workforce. The number of public and private joint publications is also high in Hungary, with a steady improvement since 2013. This improvement may have been attributable to the support for the creation of higher education and industrial cooperation centres during the 2014–2020 EU programme cycle and the active development of technology parks in several parts of the country. High-speed corporate internet coverage (above 100 mbps) has been close to the EU average for several years, but no progress has been achieved in this field (Hungary is currently ranked 15th in the EU). The ratio of people employed in knowledge-intensive services is the second highest among the Visegrád countries after the Czech Republic but shows a trend of stagnation.

Knowledge flow has improved significantly in Hungary (Chart 2-10). The sudden improvement in the composite index in 2020 was attributable to innovation cooperation between SMEs. The indicator measures cooperation between SMEs and public research institutions in the 3 years preceding the survey (2018). Despite a significant improvement in this indicator, Hungary still lags significantly behind the EU average (currently ranked 19th). Another aspect that explains the increase in the composite indicator is the improvement in the flow between knowledge-intensive jobs. This component is included

in the EIS measurement because it has been observed that the flow of labour force between science and technology firms improves innovation. Despite the improvement seen in the composite indicator, Hungary ranks only 19th in the EU, but the other countries of the Visegrád region also perform equally moderately.

Chart 2-10: Composite indicator measuring innovation cooperation



Note: The indicator includes the number of innovative SMEs cooperating with each other, the number of public and private joint publications and the mobility of R&D personnel between jobs. The EU average is a weighted average of the results from Member States, which may therefore differ from the figures in EIS. The TOP5 countries were defined based on the data available for last year and were plotted as a simple arithmetic average of the values for the same countries retrospectively. The TOP5 countries in order: Cyprus, Estonia, Finland, Denmark, Belgium.
Source: MNB based on European Commission – EIS (2021).

Looking ahead, it is a positive development that the participation of Hungarian-owned companies in R&D has improved. Hungarian-owned companies tend to seek domestic innovation cooperation more than their foreign-owned peers, and the business benefits from their patents also tend to be exploited in Hungary. In 2018, Hungarian-owned companies accounted for 40 percent of national R&D expenditure, which rose to just over 42 percent in 2020. Nominal expenditures of foreign-owned enterprises increased between 2018 and 2020, but their ratio fell from 58 percent in 2018 to 54 percent (the remaining part is the expenditure of public and non-profit enterprises). As a result, the duality of the Hungarian R&D system has eased, albeit only to a small extent, but which may also improve the utilisation of innovation in the future.

In 2021, the Hungarian R&D strategy for the period of 2021–2030 was adopted, and it proposes solutions in all the areas that we have also listed as ones that lag behind (Ministry of Innovation and Technology – National Research, Development and Innovation Office (NKFIH), 2021). On the one hand, the strategy foresees an even greater role for the public sector, and aims to increase the utilisation of innovation. In its support policy, it has set the goal of creating self-sustaining, market-based operating models with greater state support.

In the new world of digitalisation covering an increasing part of daily life and characterised by continuously changing requirements, the protection of intellectual property rights is a key area of innovation policy. The R&D Strategy for 2021-2030, adopted in 2021, sees the further stimulation of patent activities in universities and public research institutes as one way to increase patent registrations.[13] Another possible way to increase patent output is to create more efficient dispute resolution mechanisms (based on Ernst & Young 2020) or to reduce the cost of maintaining patents (MNB, 2019).

In summary, the expenditure side of Hungary's innovation performance has shown an upward trend for several years, while the output side achieved only moderate improvement. In order to improve the situation in Hungary, it is justified to maintain a high level of state aid, given that R&D subsidies are able to increase productivity to a larger degree than non-R&D subsidies (e.g. aid for asset purchases) (Ernst & Young, 2020). However, state subsidies alone do not guarantee

13 The amendment of Act CIV of 2018, which transfers the intellectual property rights to research institutions and provides a share in the exploiting companies, can be considered a significant step towards the utilisation of universities' patent rights (Ministry of Innovation and Technology – National Research, Development and Innovation Office (NKFIH), 2021).

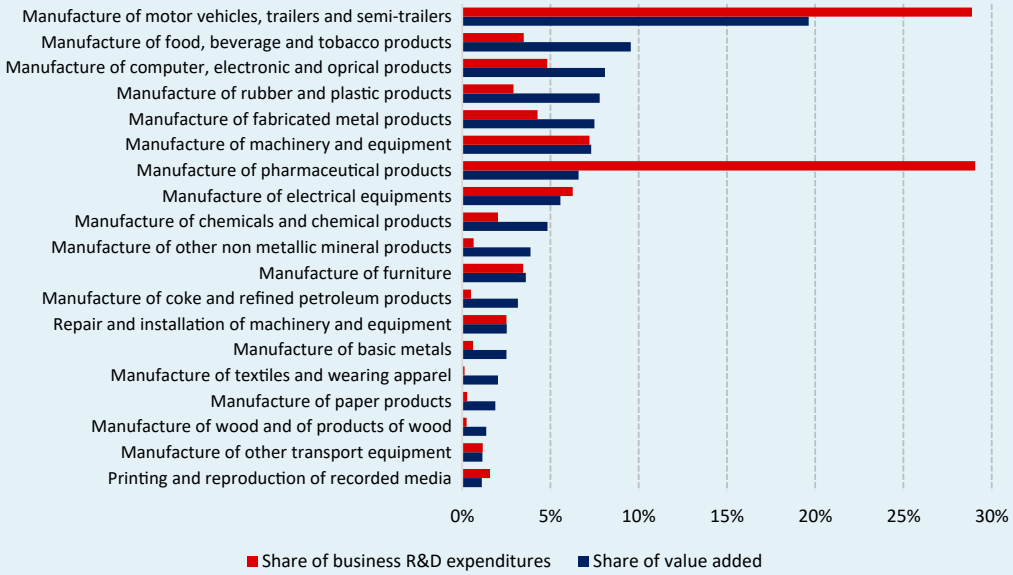
the long-term sustainability of a rise in productivity. Such a goal can only be achieved by building an ecosystem, which is also outlined in the R&D strategy adopted last year. Furthermore, as regards the past 1-2 years, it was a positive development that innovation system actors showed an increased willingness to cooperate, and the R&D expenditures of Hungarian-owned enterprises grew faster than those of foreign-owned companies.

Box 2-1: Research and development expenditure and sectoral productivity in manufacturing

The largest part of corporate R&D expenditure is financed with the aim to ensure that companies can gain a market advantage or consolidate their position by increasing their productivity. When examining the time series of manufacturing sectors, we seek to find out how the change in R&D expenditure is related to changes in labour productivity in the sector.

In Hungary's manufacturing sectors, both production and business-oriented research and development expenditure are highly concentrated within a narrow range of sectors (Chart 2-11). 53 percent of manufacturing value added was generated by the five sectors creating the highest value added, while the five sectors with the highest R&D spending accounted for 76 percent of total manufacturing expenditure in 2019. The automotive and pharmaceutical sectors excel among them, accounting for nearly 60 percent of the R&D expenditure.

Chart 2-11: Sectoral value added and R&D expenditure in domestic manufacturing



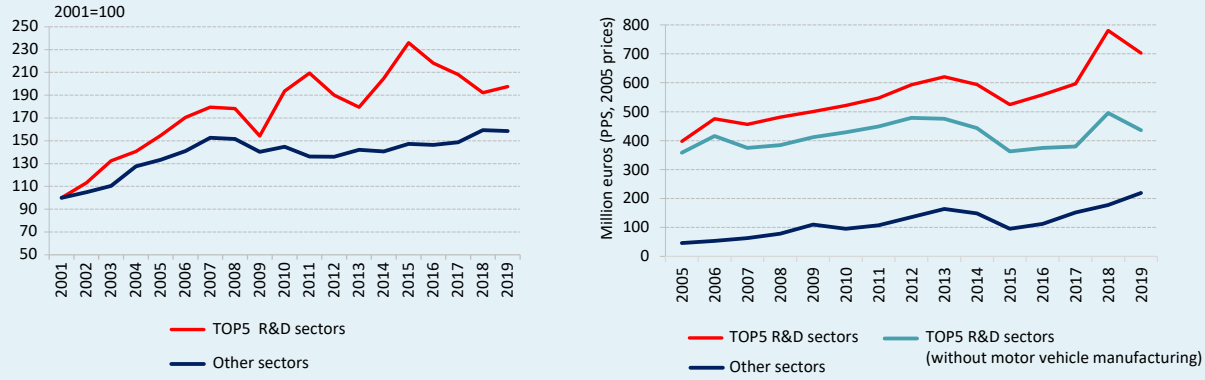
Note: Based on 2019 data.
Source: Eurostat.

Another important feature of the domestic manufacturing sector is that there is significant foreign ownership in key sectors, which partly explains this sectoral concentration. The large inflow of foreign direct investment (FDI) in past decades has created an increasing number of development centres, in addition to productive capacity. Highly skilled Hungarian workers are competitive in an international comparison, and the relative wage cost advantage may encourage international companies to move part of their research and development activities to Hungary.

The labour productivity of the five sectors with the highest R&D expenditure has almost doubled over the two decades under review, while the labour productivity of the other sectors has increased by only around 60 percent. However, we also see large fluctuations in the processes (Chart 2-12). In these sectors, external market developments play a significant role in the success of companies, and thus economic downturns have a material impact on productivity. Productivity in other manufacturing sectors has stagnated over the same period compared to the level before the financial crisis in 2007, and it rose only during the past two years.

R&D expenditure follows a positive trend. The sectors with the TOP5 R&D expenditure show a steady increase in the volume of expenditure at constant prices, which doubled between 2005 and 2018. However, this is mainly attributable to the dynamic growth in R&D expenditure of the automotive sector, which accounts for two-thirds of the increase. R&D expenditure in the four other sectors increased only to a lesser degree but remained high over the period as a whole. While R&D expenditure in other sectors is overall significantly lower than in the TOP5 sectors, it increased significantly after 2015, with the expenditure in other manufacturing sectors more than doubling. EU funds also play an important role in the manufacturing sector's R&D expenditure, and the temporary slowdown after 2013 may be explained by a decline in these funds.

Chart 2-12: Sectoral labour productivity (left pane) and sectoral R&D expenditure (right pane) in domestic manufacturing



Note: TOP5 R&D sectors: Pharmaceutical, Computers, Manufacture of electronic products, Manufacture of electrical equipment, Manufacture of machinery and equipment and Automotive industry.
Source: Eurostat.

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3 Digitalisation efficiency

IN HUNGARY THE COVERAGE OF THE DIGITAL INFRASTRUCTURE IS HIGH, AND EXCEEDS THE EU AVERAGE, HOWEVER THE UTILIZATION IS LOW IN AN INTERNATIONAL COMPARISON. AMONGST ALL FOUR PRODUCTIVITY PILLARS, IT IS IN DIGITALISATION EFFICIENCY THAT HUNGARY LAGS THE MOST BEHIND THE V3-AVERAGE.

Hungary's digitalisation efficiency is 63 percent on average compared to the EU average, and 46 percent compared to the TOP5 EU countries.

Introduction

Digitalisation and the technological progress it induces represent new opportunities, but also requires adjustment by all economic agents. By harnessing the achievements of the fourth industrial revolution, a competitive advantage can be gained that may result in a long-term improvement in productivity, and thus boost welfare in a sustainable manner[14].

The high level of digitalisation was a major competitive advantage during the pandemic and in many cases significant progress was achieved during the social emergency caused by the pandemic. Lifestyle changes resulting from lockdowns created new challenges for the corporate and government sectors as well as for households, and digitalisation played a key role in addressing them. In this situation, companies with an advanced digital infrastructure enjoyed a competitive advantage, and citizens with high digital skills adapted more easily. The pandemic also gave an impetus for significant progress in areas such as e-invoicing and cloud-based services. Nevertheless, in many areas[15] the expected digital progress still failed to take place. We examine these areas in depth at a later stage in this chapter.

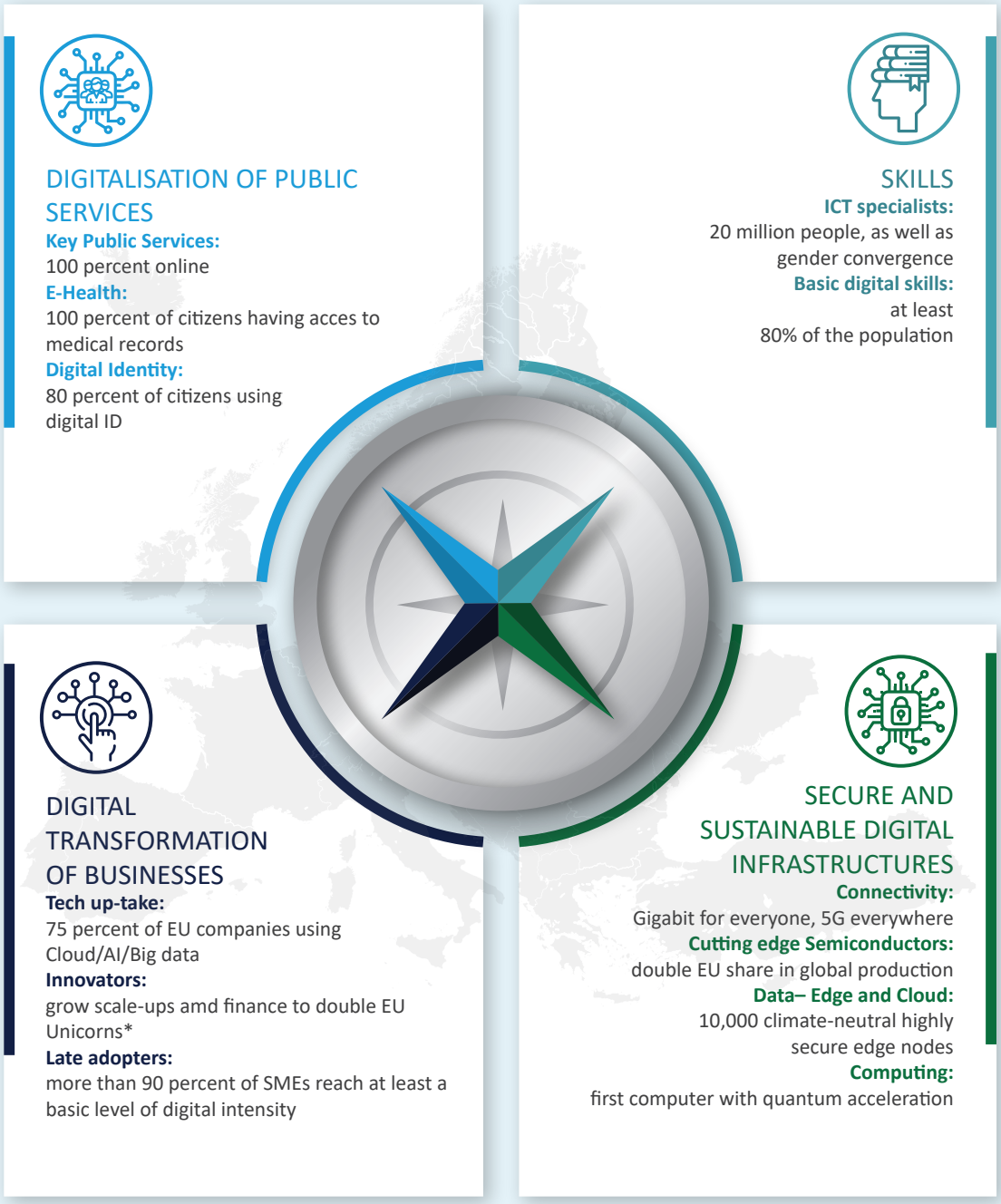
In Hungary, the development of the digital infrastructure lies in the upper mid-range compared to other EU countries, however there is room for improvement in the utilisation thereof when it comes to several areas. In Hungary, 56 percent of households have an internet connection with a speed of over 100mbps, compared to the EU average of 34 percent. **Perhaps even more impressively, 13 percent of households in Hungary use gigabit internet[16], granting Hungary the first spot in the EU ranking.** However, an advanced digital infrastructure alone is not enough for harnessing the productivity gains of digitalisation. In many areas, the digital infrastructure in Hungary is underutilised, partly due to the lack of digital skills of the population. We have identified a number of opportunities for improvement which are explained in more detail in the following chapter.

3.1 Digital Agenda for Europe

The European Commission launched two main policy initiatives in 2021 to achieve the EU's digitalisation objectives: the Recovery and Resilience Facility[17] and the Digital Compass. The latter is built around four pillars: digital skills, digitalisation of public services, secure and sustainable digital structures and digital transformation of businesses (Chart 3-1). Within the pillars, the Commission formulated a number of targets to be achieved by 2030, including improving the digital literacy of the population, increasing the EU's share of semiconductor production, supporting growing innovative businesses, and making key public services available 100 percent online. In 2021, the Digital Economy and Society Index (DESI), developed to monitor digital development, was also revised to better reflect the four cornerstones of the compass. To this end, the Commission defined four dimensions instead of five, which are now built around the four main areas of the Digital Compass. A total of 11 2021 DESI indicators measure the targets set out in the Digital Compass. Looking ahead, DESI will be aligned even more closely with the Digital Compass to ensure that all targets are discussed in the reports.

14 Małkowska et. al. (2021)
15 Among others, in the area of the efficiency of ICT professionals and the digital state.
16 Internet connection with speed of 1000 mbps or higher
17 The Recovery and Resilience Facility provides a total of EUR 724 billion in loans and non-refundable grants to EU Member States to support reforms and investments. The objective of the programme is to mitigate the economic and social impact of the coronavirus pandemic, and to increase the resilience and sustainability of European economies.

Chart 3-1: 2021 Digital Compass of the European Union (targets to be achieved by 2030)



*Note: *Unicorn – start-up with at least USD 1 billion in market valuation.*
Source: European Commission.

The updated DESI composite index is compiled by weighting 4 sub-areas, which can be categorised as follows for the purposes of our analysis (Chart 3-2):

- on the input side of our productivity indicators: network infrastructure (connectivity);
- on the output side of our productivity indicators: digital human capital, integration of digital technologies and digital public services.

These indices comprise of a combination of additional sub-indices; for example, the connectivity index contains sub-indices related to the usage and penetration of broadband internet, mobile internet and internet prices. These indices serve as a solid basis for measuring the digital efficiency of households, enterprises and the state.

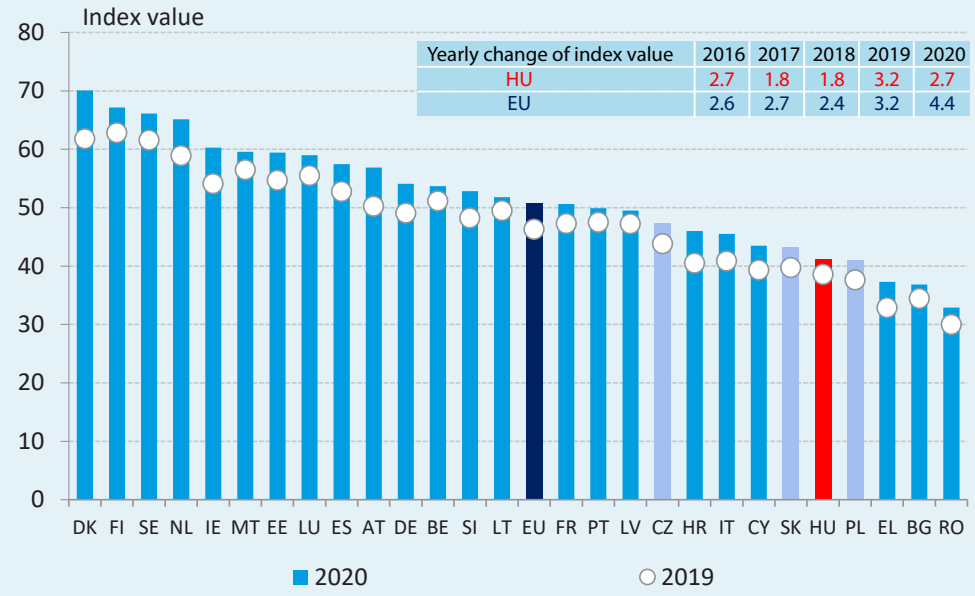
Chart 3-2: 4 sub-areas of the Digital Economy and Society Index (DESI)

Note: In our analysis, the network infrastructure (connectivity) index is on the input side of the indicators, and the following three indices (digital skills / human capital, integration of digital technologies and digital public services) are on the output side.
Source: DESI.

3.2 Digitalisation during the pandemic

In 2020, Hungary's overall performance in the European Union's digitalisation index scored 41.2 points, which placed it 23rd amongst the EU countries. Furthermore, in 2020 Hungary saw no improvement in its ranking (Chart 3-3). Hungary preceded Poland, Greece, Bulgaria and Romania, but the rise in Hungary's index value did not result in a change of ranking (38.5 points in 2019). Thus, Hungary performed well compared to previous years, but maintained its lag when compared internationally.

Chart 3-3: Digital performance index of the European Union



Yearly change of index value	2016	2017	2018	2019	2020
HU	2.7	1.8	1.8	3.2	2.7
EU	2.6	2.7	2.4	3.2	4.4

Source: Eurostat.

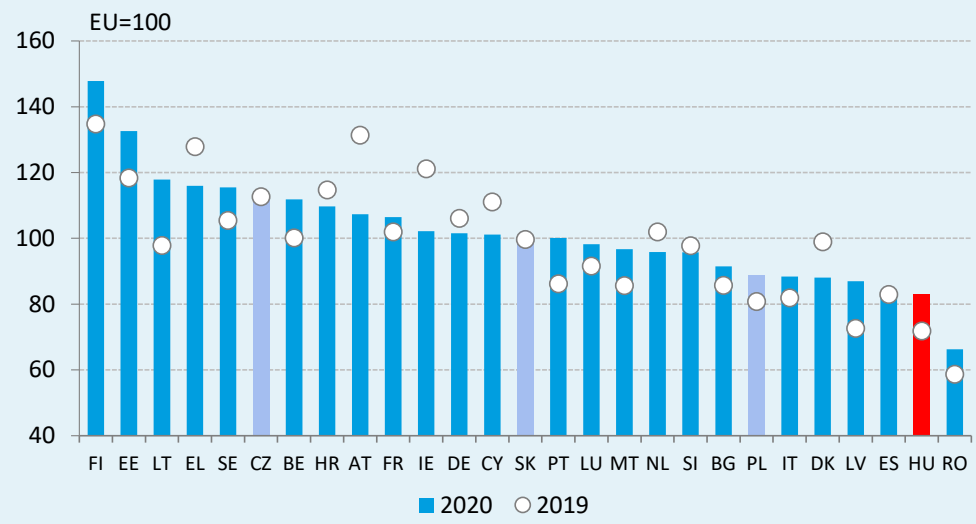
Between 2019 and 2020, Hungary's digital performance improved by 2.7 points, while the EU as a whole registered an improvement of almost 4.4 points on average. Between 2018 and 2019, Hungary and the EU both improved by 3.2 points. While the introduction of restrictions was expected to lead to the penetration of digital technologies, in reality this happened only partially. In the 2020 index, the digitalisation of the Hungarian economy and society stagnated relative to EU countries (Chart 3-3). While Hungary's digitalisation growth rate was in line with the EU average in 2019, it fell almost 2 points below the EU average in 2020.

3.3 Households digitisation efficiency

The efficient use of the domestic population's skills in 2020 was 83 percent relative to the EU average and 66 percent compared to the average of the TOP5 EU countries (Finland, Estonia, Lithuania, Greece, Sweden). The indicator is given by the quotient of the digital human capital and network quality indices. The efficiency of the Hungarian population's digital skills improved compared to the previous year, however Hungary still ranks 26th in the EU (Chart 3-4). The improvement is essentially attributable to a decline in the EU average. Between 2019 and 2020, Hungary registered an improvement of 11 percentage points compared to the EU average. The ratio decreased by the largest degree, 24 percentage points, in Austria. T**he change is attributable to a strong improvement in network quality, which was not matched by the digital development of human capital. In Austria, network quality improved by 28 percentage points, while in Hungary it deteriorated by 13 percentage points compared to the EU average.**

In 2020, Hungary had the 12th best network quality in the EU. A year before that however, it was ranked 8th, which shows that although it is still in the upper mid-range, its relative position has weakened. That being said, solid infrastructure conditions are not utilised adequately by Hungarian households. One reason for this is that the information search and communication habits of average internet users, as well as their problem solving capabilities in the digital world, are below average.

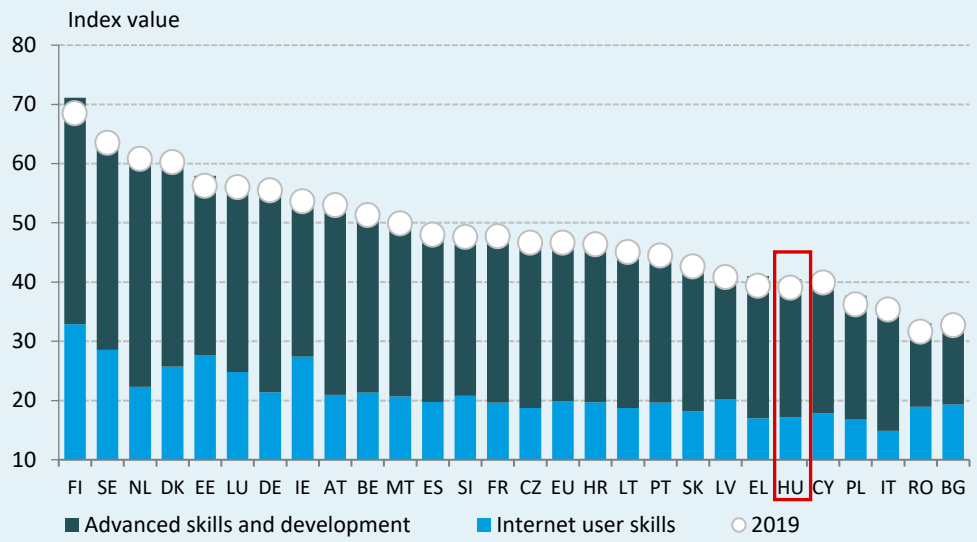
Chart 3-4: Households digital skills efficiency



Note: The quotient of digital human capital and the network quality (DESI indices).
Source: MNB calculation based on Eurostat data.

When it comes to the digital human capital index, i.e. the denominator of population's digital efficiency, Hungary ranked 22nd among EU countries in 2020 with an index value of 40.5 (EU average 47.1) (Chart 3-5). One of the sub-pillars of this is the population's internet skills, which include basic and intermediate digital literacy and at least basic software management skills. In this sub-pillar, Hungary ranks 22nd. The other pillar is advanced digital skills and development, which measures the penetration of ICT skills in which Hungary takes 24th place. Nevertheless, it is encouraging that between 2019 and 2020, Hungary's digital human capital improved by 1.4 points, which exceeds the EU average of 0.4 points over the same period.

Chart 3-5: Digital human capital performance in EU countries 2019 and 2020

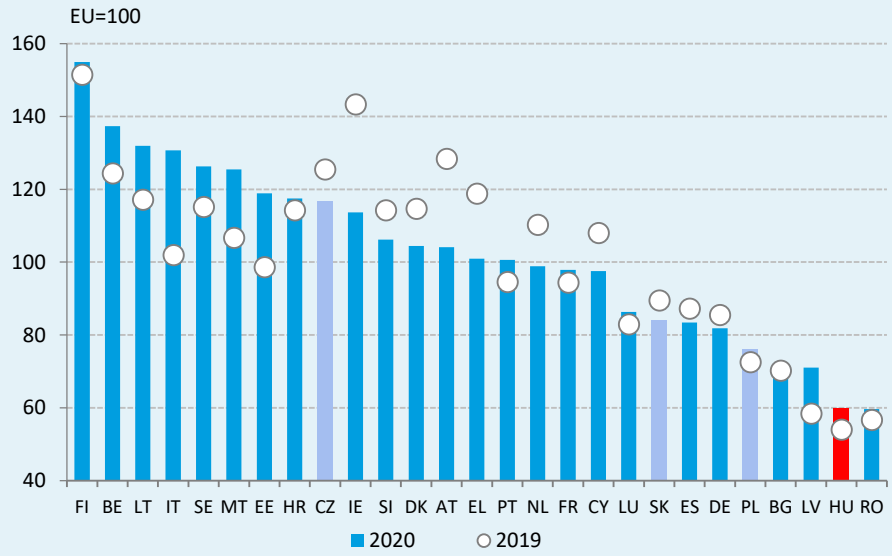


Source: Eurostat.

3.4 Digitalisation productivity of enterprises

In 2020, the corporate efficiency of digital technologies in Hungary was 60 percent of the EU average and 44 percent of the TOP5 EU countries (Chart 3-6). This indicator is obtained as the quotient of corporate digital technology usage and network quality indices. The countries with the highest efficiency include Finland, Belgium, Lithuania, Italy and Sweden. In 2020, Hungary ranked 26th, one place higher than the previous year, however no significant change was observed in the level of digital infrastructure utilisation by enterprises. Meanwhile, in several countries (such as Ireland and Austria), utilisation declined, largely due to the sudden improvement in digital infrastructure caused by the pandemic. The exceptions are Italy, Estonia and Malta. In these cases, not only did network quality see improvement but also corporate digital integration was able to keep pace thereby significantly increasing the utilisation of the digital infrastructure by enterprises.

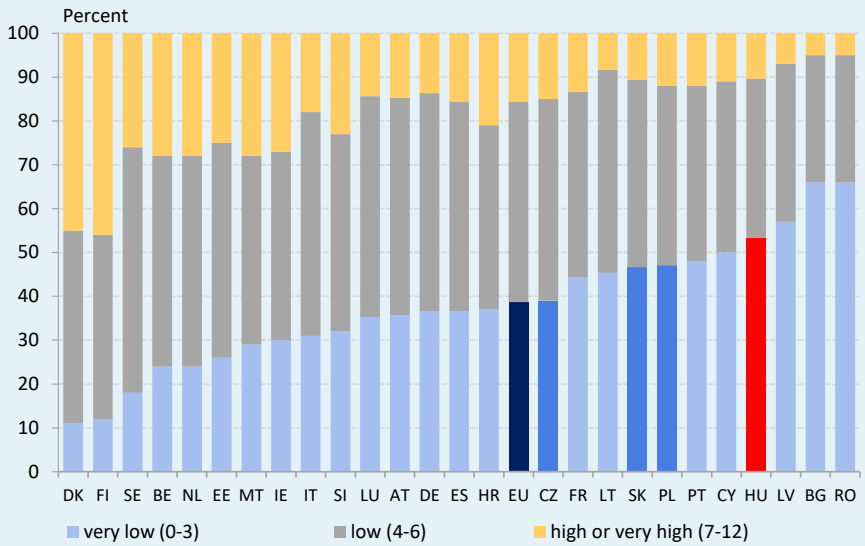
Chart 3-6: Utilisation rate of digital infrastructure by enterprises



Note: The quotient of the utilisation of digital technology by enterprises and network quality (DESI indices)
Source: MNB calculation based on Eurostat data.

According to the enterprise sub-index of the European Union's Digitalisation Index, 53 percent of Hungarian enterprises only possessed basic technologies in 2020 (Chart 3-7)**.** Based on the enterprise digitization sub-index, domestic companies only invest in digital technologies to a small extent. The figure of 53 percent exceeds the EU average of 39 percent (Chart 3-7), hence the share of enterprises where technology is underutilized is markedly higher in Hungary. Moreover, only a very low ratio of enterprises – 7 percent – use big data for decision-making, which ranks Hungary 22nd in the EU.

Chart 3-7: Distribution of enterprises based on the digital intensity index (DII) in the European Union (2020)

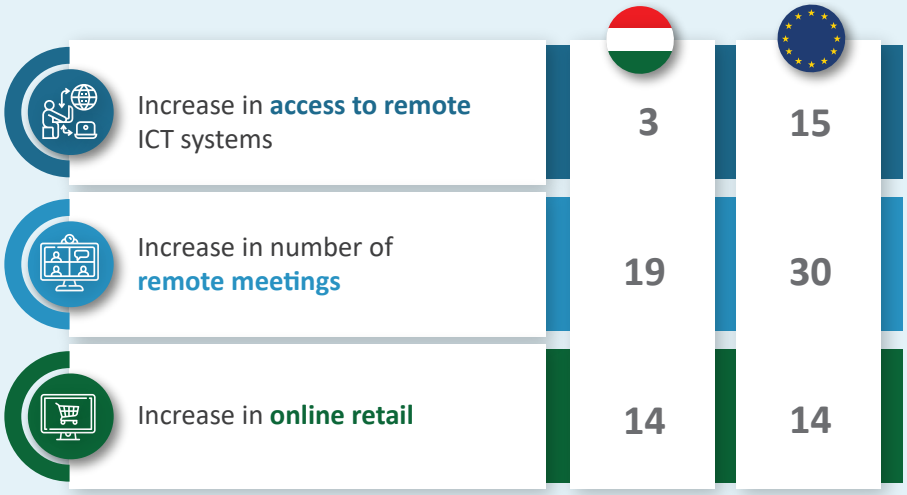


Note: For the measurement of DII, corporations had to select the applied digitalisation methods from a list of 12 items, such as: use of ICT security solutions, internet speed reaches 30 Mbps, use of social media, online commerce, presence of portable devices, value of electronic orders. Use of up to 3 digital technologies represents a very low level, 4-6 technologies is low, and a minimum of 7 technologies is required for high or very high. The figure shows percentages for all companies. Greece is not included in the chart due to lack of data.
Source: Eurostat.

In the area of e-commerce, it is mainly Hungary's small and medium-sized enterprises that perform below average. In terms of the ratio of enterprises having their own website, Hungary falls in the lower mid-range. On the other hand, the participation rate in online marketplaces is decidedly low (3 percent). Online marketplaces reduce information asymmetry at corporations and vis-à-vis consumers, which boosts competition among the actors. This fosters the use of more cost-efficient solutions, which increase productivity.

Compared to other EU countries, Hungarian companies have shown limited willingness to adapt to the lifestyle changes caused by the pandemic in the long term (Chart 3-8). In spring of 2020, only 3 percent of Hungarian companies increased remote access to workplace systems, compared to an EU average of 15 percent. Furthermore, at an EU level, on average 30 percent of companies decided to increase the number of virtual meetings due to the pandemic, while only 19 percent of companies in Hungary opted for this solution, which is the second lowest rate in the EU. Hungary ranked mid-range in terms of the efforts of enterprises to increase online sales. In Hungary, 14 percent of companies made efforts to increase their online sales in 2020, which corresponds to the EU average.

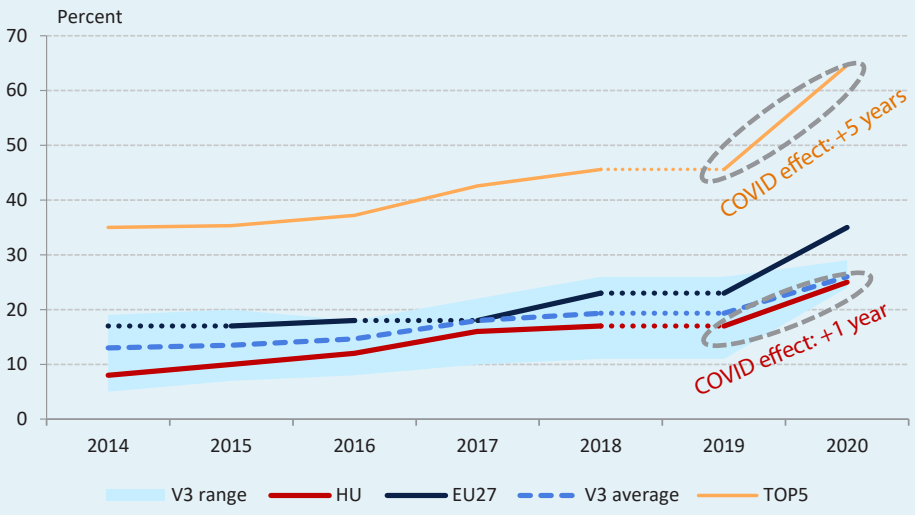
Chart 3-8: Willingness of enterprises to adjust as a result of the pandemic in 2020 (percentage of enterprises)



Source: Eurostat.

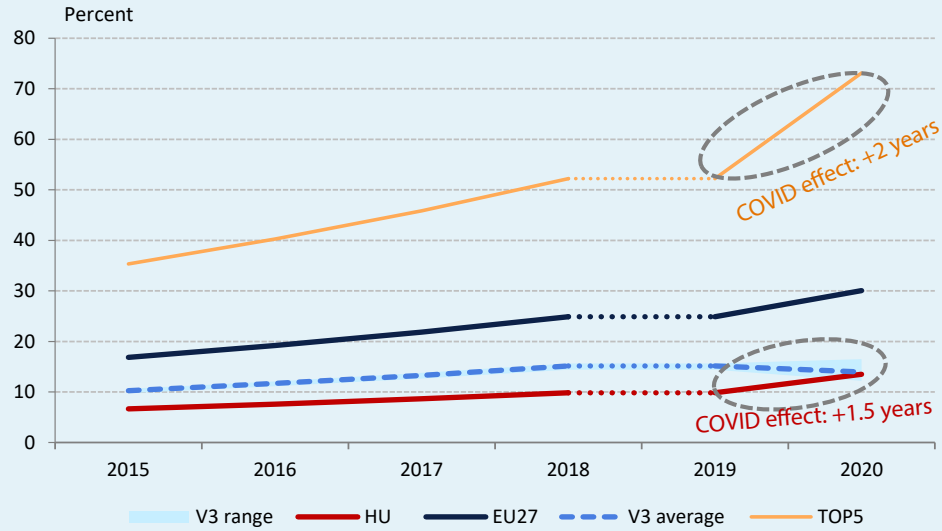
However, in certain areas, the digitalisation of domestic companies has seen an increase. Between 2018 and 2020, the ratio of Hungarian corporations using cloud-based services rose from 17 to 25 percent (Chart 3-9). Here, a leap in digitalisation caused by the coronavirus pandemic can be identified, albeit the degree of which cannot be deemed significant. Considering the 2014–2018 growth rate, the level of cloud technology integration achieved by 2020 would only have been reached one year later by Hungarian companies without the digitalisation adjustment caused by the pandemic. There was also some improvement in the use of e-invoicing. In 2018, only 10 percent of corporations used e-invoicing in Hungary, while this ratio rose to 13 percent in 2020. (Chart 3-10). The favourable impact of the pandemic on digitalisation can be identified here as well; considering the 2015–2018 growth rate, the e-invoicing adoption level achieved by 2020 would only have been reached one-and-a half years later by Hungarian companies without the digitalisation adjustment caused by the pandemic. The TOP5 countries precede Hungary not only in terms of level, but they have also adapted much faster: the adjustment resulting from the pandemic has brought forward the penetration of digitalisation in cloud-based services and e-invoicing by 5 and 2 years, respectively, in the top-ranking countries.

Chart 3-9: The spread of cloud computing services



Note: Data for 2015, 2017 and 2019 were not available for the EU. Data for the Czech Republic were not available for 2016, meaning the V3 average is an estimate for this year. The impact of COVID means the number of years by which the adjustment resulting from the pandemic accelerated the penetration of digitalisation. The TOP5 countries were defined based on the data available for last year, and were plotted as a simple arithmetic average of the values for the same countries retrospectively. The TOP5 countries in order: Finland, Sweden, Denmark, Italy and Estonia. Data for Sweden, Estonia and Italy are missing for 2015 and 2017, and thus data for these years are estimates. Data for 2019 were not available for any country.
Source: MNB estimate based on Eurostat data.

Chart 3-10: The spread of e-invoicing



Note: Data for 2014 and 2019 were not available. The impact of COVID means the number of years by which the adjustment resulting from the pandemic accelerated the penetration of digitalisation. The TOP5 countries were defined based on the data available for last year, and were plotted as a simple arithmetic average of the values for the same countries retrospectively. The TOP5 countries in order: Italy, Finland, Estonia, Slovenia and Denmark.
Source: MNB estimate based on Eurostat data.

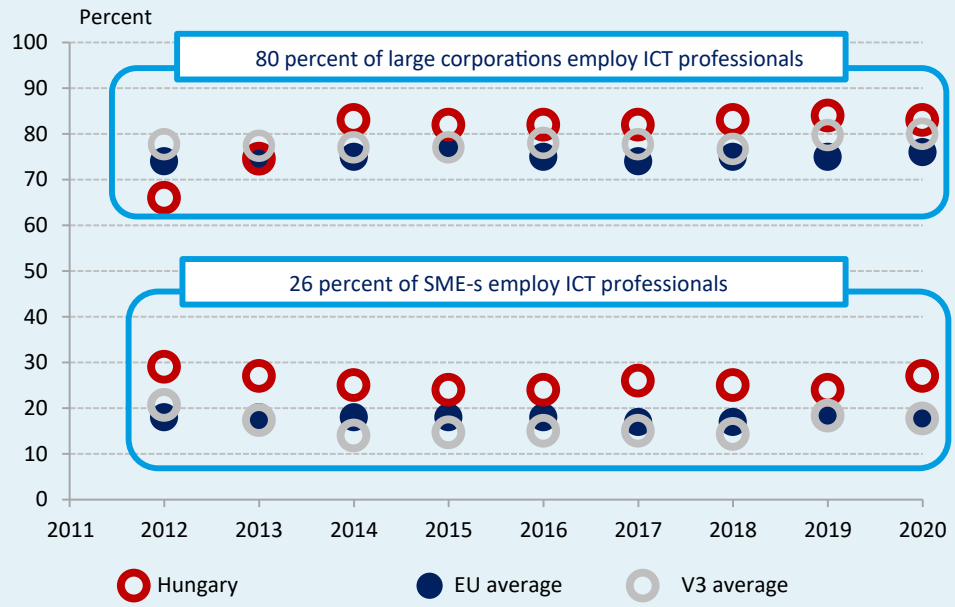
3.5 Efficiency of digital specialists

ICT specialists play a key role in the building of a digitalised economy. Enterprises may decide to employ ICT experts or outsource the tasks to external partner companies. However, the continuous education of IT specialists is essential for the welfare of the country. This is evidenced by the fact that there is huge demand in the private sector for IT specialists and the average wage is also well above the national economy average (by almost 70 percent)[18].

Between 2012 and 2020, on average 26 and 80 percent of Hungarian SMEs and large enterprises employed ICT professionals, respectively (Chart 3-11). It can be observed, therefore, that larger enterprises have greater opportunity to maintain the required team of professionals and thus to employ ICT specialists. Furthermore, large corporations registered strong growth. The frequency of employment rose from 66 percent in 2012 to 83 percent in 2020, while SMEs recorded a minor decrease (from 29 percent to 27 percent). However, the Hungarian ICT employment indices have exceeded the regional average in recent years, which has a positive impact on the penetration of digitalisation.

18 In the ICT sector, full time employment average salary was 677,000 HUF in 2020 before taxes compared to the national average of 403,000 HUF. (KSH)

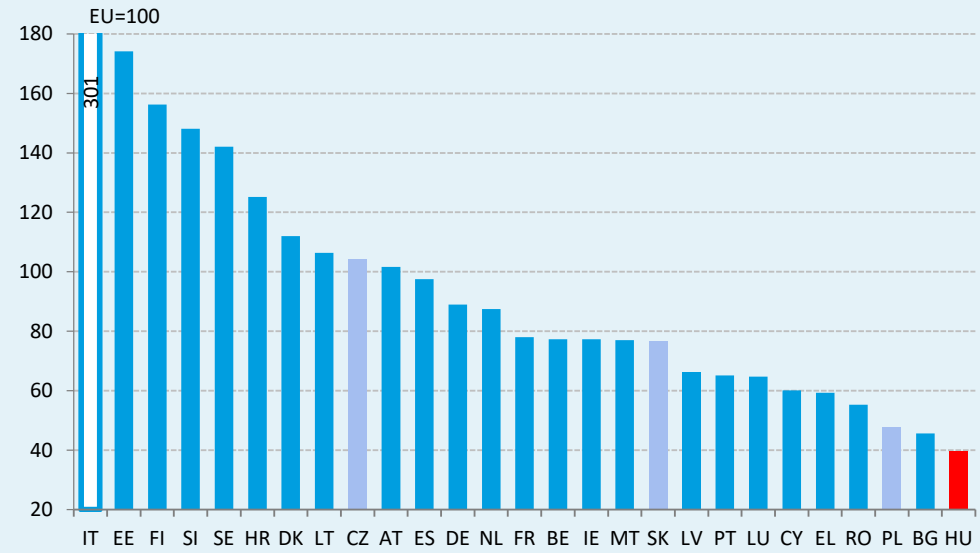
Chart 3-11: ICT specialists in employment in individual size categories



Note: Estimate for 2013, SMEs without micro enterprises. Average values for the entire period.
Source: MNB calculation based on Eurostat data.

In 2020, the efficiency of Hungarian digital specialists was 40 percent of the EU average and 21 percent of the average of the TOP5 countries. Hungary's efficiency indicator also lags behind that of the V3 countries (Chart 3-12). The indicator is obtained as the quotient of the use of ERP and CRM software and the penetration of ICT professionals in enterprises. The countries with the highest efficiency are Italy, Estonia, Finland, Slovenia and Sweden. Italy's significant high score within ERP/CRM software is due to the almost 100 percent penetration of e-invoicing and the small percentage of ICT specialists employed. Hungary is ranked last, i.e. 27th in the EU. It can be seen that Hungarian ICT specialist are able to digitise corporate processes to a relatively small degree compared to the V3 and EU countries, since domestic enterprises employing ICT specialists tend to use modern enterprise resource planning (ERP) and customer relation management (CRM) software less frequently (Baksay–Matolcsy–Virág, 2022). One of the common measures of the digital economy is the penetration of modern enterprise resource planning (ERP) software, which accelerate enterprises' administration, document and process management systems. ERP systems support the collection, storage, management, processing and interpretation of data generated in certain areas. The software monitors organisational resources, such as cash, inventories, base materials and human resources as well as liabilities, such as customer orders, sub-contractor orders and wage costs. It is thus of great help to enterprises. In addition, major productivity growth may be achieved through the application of customer relation management (CRM) software, since monitoring counterparties, suppliers and customers can increase the adaptability of enterprises. One of the reasons for the low penetration of modern enterprise resource planning software is the limited nature of domestic enterprise relations. The average small number of partner companies per enterprise (supplier and customer) determines the interconnectedness and complexity of the corporate network. Since the purpose of using ERP and CRM software is to systematise and accelerate daily administration for enterprises, the absence of such software is connected to their relationship structures.

Chart 3-12: Efficiency of digital specialists



Note: Application of ERP and CRM software divided by the corporate penetration of ICT specialists. Data for 2019 were not available.
Source: MNB calculation based on Eurostat data.

A large number of Hungarian SME managers lack precise understanding of the obstacles to and the opportunities of digital developments. In the 2020 Eurobarometer[19] survey, the topic of which was the willingness of SMEs, start-ups and scale-ups to invest, one of the questions was aimed towards the obstacles related to digital developments. The results of the survey show that almost half (47 percent) of the responding Hungarian SMEs see no obstacle to digital investments, while in the EU only 32 percent of enterprises were of similar opinion.[20] In its own right, this is positive, but in light of the moderate IT investment activity, it implies that the level of information related to digital technologies is low in the SME sector.

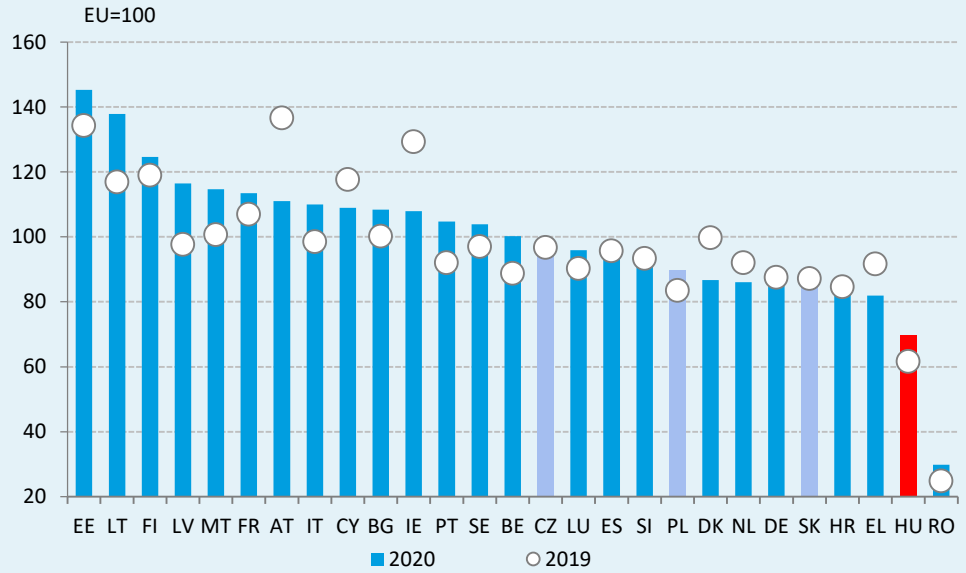
3.6 Digital efficiency of the state

The developments of government digitalisation create a more efficient framework for the economy. Electronic public administration (e-governance) saves money and time for households and enterprises, while government expenditure also decreases; accordingly, these types of investments are vital. Governmental digital development also fosters digital developments in enterprises, setting a good example and boosting entrepreneurship. Electronic administration is faster, since the connection of public administration data systems reduces waiting times and there are fewer personal identification steps. In Hungary, such types of development includes the new e-personal ID card, as a result of which it is no longer necessary to physically carry a health insurance card. Furthermore, at a later stage it will also be used to store public transport tickets and passes, as well as serve as a form of identification for home access to official administration services.

In 2020, the efficiency of digital public administration in Hungary was 70 percent of the EU average and 55 percent of the TOP5 EU countries. The indicator is obtained as the quotient of the usage of digital public administration systems and network quality indices. The 5 most developed countries in terms of state digitalisation are: Estonia, Lithuania, Finland, Latvia and Malta. The indicator takes into account the use of e-governance, pre-filled forms (e.g. tax returns), digital public services available to enterprises and households, and data availability. In 2020, Hungary's place in the ranking remained unchanged compared to 2019. (Chart 3-13). The maturity of Hungary's e-governance is only the 26th best in the EU. Thus, despite the recent major developments in Hungarian public administration, there is still considerable room for increasing the efficiency of digitalisation in this sector.

19 Flash Eurobarometer 486 (2020)
20 Possible answers: 1) Uncertainty with regard to future digital standards (9 percent); 2) Lack of financial resources (14 percent); 3) Legislative obstacles (10 percent); 4) IT security problems (7 percent); 5) Lack of qualifications, including manager skills (11 percent); 6) Absence of information technology infrastructure (8 percent); 7) Internal resistance to change (4 percent) It was possible to select more than one response (Flash Eurobarometer 486, 2020).

Chart 3-13: Efficiency of digital public administration



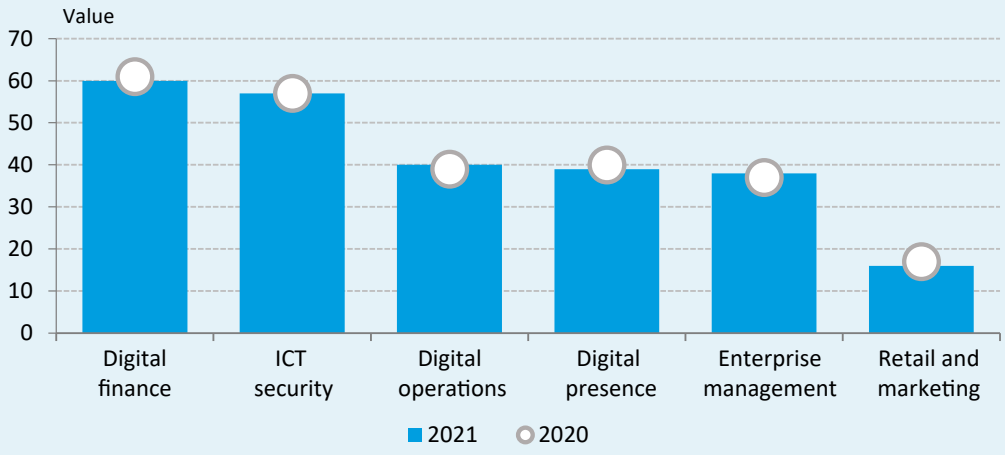
Note: The quotient of digital public administration systems and the network quality (DESI indices).
Source: MNB calculations based on Eurostat.

Box 3-1: Digiméter survey on the digitalisation of the Hungarian SME sector

Digital transformation is a journey not a destination, and it is not something to go down, because there is no end, just as there is no end to progress.[21]

In addition to the efficiency indicators derived from the European Union Digital Index, the Digiméter survey can provide an additional view on the digitalisation of Hungarian SMEs. The survey examined the digital capabilities of enterprises across six topics. These are digital finance, IT security, digital presence, digital everyday life, business management, and finally sales and marketing. For each topic, 100 points could be scored. In 2021, Hungarian SMEs earned the highest score in digital finance and the lowest one in sales and marketing. The survey was conducted both in 2020 and 2021, which can be used for qualifying the results obtained from EU databases.

Chart 3-14: Digiméter survey results for 2020 and 2021



Source: Digiméter 2020 and 2021.

21 Digiméter 2020

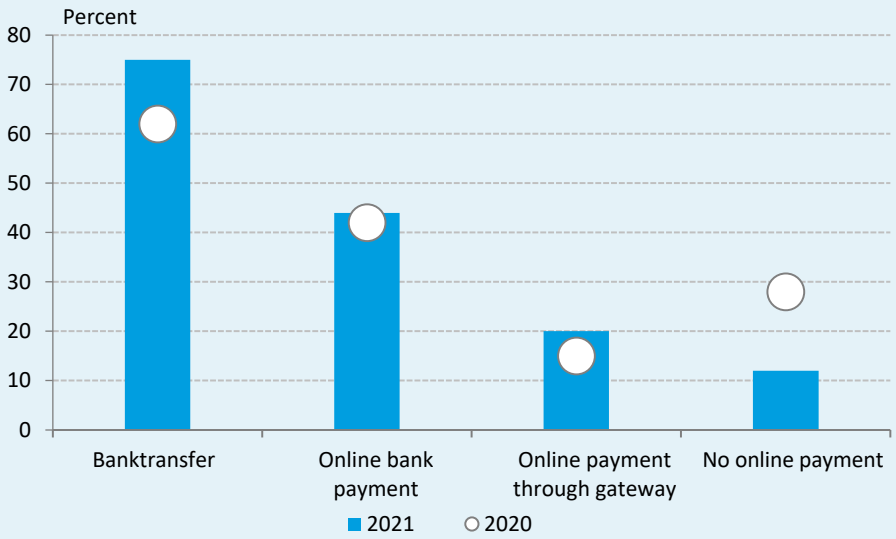
In both 2020 and 2021, Hungarian SMEs performed best in digital finance (scoring 60 and 61 points, respectively). In 2020, 79 percent of Hungarian SMEs used invoicing software. Results from the European Union's digital index show a similar picture, according to which the ratio of Hungarian companies using e-invoices increased between 2018 and 2020. Nevertheless, the situation is less favourable in the area of accounting and financial software. Only 35 percent of SMEs use such software. It should also be noted that no improvement could be identified in digital finance as a result of the pandemic between 2020 and 2021. In addition to the limited potential for improvement due to the high score from the outset, there is also a gap between the average and those lagging. In the 2021 Digiméter, the top 20 percent exceed the average by 17 points.

Hungarian SMEs achieved a high score, i.e. 57, in IT security both in 2020 and 2021. There is however a high degree of heterogeneity among the participating enterprises. Based on scope of activity, the highest score of 74 was given to SMEs providing ICT services in 2020 and the lowest score of 47 was achieved by SMEs in construction. Differences can also be spotted between Hungarian regions: SMEs in Budapest scored the highest with 64 points, while enterprises in South Transdanubia scored the lowest with 49 points in this category (Digiméter 2021).

In the categories of digital presence, digital daily operations and corporate management, Hungarian enterprises scored around 40 points in both years. It was also noted in our digital efficiency indicators that while the development level of infrastructure in Hungary remains adequate, there is room for improvement in the area of its utilisation.

In both years, SMEs performed particularly poorly in sales and marketing, with a score of 17 in 2020, and 16 in 2021. In 2020, only 15 percent of SMEs used some kind of customer relationship management (CRM) system, and in 2021 the figure was even lower at 11 percent. In 2020, 55 percent of companies had no online sales platform at all, and only 6 percent of companies advertised their products on online marketplaces. This can be compared with the EU data, according to which the same ratio for Hungarian SMEs is 3 percent. Nevertheless, we can see some progress in certain areas between the two surveys. While 28 percent of SMEs did not provide any online payment facility in 2020, in 2021 this option was unavailable only at 12 percent of them (Chart 3-15).

Chart 3-15: Use of online payment solutions



Source: Digiméter 2021.

The Digiméter main index scored 40 points both in 2020 and 2021. According to this, the digitalisation of Hungarian SMEs faltered between the two years. While sub-indices can be used to identify areas such as online payment where the pandemic has had an impact, overall the pandemic has not given a spectacular impetus to improving the digitalisation levels of Hungarian SMEs.

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4 Ecological productivity

AMONG THE FOUR PILLARS OF PRODUCTIVITY, HUNGARY IS PERFORMING BEST IN ECOLOGICAL PRODUCTIVITY. HOWEVER, THERE IS STILL ROOM FOR IMPROVEMENT: FOR EXAMPLE, BY INCREASING THE RATIO OF RENEWABLE ENERGY SOURCES.

Hungary's ecological productivity is 79 percent of the EU average, and 50 percent when compared to the TOP5 EU countries.

Introduction

The historically unprecedented growth in the world's economy and population resulted in increased utilisation of the available natural resources. As a result, the environmental burden has increased in past decades and has now become a tangible barrier to long-term sustainable growth. Natural resources are not merely input factors of production, but also serve as a framework of economic and social subsystems. The volume of available resources is finite, and thus – with a view to ensuring sustainable growth – the depletion of resources together with environmental damage must be prevented, i.e. in ecological terms, efforts should be made to use resources efficiently (Virág, 2019).

Ecological productivity means the efficiency of absorbing the environmental resources (or emission of air pollutant and waste) necessary for producing the value added created by an entire economy (macro) or by an enterprise (micro). Acquiring production and consumption habits consistent with the principles of a circular economy also contributes to reducing waste generation in the economy, the emission of greenhouse gases, energy consumption and material use. With economic policy taking on an active role, it may greatly foster the shift in attitude necessary to curb the presently unsustainable processes, and may become the driver for a turnaround. It can be regarded as a milestone that the mandate of the Magyar Nemzeti Bank also includes the fostering of environmental sustainability since the 28 May 2021 decision of Parliament.

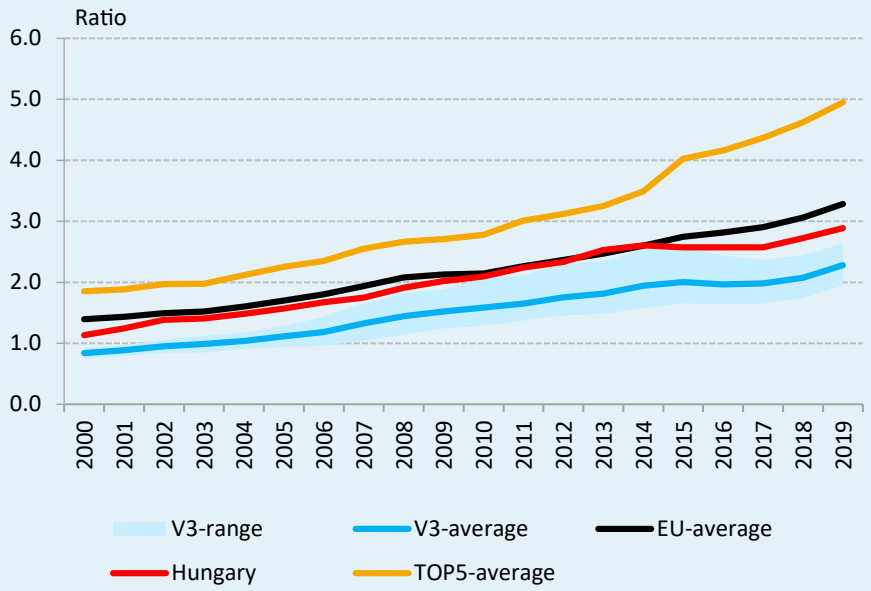
Ecological productivity measures the volume of natural resources required for producing goods or services and the environmental burden generated by production. There are several possibilities of quantifying ecological productivity depending on the approach, which are discussed in more detail in the following subsections.

4.1 Air pollutant emission

Hungary ranks first in the region in terms of value added per unit of carbon dioxide emissions, but it falls short of the average of the TOP5 EU Member States. Since 2000, the value added per unit of carbon dioxide emissions has more than doubled in Hungary (Chart 4-1). This means that the Hungarian economy can produce more than twice as many goods and services as previously under the same level of emissions.

Despite a significant improvement in the indicator, the Hungarian figure is still below the EU average, but has improved at the same rate in recent years. In this respect Hungary stands at 88 percent of the EU average, while compared to the average of the TOP5 countries this value is 58 percent. Compared to the EU average no significant change can be identified (compared to the 89 percent registered in 2018) and the same applies also to the average of the prevailing TOP5 EU countries (it fell from 59 percent registered in 2018 to 58 percent in 2019).

Chart 4-1: Value added per unit of carbon dioxide emissions

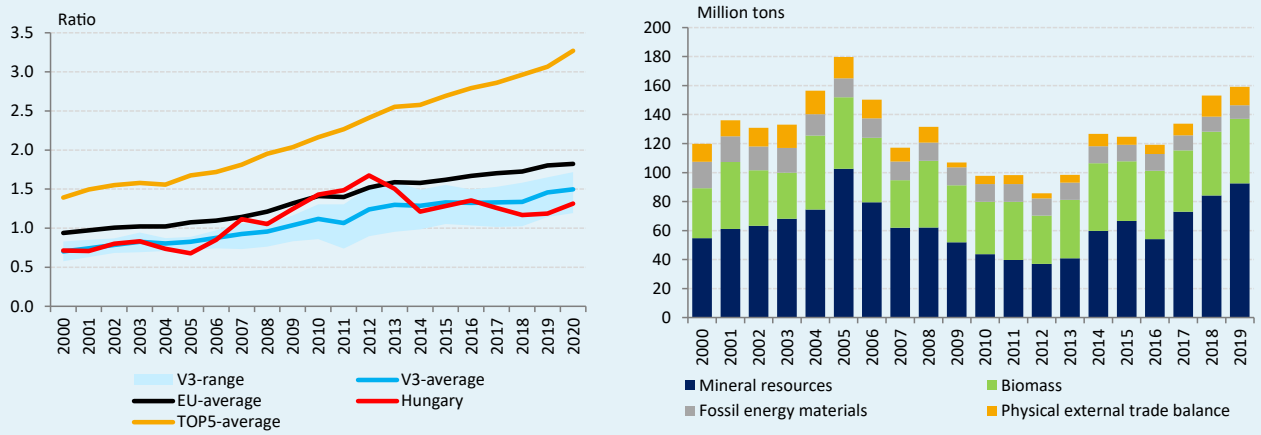


Note: Ratio of value added at purchasing power parity and carbon dioxide emissions. The TOP5 countries were defined based on the most recently available data and were plotted as a simple arithmetic average of the values for the same countries retrospectively. The TOP5 countries in order: Sweden, Malta, France, Ireland and Denmark.
Source: MNB calculation based on Eurostat.

4.2 Material use efficiency

Hungary's material use efficiency lags behind both the regional and the EU average. Material use efficiency is defined as the value added per unit of domestic material consumption. A country's material use efficiency improves when it is able to produce one unit of value added by lower material consumption, and at a macro level, when the economy grows faster than its material consumption. Relatively speaking, the economy detaches from its raw material demand when it is able to produce higher value added by absorbing a specific volume of material. Based on OECD data, Hungary's material consumption per capita is around 30 kg, which is lower than the OECD average of 35 kg (OECD, 2018). Hungary's material use efficiency trend fits into the regional pattern, and in certain years it was even better than across the region, but in recent years it has typically lagged behind (Chart 4-2, left). In Hungary, the fluctuations of domestic material consumption over time are mainly determined by mineral resources, while the consumption of fossil energy materials has gradually decreased in recent decades (Chart 4-2, right). Based on international comparison, a higher share of industry in the economy is accompanied by a higher material requirement, and thus material use efficiency is a more important consideration in these countries. The value added of industrial production doubled in Hungary between 1995 and 2021, and increased by almost one and a half times in the EU. In 2020, Hungary's material use efficiency was 72 percent of the EU average and 40 percent of the average of TOP5 EU countries. Despite the improvement compared to 2019 (66 and 37 percent, respectively), there is still significant room for improvement.

Chart 4-2: Value added per unit of domestic material consumption (left), factors of domestic material consumption (right)



Note: Ratio of value added at purchasing power parity and domestic material consumption. The TOP5 countries were defined based on the most recently available data and were plotted as a simple arithmetic average of the values for the same countries retrospectively. The TOP5 countries in order: The Netherlands, Luxembourg, Italy, France and Ireland.
Source: MNB calculation based on Eurostat.

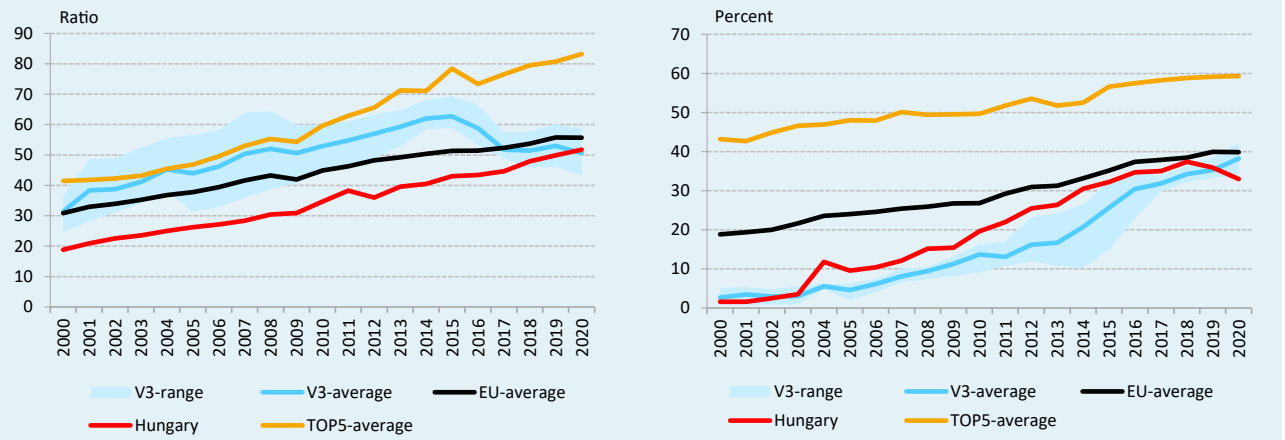
Ecological efficiency can be raised by increasing material use efficiency. Prolonging the life cycle of products and recycling materials has a beneficial effect on our environment. The degree of environmental burden may be reduced, not only by improving material efficiency, but also by including the positive role of waste management, considering the full life cycle of products.

4.3 Waste management efficiency

Globally, a growing population and higher income levels entail the production of larger volumes of waste. However, this trend may be decelerated and turned around via green investments, more intensive waste collection and increased recycling. In 2018, municipal waste generation per capita was 381 kg per year in Hungary, which is well below the EU average of 492 kg. Over the past one and a half decades, the degree of municipal waste generation fell by 18 percent in Hungary, and the volume of hazardous waste generation declined by 60 percent during the same period (OECD, 2018).

International waste management efficiency trends are improving, in which the trends observed in Hungary fit well (Chart 4-3, left). The efficiency of waste management in Hungary has more than doubled over the past two decades, reaching the V3 average by 2020, and coming closer and closer to the EU average. By 2020, the Hungarian indicator reached 93 percent of the EU average and 62 percent of the average of the TOP5 countries. With this favourable value, Hungary performs best in an international comparison of the indicators of the ecological pillar in terms of the value added per unit of municipal waste generation.

Chart 4-3: Value added per unit of municipal waste generation (left), rate of waste recycling (right)



Note: Ratio of value added at purchasing power parity and municipal waste generation. The TOP5 countries were defined based on the most recently available data and were plotted as a simple arithmetic average of the values for the same countries retrospectively. The TOP5 countries in order of municipal waste generation: Ireland, Luxembourg, Belgium, Sweden and Romania. TOP5 countries in order of rate of waste recycling: Germany, Slovenia, Austria, the Netherlands and Belgium.
Source: MNB calculation based on Eurostat.

With the selective collection and recycling of municipal waste, the economy's demand for raw materials can be reduced, along with the demand for primary energy sources. Waste management and recycling is one of the key elements of sustainability. Compared to 2008, the volume of recycled waste almost doubled in Hungary, while the rate of municipal waste generation started to decouple from the growth rate of the economy, i.e. the rate of waste generation began to lag behind economic growth (OECD, 2019).

Significant development potential can be identified in the field of waste recycling in Hungary. Empirical data show that in 2020, only one third of municipal waste was recycled in Hungary, compared to nearly 60 percent in the TOP5 EU Member States. Most countries register a positive trend, with an increasing ratio of recycled waste, while in Hungary a decline can be observed since 2018 (Chart 4-3, right). The improving trend started in 2005 and peaked in 2018 at 37 percent, which then declined to 33 percent by 2020. The decline in the proportion of recycled waste over the last two years is mainly due to a fall in the volume of material recovery. As a result of the decline in the indicator, Hungary now lags behind not only the EU average, but also the regional average.

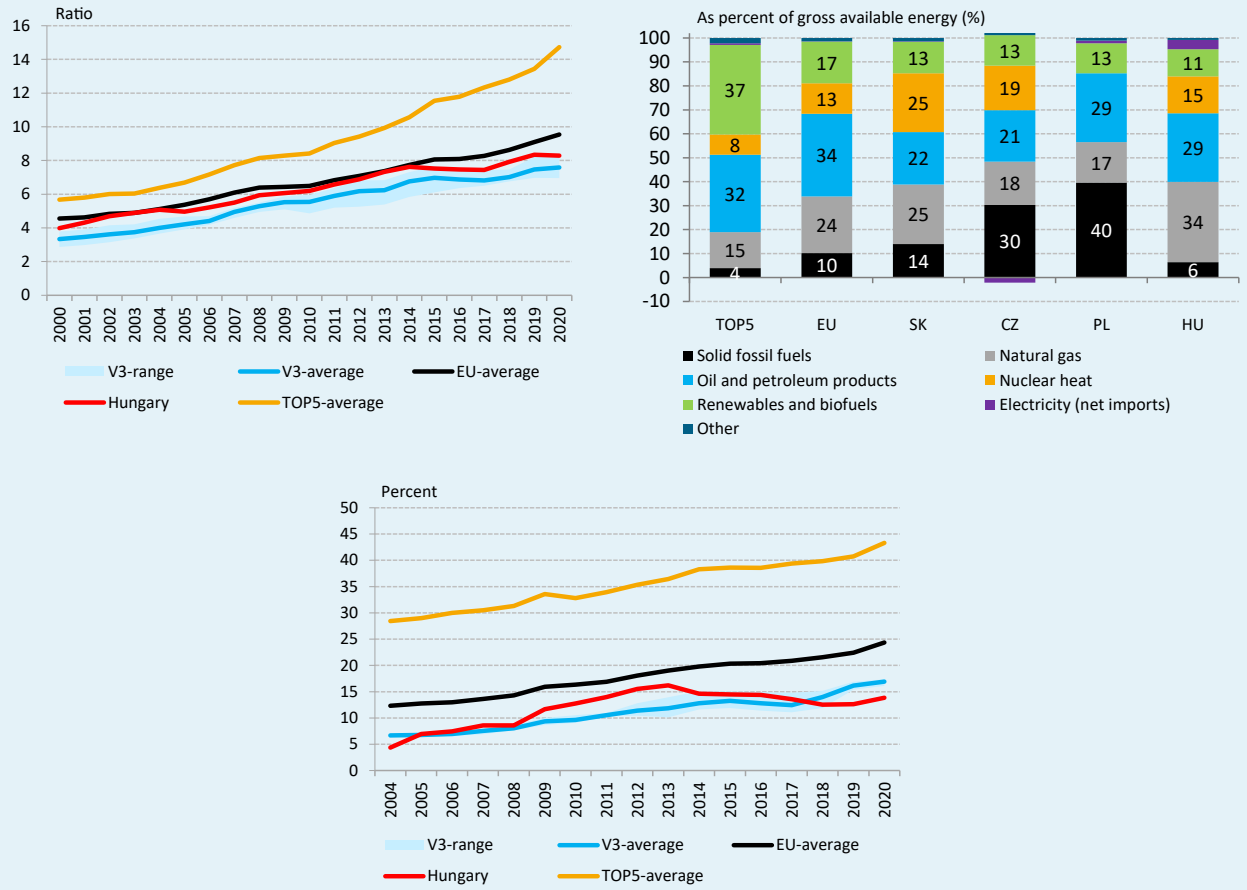
4.4 Energy absorption efficiency

Today's geopolitical tensions place particular emphasis on making the most efficient use of available energy. Energy absorption efficiency is in itself a cardinal criteria of ecological productivity, since it shows the volume of value added that can be created by absorbing one unit of energy. The more output that is produced per unit of energy consumption, the more efficient and sustainable the production process is. The energy absorption efficiency of the Hungarian economy may be deemed good in an international comparison and shows an improving trend (Chart 4-4, upper left). Similar to the energy absorption efficiency of the Hungarian economy, the international trend is also positive. By 2020, the Hungarian indicator reached 87 percent of the EU average and 56 percent of the average of the TOP5 countries.

Owing to the penetration of renewable energy sources, Hungary's dependence on fossil fuels declined, but there is still considerable unutilised potential in this area. Similar to most countries, the Hungarian economy also relies on fossil fuel to a large degree, which accounted for almost 70 percent of the total primary energy supply. Due to the penetration of renewable energy sources, dependence on fossil fuel fell significantly over the past one and a half decades. During this period, the ratio of electricity from renewable resources (produced from biomass, water, solar and wind energy) has trebled in Hungary, and thus 11 percent of total power generation comes from such sources (Chart 4-4, upper right). In 2020, 17 percent of the EU average and around 40 percent of the average of the TOP5 EU Member States came from renewable energy sources. On the consumption side, renewable energy in Hungary accounted for 14 percent of energy

consumption in 2020, compared to the EU average of 24 percent, and the average of the EU TOP5 countries of over 43 percent. (Chart 4-4, bottom). Utilising the potential inherent in this factor would greatly contribute to further improving Hungary's ecological productivity.

Chart 4-4: Energy absorption efficiency (upper left), distribution of energy sources (upper right), ratio of renewable energy in energy consumption (bottom)



Note: Quotient of value added at purchasing power parity and energy consumption. The TOP5 countries were defined based on the most recently available data and were plotted as a simple arithmetic average of the values for the same countries retrospectively. The TOP5 countries in order of energy absorption efficiency: Ireland, Denmark, Romania, Luxembourg and Italy. For electricity, a negative value indicates net exports. Other: Manufactured gases, Peat and peat products, Oil shale and oil sands, Heat, Non-renewable municipal waste. The ratio of other items is usually around 1 percent. The TOP5 countries in order of renewable energy rate: Sweden, Finland, Latvia, Austria and Portugal.
Source: MNB calculation based on national energy balances and Eurostat data.

The decrease in dependence on fossil fuels has a number of benefits. On the one hand, it reduces Hungary's dependence on fuel imports, and on the other hand the substitution of power plants using fossil fuel with renewable energy sources is a significant change both in terms of environmental protection and sustainability. As the energy sector is responsible for a significant portion of emissions, the use of renewable energy instead of fossil fuels may substantially reduce emissions of greenhouse gases.

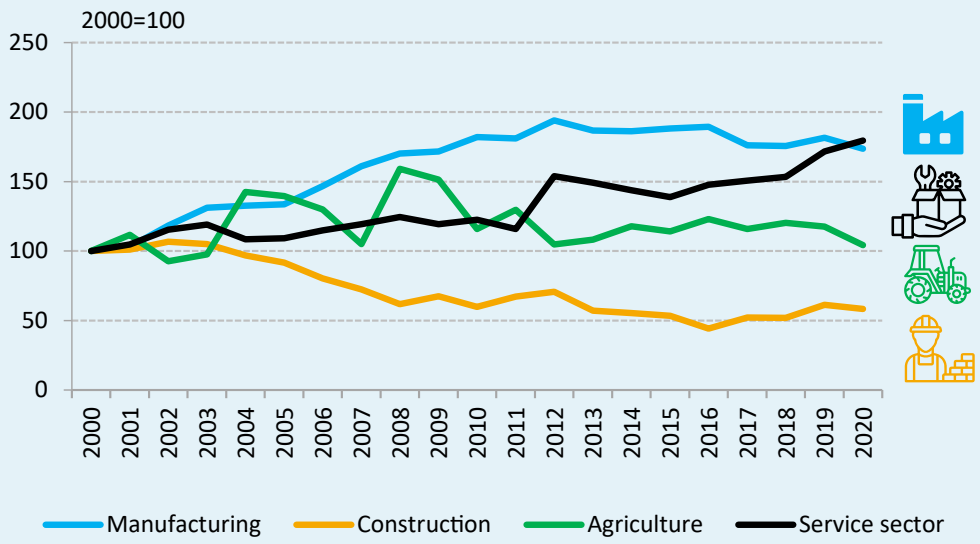
In parallel with the emergence of the decarbonisation process, Hungary may gradually change over to the low carbon-dioxide emission economic model. The economy's improving energy absorption efficiency, material use efficiency and waste management contribute to this favourable trend.

4.5 Sectoral breakdown

Energy absorption is also influenced by the structure of the economy. Both the energy intensity and GHG emissions of individual economic sectors vary. We regarded those sectors that produce the same or higher value added under a low absorption of harmful substances to be of higher ecological efficiency.

There is an improving trend in the green productivity ratios across a wide range of sectors. Over the past two decades, value added per unit of carbon dioxide emissions has almost doubled in manufacturing and services (Chart 4-5). The ecological productivity of the services sector has been steadily improving since 2015, and by 2020 it improved to the same degree as that of the manufacturing sector. There is a duality in time at sector level: the manufacturing sector registered significant efficiency improvements in the 2000s, while the same took place in the services sector in the 2010s. Services typically require smaller material expenditures, due to which their emissions are lower compared to industrial activities. A large part of the service sector's emissions is attributable to the transportation sector and storage. A moderate improvement was observed in agriculture. However, ecological productivity deteriorated in construction, stabilising at around 60 percent of the 2000 figure in recent years.

Chart 4-5: Change in value added by sector in relation to direct CO2 emission

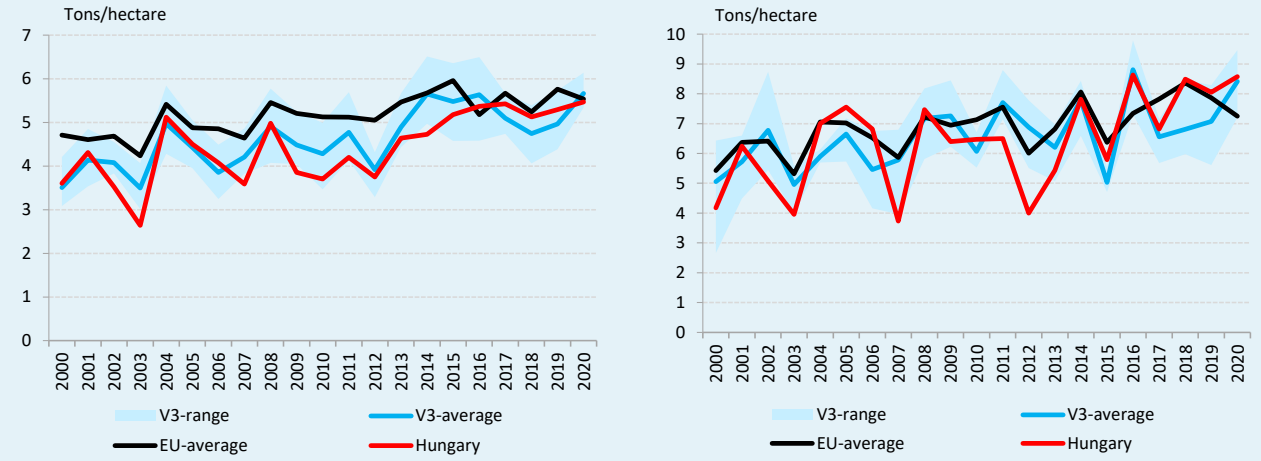


Source: MNB calculation based on Eurostat.

In Hungary, emissions of greenhouse gases come mostly from the activity of the energy sector, manufacturing, transportation and agriculture. The energy sector is responsible to the largest share (23.6 percent) of greenhouse gas emissions. Half of the energy sector's high ratio comes from the use of old, inefficient power plants. Manufacturing is the other sector with the highest emissions, accounting for 22.7 percent of emissions. Emissions from transportation have shown a positive turnaround in recent years. The ratio of emissions from transportation fell from 13 percent to 10.9 percent between 2018 and 2020. The changeover to greener transportation and the restrictive measures introduced in response to the coronavirus pandemic contributed to the turnaround. Agriculture's share in emissions is also high (19.5 percent) and it is rising. The volume of agriculture's greenhouse gas emissions stems from the use of chemicals and fertilisers. The wider penetration of organic farming and the use of organic fertilisers foster sustainable agricultural production in the longer term.

In recent years, the crop yields of Hungarian agriculture reached the EU average (Chart 4-6). Over the past two decades, the crop yields in agriculture improved, which is mostly attributable to rising capital intensity and the penetration and modernisation of irrigation systems. However, there is still significant room for improvement in irrigation in Hungary, as just over half (53 percent) of the irrigable arable land in Hungary is irrigated. As a ratio of total agricultural area, the same figure is less than three percent (MNB, 2021). Between 2000 and 2010, maize yields in Hungary were almost 10 percent below the EU average, catching up by 2020. Over the same period, Hungarian wheat yields were by 18 percent below the EU average, while by 2020 the Hungarian figure exceeded the EU average.

Chart 4-6: Wheat (left) and maize (right) crop yield per hectare



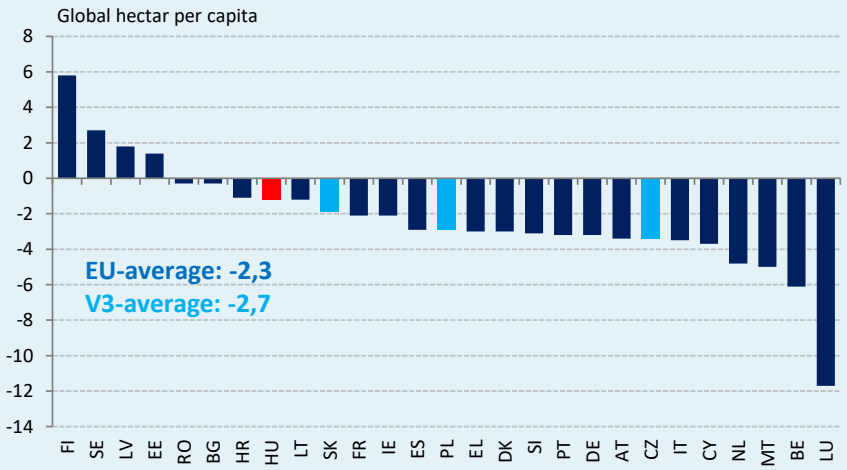
Source: MNB calculation based on Eurostat.

Box 4-1: Innovation turnaround and digital transformation to reduce the ecological footprint

Today, the global ecological footprint significantly exceeds the Earth's carrying capacity. The ecological balance is the difference between the available natural resources (biocapacity) and the resources utilised (ecological footprint). Typically, most countries have an ecological footprint that exceeds their biocapacity and thus they have an ecological deficit. The desired goal would be to prevent an ecological deficit. By now, the global ecological footprint is estimated at 1.7 Earths, which is well beyond the Earth's carrying capacity.

Hungary's ecological balance shows a slight deficit (-1.2 global hectares per capita), but it is better than both the EU (-2.3 global hectares per capita) and the regional averages (-2.7 global hectares per capita) (Chart 4-7). Hungary's ecological balance is in the top third of EU countries, based on 2018 data. A positive balance has been registered only in four EU countries, meaning that only 4 Member States have an ecological footprint that does not exceed their biocapacity. The Nordic countries (Finland, Sweden, Lithuania and Estonia) show a favourable situation, while the Mediterranean (Malta, Cyprus, Italy) and Benelux countries are the worst performers.

Chart 4-7: Ecological balance in the European Union countries



Note: Based on 2018 data. The EU and regional average is based on an unweighted arithmetic mean. The ecological footprint is calculated by determining how much biologically productive land it takes to provide for all the demands of people.
Source: Global Footprint Network.

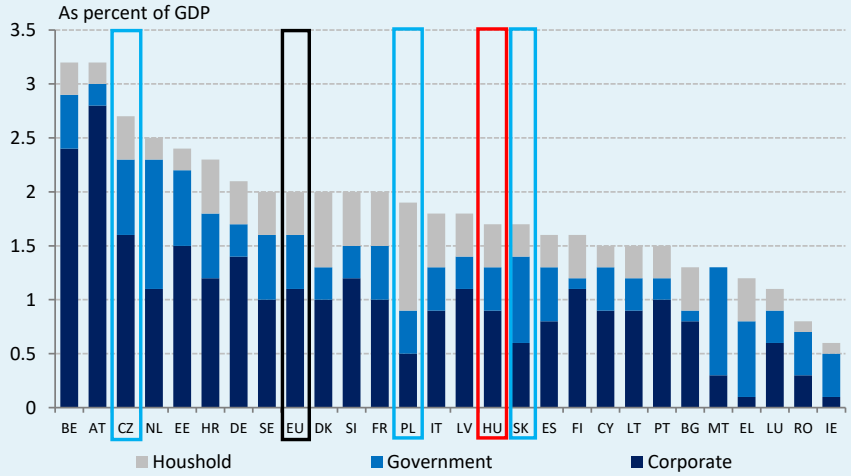
In addition to changing the behaviour of agents (acquiring environmentally responsible habits), a turnaround in innovation and the adaptation of clean technologies are essential for change. By modernising their production process and making green investments, enterprises can reduce their emissions of air pollutants, material and energy consumption, all of which contribute to reducing their ecological footprint. According to OECD data, the ratio of environmental-related technological developments within total technology developments in 2018 was between 10 and 20 percent, depending on the country, and this ratio should be increased to make the ecological turnaround happen.

Improving energy efficiency and drastically reducing dependence on fossil fuels is a cardinal issue. Innovation is a major contributor to improving energy efficiency through the use of more modern technology. In Hungary, fossil fuels account for more than two-thirds of gross available energy, which is in line with the international pattern. In Poland, the same dependence is even higher, at 85 percent. The key issue is to reduce dependence on fossil fuels and at the same time to increase the ratio of renewables as quickly as possible.

The plan outlined in the International Energy Agency's (IEA) paper notes a net zero emission global economy is achievable by 2050. The paper notes that by 2050, two-thirds of the total energy supply could be provided from renewable energy sources, while dependence on fossil fuels could fall from a current value of nearly four-fifths to one-fifth. By 2050, global energy demand could be 8 percent lower than it is today, despite the fact that the global economy would be twice the size of that of today's and the population would have increased by two billion people. This can only be achieved if energy efficiency is significantly improved and agents acquire environmentally responsible habits.

In Hungary, the ratio of environmental expenditures compared to the GDP is below the EU and regional averages. According to the definition published by the HCSO, environmental investment is any investment expenditure the primary purpose of which is to prevent, reduce or eliminate pollution or any other damage to the environment. In Hungary, environmental expenditure as a percentage of GDP is 1.7 percent, compared to the EU average of 2 percent (Chart 4-8). Austria and Belgium have outstanding levels of national economy environmental expenditure, mostly attributable to corporate expenditure. In Hungary, approximately half of environmental investments concern waste water treatment, a quarter of them waste management, and the remainder typically concerns the protection of air quality and groundwater.

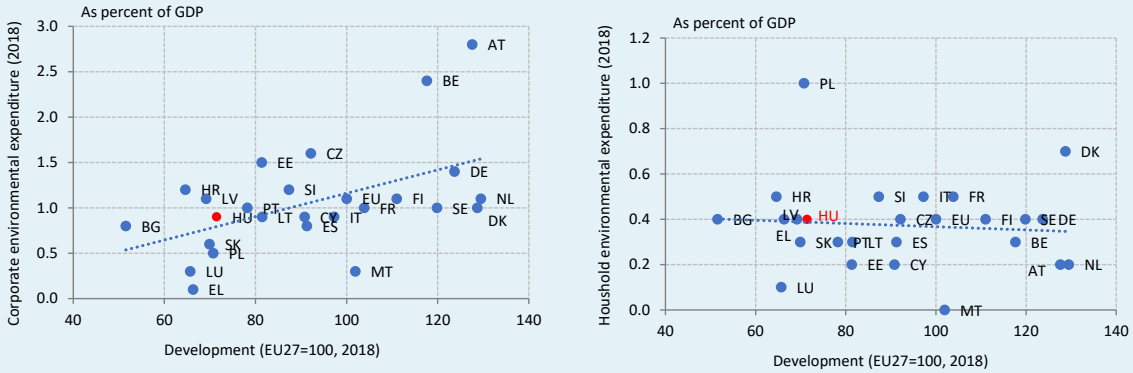
Chart 4-8: Environmental expenditure as a percentage of GDP in EU countries



Note: Based on 2018 data.
Source: Eurostat.

Expenditure for environmental protection typically comes from the private sector, and within that mainly from the corporate sector. There is a positive correlation between a country's development level and their spending on environmental protection, which is fully attributable to the corporate sector's expenditures (Chart 4-9). The proportion of household and government spending on the environment is independent from the development level of countries.

Chart 4-9: Relationship between environmental expenditure as a percentage of GDP and the level of development of countries in the European Union



Note: Based on 2018 data. GDP per capita at purchasing power parity was used to calculate development, excluding Ireland and Luxembourg.
Source: Eurostat.

Digital transformation can accelerate reaching a circular economy through its positive impact. Large-scale corporate innovations imply significant changes, and digitalisation is becoming an increasingly important part of this. Digital transformation helps to optimise production and operational processes, develop and exploit new sales channels and dematerialisation. The dematerialisation process can greatly reduce the use of materials and energy in production, administration and payment transactions. By optimising the production process, the same volume of products can be produced with lower material inputs. Using a digital solution instead of paper-based administration also reduces material requirements, and the same applies to using modern digital solutions instead of cash payment. Today, there are well-known, modern digital technologies that can foster digital transition (numerous info-communication products, the Internet of Things, Big Data, Blockchain technology and Artificial Intelligence).

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ANNEX 1

The productivity ratios belonging to the individual pillars present the ratio of two variables. Formally this means that we divide a valuable output (gain, numerator) by a scarce resource (using item as denominator). In the table below, we summarised the productivity indicators used in the report, the derivation of those and the reference year of the latest available data.

Various productivity ratios and their definition

VARIABLE NAME	NUMERATOR	DENOMINATOR	DATA YEAR
I. LABOUR PRODUCTIVITY			
GDP per employment (PPS)	GDP (PPS)	Employment (total, national accounts concept)	2021
GDP per hour worked (PPS)	GDP (PPS)	Full Time Equivalent	2021
SME labour productivity in comparison to the EU labour productivity	Labour productivity of SMEs (PPS)	EU-27 labour productivity (PPS)	2020
II. INNOVATION			
Patents in the ratio of R&D expenditures	Patent applications	National R&D expenditures (PPS)	2020
Average citation index per document by year of publication	Citations per document HUN	Citations per document EU-28	2021
Trademark and design patents per knowledge-intensive employees	Number of knowlede-in-tensive employees	Number of trademark and design patents	2020
Composit indicator measuring collabo-ration in innovation	Composit indicator		2020
III. DIGITAL PRODUCTIVITY			
Households' digital skills and quality of infrastructure	Digital skills, human capital (DESI index)	Connectivity (DESI index)	2020
Utilisation rate of digital infrastructure by enterprises	Integration of digital services (DESI index)	Connectivity (DESI index)	2020
Efficiency of digital specialists	Proportion of companies using ERP and CRM softwares	Proportion of companies employing ICT specialists	2020
Maturity of digital public administration	Digital public services (DESI index)	Connectivity (DESI index)	2020
IV. ECOLOGICAL PRODUCTIVITY			
Value added per GHG emission	Value Added (PPS)	CO_2 Equivalent GHG Emission	2019
Energy absorption efficiency	Value Added (PPS)	Total Energy Supply	2020
Share of renewable energy	Renewable Energy Supply	Total Energy Supply	2020
Value added per Domestic material consumption	Value Added (PPS)	Domestic Material Consumption	2020
Value added per Municipal waste generation	Value Added (PPS)	Municipal Waste Generation	2020

Source: MNB compilation.

List of charts and tables

Ányos Jedlik

Hungarian naturalist, inventor, a Benedictine monk, university professor and academic

(Szímő, 11 January 1800 – Győr, 13 December 1895)

Ányos Jedlik, a Benedictine monk and naturalist, dedicated his life to the study of electromagnetism and light. Although Jedlik's name has remained in the public mind primarily because of the dynamo and soda water, the scientist pursued a much more diverse research programme, and by describing the principle of dynamo and self-excitation, he even preceded his world-famous contemporaries.

The inventor was born under the name of István Jedlik in Szímő, Komárom county. His parents were simple farmers, yet Jedlik's father put great emphasis on his son's education, so after the third grade of high school, he sent the child to the Benedictines in Pozsony (Bratislava). Jedlik soon applied to Pannonhalma, and in 1847, he also entered the Order of Saint Benedict. That is when he took on the first name Ányos.

He later continued his studies in Győr and then at the University of Pest, where he earned a doctorate at the age of 22. Already at the beginning of his career, Jedlik had a wide range of interests, as he embarked on research in physics, chemistry and optics as well. In 1821, even as a university student, he published an article about what he called "lightning-magnetic self-rotor", which he indeed built around 1827–1828.

The device was an early electric motor, which, due to electromagnetism, made a continuous rotational motion. Furthermore, the lightning-magnetic self-rotor laid the foundation for Jedlik's later discoveries, as the dynamo created by 1861, the tubular voltage generator built by the early 1870s, or even the invention of the arc lamp presented in Pannonhalma in 1856 were due to the scientist's efforts to develop more and more powerful devices.

After his ordination in 1825, Ányos Jedlik taught in Győr. The scientist accepted a position in Pozsony in 1831, and then in 1839 at the department of the University of Pest, and a year later, he was appointed to a chair as a head of department. In 1846, Jedlik became the Dean of the Faculty of Humanities. In 1848–1849, he joined the National Guard, and therefore he soon lost his teaching position. However, even after having been set aside, the great scientist worked for the benefit of his nation and science.

He printed at his own expense his university textbook's first volume entitled Súlyos testek természettana [Physics of Heavy Bodies]. In 1858, Jedlik was immediately made a full member of the Hungarian Academy of Sciences, and five years later, he was appointed as Rector of the University of Pest. The inventor finished his earthly course on 13 December 1895.

The physicist Lóránd Eötvös said of Ányos Jedlik: "His patriotism was just as simple as he himself was, not something viewed as a merit entitling him to a special reward, but only the fulfilment of his duty, yet multiplied in the hearts of millions it is the strongest guarantee of the life and prosperity of a nation."

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