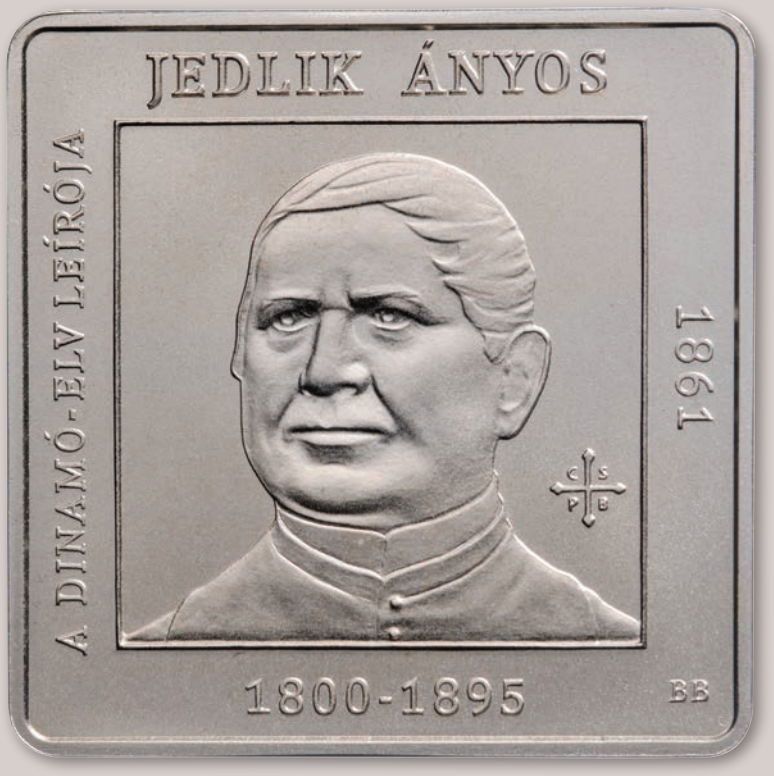
PRODUCTIVITY REPORT



2024

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

Ányos Jedlik, 1895

PRODUCTIVITY REPORT

2024

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Pursuant to Act CXXXIX of 2013 on the Magyar Nemzeti Bank, the primary objective of the central bank of Hungary (MNB) 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 affect both households and companies. Without compromising 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 and, relying on the monetary policy instruments at its disposal, supports the economic policy of the government.

The Productivity Report supports the fulfilment of the statutory tasks of the central bank. It does so by promoting an understanding of the drivers, characteristics, distribution and dynamics of economic growth and the key factors of convergence, thus helping to bring Hungary closer to formulating and implementing reforms to improve productivity.

The Productivity Report achieves this with a complex approach, examining a wide range of efficiency indicators, such as labour productivity, innovation, digitalisation and ecological efficiency.

The analysis was carried out under the general direction of Gergely Baksay, Executive Director Economic and Fiscal Analyses and Statistics, at the Directorate Economic Forecast and Analysis.

Data available up to 24 October 2024 were used to produce the Report.

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Executive Summary

The Productivity Report helps the central bank to fulfil its statutory duties. The central bank's primary task is to achieve and maintain price stability. The relationship between productivity and inflation has long been known in economics. The examination and analysis of productivity and efficiency helps us to better understand inflationary trends, and the Report thus facilitates the achievement of the central bank's objectives. The central bank also has a mandate to support the government's economic policies without compromising its primary objective. The Productivity Report does this by promoting an understanding of the drivers, characteristics, distribution and dynamics of economic growth and the key factors of convergence, helping to bring Hungary closer to formulating and implementing reform proposals to improve productivity.

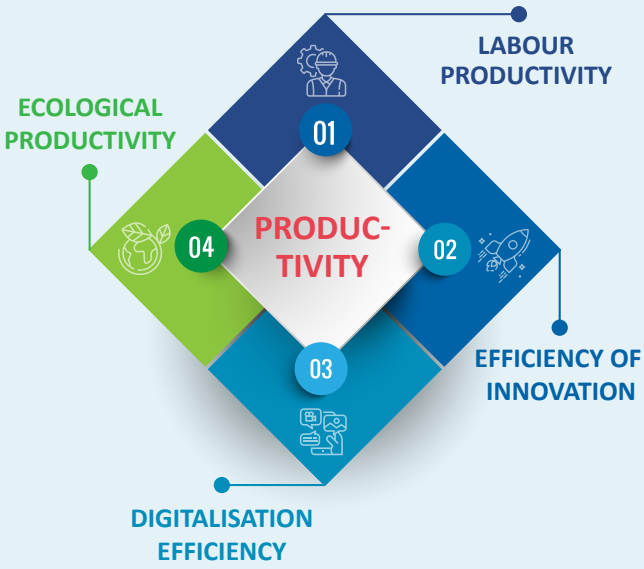
Productivity forms the basis for long-term growth and sustainable convergence and is closely linked to the concept of efficiency. Welfare can grow steadily in an economy if the efficiency of production/service processes increases tangibly over longer periods. Accordingly, the continuous, broad-based measurement and analysis of productivity is essential for monitoring changes in welfare. Productivity in general refers to efficiency ratios that show the value created per unit of resource used. This Report refers to the value created as output and the expenditures as input.

For Hungary, sustainable convergence after a successful period of extensive growth requires a transition to intensive growth, where the key aspect is to increase productivity and efficiency. Productivity and efficiency gaps also represent a growth reserve for Hungary, which are worth highlighting in terms of competitiveness.

The megatrends of the current decade, such as demographic shifts, geopolitical restructuring, rapid technological progress and the green transition, are transforming our daily lives and economic activity, and the Hungarian growth model must adapt to the character of the new decade. In line with previous practice, four pillars of productivity were analysed: along with labour productivity, the efficiency of the innovation system, digitalisation and ecological processes were also examined (Chart 1).

Hungary's productivity and efficiency indicators lag behind the average of developed EU countries, which provides a growth reserve for the domestic economy. Advanced economies feature a high level of technology, and supply of goods and services, and thus it is worth examining Hungary's position regarding efficiency indicators compared to the EU countries. For cross-sectional analyses, the comparisons are mainly to the EU average, the other Visegrád countries and the TOP5 countries that are the most prominent in the respective indicator. With regard to labour productivity indicators on average, Hungary is at 64 percent of the EU. The Hungarian economy is 55 percent efficient in terms of the innovation system. In digitalisation and ecological productivity, Hungary lags behind the least in relative terms, coming in at 78 percent and 81 percent, respectively, compared to the EU average. Overall, in the 2020s, substantial improvement has only been seen in the digitalisation pillar, mainly due to an increase in the digitisation efficiency of companies.

Chart 1: Productivity pillars



I. LABOUR PRODUCTIVITY

In 2023, GDP per person employed amounted to 73.3 percent of the EU average (ranked 4th from the bottom in the EU), marking an improvement of 1.6 percentage points compared to 71.7 percent in 2019. Due to a series of crises in recent years, productivity improvements have slowed compared to the trend seen at end of the previous decade. While real labour productivity increased at an average rate of 3.3 percent annually between 2017 and 2019, it increased by an annual average of 0.8 percent between 2020 and 2023. During the period 2020–2023, developments in the productivity of the national economy were mainly driven by productivity in service industries. In this period, market services sectors achieved an average annual increase in real labour productivity of 2.4 percent, while the efficiency of manufacturing firms remained stable.

In Hungary, the labour productivity of SMEs reached 54.4 percent of that of large enterprises in 2022, compared to 60 percent in the EU. This duality decreased from 2012 until 2018 (as the relative performance of SMEs improved from 47.9 percent to 58.6 percent) and then gradually increased until 2021 (to 52.2 percent). The productivity of microenterprises relative to large enterprises was 37.8 percent in 2022, that of small enterprises 67.0 percent and that of medium-sized enterprises 80.9 percent.

II. INNOVATION EFFICIENCY

The crises of recent years have reduced the real value of domestic innovation spending, leading to modest deterioration in innovation efficiency and a decline in results. R&D expenditure as a share of GDP in Hungary fell slightly between 2020 and 2022, mainly due to lower spending in the corporate sector. In 2020, the economy-level expenditure was 1.6 percent of GDP, declining to 1.4 percent by 2022, while the EU average was 1.8 percent in both years. The corporate sector reduced its development spending mainly due to the energy crisis, the high inflation environment and the resulting weak domestic and foreign demand. The drop in efficiency was primarily registered in respect of activity in patents and designs. The number of new patents per R&D expenditure reached a historic low in 2022 (28.2 percent of the EU average).

Looking ahead, one positive trend in the development of the domestic innovation ecosystem is the participation of the MNB in the MIT-REAP programme, which aims to support regional innovation-based enterprise development strategies with active recommendations, in addition to various government measures. The role of the state in the field of

innovation has been further strengthened, with the Ministry of Culture and Innovation (KIM) taking over the coordination of tasks from 2022, as laid down in the János Neumann Programme adopted in 2023. The institutional support system was further strengthened by the reorganisation of the HUN-REN Hungarian Research Network and the establishment of the Hungarian Innovation Agency. Another step forward in the development of the domestic innovation ecosystem is the creation of the legal institution of the convertible note. This financing scheme can greatly support the start-up of innovative businesses with high growth potential by providing funding to start-ups with no credit history. In addition, the Hungarian Innovation HUB (HIH), established in October 2023, serves as a background organisation to support innovation projects across the country, while creating a cohesive environment for the ecosystem.

III. DIGITALISATION EFFICIENCY

Hungary's digital infrastructure is above the EU average but is under-utilised. The efficient use of the domestic population's skills in 2023 compared to the EU average was 88 percent. The use of digital technologies among residential users has improved slightly in recent years, in line with the development of digital skills among the population. This notwithstanding, the level of utilisation relative to the development level of the infrastructure is still low, with significant room for improvement.

The corporate efficiency of digital technologies has increased significantly in recent years in Hungary, from 60 percent of the EU average in 2020 to 89 percent in 2023. Progress has been made in corporate digitisation in many areas (cloud services, e-invoicing, data analytics), but there is still potential for improvement. In 2023, 47 percent of Hungarian SMEs still had a very low digital intensity (EU average: 42 percent). However, this indicator has improved (i.e. decreased) by 19 percentage points compared to 2021, which has resulted in Hungary overtaking the V3 countries (Poland, the Czech Republic and Slovakia with 50, 51 and 58 percent, respectively).

The efficiency of e-governance in Hungary in 2023 was 79 percent of the EU average. Hungary's second-to-last place (ahead of only Romania) in the ranking remained unchanged in 2023 compared to 2020. Despite the recent improvements in Hungarian public administration, there is still considerable room to boost the efficiency of digitalisation in public administration.

IV. ECOLOGICAL PRODUCTIVITY

Of the pillars examined, Hungary performs the best in ecological productivity, but there is room for improvement in this segment as well, such as increasing the share of renewable energy. One of the key indicators of ecological productivity in our analysis is value added per unit of environmental pollution, which expresses the extent of overuse of ecosystem services and its relationship to production. 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.

Hungary's ecological productivity is 81 percent compared to the EU average and 51 percent compared to the TOP5 EU countries' average, and thus conforms to the regional pattern. The share of electricity generated from renewable sources (biomass, hydro, solar and wind) has tripled over the past decade and a half in Hungary, accounting for 13 percent of total energy production, but this level remains low by international standards; on average, renewables accounted for 18 percent in the EU countries and 41 percent in the TOP5 EU Member States in 2022. Hungary's eco-productivity is continuously improving, but still falls short of the EU average. Further progress is also needed in this area to achieve environmental sustainability and decarbonisation targets.

Summary of Hungary's main achievements

HUNGARIAN LABOUR PRODUCTIVITY IS LOWER THAN THE EU AND REGIONAL AVERAGES; THUS, IMPROVING PRODUCTIVITY REPRESENTS THE LARGEST SOURCE OF GROWTH.

The average for Hungarian labour productivity indicators amounts to 64 percent of the EU level and 49 percent of the TOP5 EU countries.

In Hungary, in 2023 GDP per person employed was 73.3 percent of the EU average, reflecting an improvement of 1.6 percentage points compared to 71.7 percent in 2019. Accordingly, Hungary was still ranked 24th in the EU last year. Improving labour productivity is crucial for a sustainable convergence path. The megatrends of the current decade – such as demographic shifts, geopolitical restructuring, rapid technological progress and the green transition – are transforming our daily lives and economic activity, and the Hungarian growth model must adapt to the character of the new decade.

In Hungary, GDP per hour worked amounted to 70.3 percent of the EU average in 2023 and 67.5 percent of the EU27 average in 2019. Part-time employment in Hungary is low by EU standards (4.0 percent compared to an EU average of 17.8 percent) and, closely related to this, the average number of hours worked is high (39.6 hours per week compared to an EU average of 37.1). These two factors result in a slightly lower level of working hour-based productivity in Hungary compared to the per capita indicator.

The evolution of domestic labour productivity over the past ten years can be broken down into three main stages. First, the growth turnaround from 2013 led to the start of an extensive economic expansion with employment growth (MNB 2023). Subsequently, from 2017 onwards, as the scope for extensive growth narrowed, the main source of growth became an increase in labour productivity: the indicator for Hungary rose by an average of around 3.3 percent in 2017–2019, higher than the V3 average (2.7 percent) and significantly higher than the average growth of 0.8 percent in the EU Member States. In the 2020s, however, this productivity growth slowed considerably.

Severe global crises and competitiveness problems have sharply reduced productivity growth in the 2020s. The Covid-19 pandemic, the energy crisis and escalating geopolitical tensions have all restrained the rise in Hungarian labour productivity, which improved by an average of just 0.8 percent annually in the 2020–2023 period. By comparison, in this period labour productivity in the V3 countries grew by 1.0 percent on average, while in the EU it increased by 0.2 percent on average.

The modest increase in labour productivity in the 2020s was almost entirely driven by the service industries. In the new decade, the relative importance of service providers in improving aggregate real labour productivity has increased further compared to the 2017–2019 period. In 2020–2023, productivity in the services sectors grew by an average of 2.4 percent annually, and thus labour productivity in the economy was almost exclusively driven by firms operating in these sectors. Overall, the value added per capita of manufacturing actors stagnated during this period (increasing by only 0.2 percent in 2017–2019). The nominal labour productivity of market service providers and manufacturing firms was close to the same level in 2023 (HUF 14.8 million and 14.7 million per person employed, respectively). Together, these two sectors account for around 70 percent of domestic GDP.

Among market service providers, the information and communication sector recorded the highest average productivity growth (4.5 percent) in the 2020–2023 period and was the only service sector to approach its average performance for the years between 2017 and 2019 (growth of 5.4 percent). Labour productivity growth in this sector is closely linked to the mounting demand for digitalisation and the spread of digital technology innovations. The infocommunications sector in particular is characterised by its scalability, its digital technology services can be greatly expanded with a small increase in marginal costs. In addition, players in this sector are highly adaptable to rapidly changing technological trends. The output of firms operating in this sector also has a significant indirect impact on the productivity of other sectors (Anghel – Bunel 2024).

In Hungary, the labour productivity of SMEs reached 54.4 percent of that of large enterprises in 2022, compared to 60 percent in the EU. This duality decreased from 2012 until 2018 (as the relative productivity of SMEs rose from 47.9 percent to 58.6 percent) and then gradually increased until 2021 (52.2 percent). However, the productivity gap between SMEs and large enterprises remained significant in Hungary in 2022: the productivity gap of microenterprises relative to large enterprises was 37.8 percent, that of small enterprises 67.0 percent and that of medium-sized enterprises 80.9 percent, respectively. In calculating the average pillar value, the relative SME productivity rate was set against the EU average labour productivity rate for all size categories, which stands at 47.6 percent according to the latest data.

In 2020–2022, labour productivity growth in SMEs averaged 3.0 percent per annum, around one half of the growth rate for the 2017–2019 period (5.9 percent). The productivity index of large firms increased by an average of 4.9 percent in 2020–2022 and by an average of 2.8 percent in 2017–2019.[1] The fastest growing segment in 2017–2019 was the microenterprise group (9.1 percent annual average), with small businesses increasing their efficiency the most in the 2020s (7.1 percent). It is important that SMEs remain competitive in the labour market against large companies. If SMEs cannot improve efficiency, they will lose the skilled workforce needed to adopt advanced technologies.

THE CRISES OF RECENT YEARS HAVE REDUCED THE REAL VALUE OF COMPANIES' INNOVATION SPENDING, LEADING TO A SLIGHT DETERIORATION IN INNOVATION EFFICIENCY AND A DECLINE IN RESULTS.

Hungary's innovation efficiency is 55 percent of the EU average and 36 percent compared to the TOP5 EU countries.

Innovation is a key driver of labour productivity and economic development. Limited human and physical resources are also elevating the importance of innovation in converging countries. Innovation is crucial in the transition from a quantitative to a qualitative growth model.

Between 2020 and 2022, R&D expenditure as a share of GDP in Hungary decreased slightly, due to lower spending in the corporate sector. In 2020, the economy-level expenditure was 1.6 percent of GDP, declining to 1.4 percent by 2022, while the EU average was 1.8 percent in both years. The corporate sector may have reduced its development spending mainly due to the energy crisis, the high inflation environment and the resulting weak domestic and foreign demand.

In an international comparison, Hungary's innovation efficiency has declined, i.e. results have decreased more than innovation expenditure. The decrease in the efficiency of R&D expenditure was mainly registered in activity related to patents and designs. The number of new patents per R&D expenditure reached a historic low in 2022 (28.2 percent of the EU average). Knowledge-intensive employment in Hungary in 2023 is above the pre-Covid levels but remains below the EU average. On the other hand, scientific citation rates remain favourable and publication activity is significant.

To improve the efficiency of the innovation system, comprehensive ecosystem building is needed, guided by the Neumann Janos programme that was adopted in 2023. The newly founded Hungarian Innovation Agency aims to extend the successful work of the National Research, Development and Innovation Office to the other segments of the economy. The reorganised Eötvös Lorand Research Network operating under the name HUN-REN Hungarian Research Network will finance basic and applied research in a wide range of sciences. Another positive event in the development of the Hungarian innovation ecosystem is the participation of the MNB and other domestic actors in the MIT-REAP programme, which aims to support regional innovation-based enterprise development strategies with active recommendations. Basic research has successfully identified Hungarian innovation-driven enterprises (HIDEs), which are distinguished from traditional SMEs by two main factors (MNB 2023): On the one hand, they base their competitiveness on innovation, while on the other hand, they are able to achieve outstanding business results based on their innovation performance.

1 Productivity improvements at SMEs and large firms in 2020–2022 will exceed the national average for 2020–2023. This is because SME statistics cover only a subset of industries (they measure market-based firms) and firm size data are not yet available for 2023 (real labour productivity in the economy in 2023 decreased by 1.1 percent).

Yet another step forward in the development of the domestic innovation ecosystem is the creation of the legal institution of the convertible note. This financing scheme can strongly support the start-up of innovative businesses with high growth potential by providing funding to start-ups with no credit history.

WHILE UTILISATION IS LOW, THE COVERAGE OF DIGITAL INFRASTRUCTURE IN HUNGARY IS ABOVE THE EU AVERAGE, BUT THE GAP HAS NARROWED SIGNIFICANTLY IN THE CORPORATE SECTOR.

Hungary's digitalisation efficiency is 78 percent of the EU average and 59 percent compared to the TOP5 EU countries.

Hungary's digital efficiency is characterised by the fact that it reflects above-average performance for input indicators, but often falls below the average in terms of output indicators. As regards input indicators, Hungary is ranked 6th in the EU for network infrastructure. For output indicators, however, its best ranking of 16th was achieved for the digital skills of household users and the integration of digital technology by enterprises. Accordingly, in the productivity and efficiency ratios obtained as a quotient of the below-average output and the above-average input indicators, Hungary is in the middle or lower half of the EU rankings. At the same time, notable improvements have been seen in some areas, especially in the corporate sector.

In 2023, the efficient utilisation of digital technology among households was 88 percent of the EU average, while it was 68 percent compared to the average of the TOP5 EU countries. Consequently, Hungary was ranked in 21st place in the EU in 2023 in this regard, advancing five places compared to 2020. Efficiency was improved by the fact that, while the coverage of digital infrastructure is at consistently high levels in Hungary, the digital skills of the population have also improved in recent years. This notwithstanding, the level of utilisation relative to the development level of the infrastructure is still low, with significant room for improvement.

The corporate efficiency of digital technologies has risen considerably in recent years in Hungary, reaching 89 percent of the EU average and 66 percent of the average of the TOP5 EU countries in 2023 (versus 60 percent and 44 percent, respectively, in 2020). Similar to the field of individual users, Hungary ranked 21st among the EU countries in 2023, moving up five places compared to 2020. In some areas, the digitalisation of enterprises has increased significantly, nearly doubling in recent years, but it nevertheless still often falls short of the EU average. Between 2020 and 2023, the ratio of enterprises using e-invoicing rose from 13 to 26 percent, which currently puts Hungary in 17th position in the EU. In addition, a major improvement was observed in the use of cloud-based services. In 2020, only 25 percent of enterprises used such technology, while this figure rose to 45 percent in 2023. Another positive development is that 53 percent of Hungarian enterprises use data analytics in their operations, putting Hungary at the top of the EU ranking. However, there are significant shortfalls in some areas. According to the enterprise digitalisation sub-index, 47 percent of Hungarian SMEs have minimal digital technology.

Hungary continues to lag significantly behind in the productivity of hiring digital specialists, which was 58 percent of the EU average in 2023 and 39 percent of that of the TOP5 countries. In Hungary, 88 percent of large enterprises and 29 percent of SMEs employed ICT specialists in 2022, which exceeds the EU average of 75 percent and 18 percent, respectively. However, despite the widespread employment of specialists, the digitalisation of enterprise processes is moderate relative to both the V3 and the EU average.

In 2023, the efficiency of e-governance in Hungary was 79 percent of the EU average and 64 percent of the average for the TOP5 EU countries. In 2023, Hungary's second-to-last place in the ranking remained unchanged versus 2020. Despite recent developments in Hungarian public administration, there is still considerable room to boost digital efficiency in public administration.

HUNGARY'S ECOLOGICAL PRODUCTIVITY IS MORE FAVOURABLE THAN ITS OTHER PRODUCTIVITY FACTORS, BUT THERE IS STILL ROOM FOR IMPROVEMENT, E.G. BY INCREASING THE SHARE OF RENEWABLE ENERGY.

Hungary's ecological productivity is 81 percent of the EU average and 51 percent compared to the TOP5 EU countries' average.

In our analysis, the so-called ecological productivity is based on the sustainability of the use of natural resources and potentials, which ensures that long-term economic growth remains ecologically sustainable. One of the key indicators of ecological productivity in our analysis is value added per unit of environmental pollution. This indicator reflects the extent of the overuse of ecosystem services in general and its relationship to production. As the ecological productivity of an economy increases, it becomes possible to produce the same or higher volume of goods and services, with less environmental pollution.

Hungary's ecological productivity is 81 percent of the EU average and 51 percent versus the average for the TOP5 EU Member States. Hungary's eco-efficiency indicator has improved by 2 percentage points over the past two years compared to the EU average and by 1 percentage point compared to the average of the TOP5 EU countries. Although there have been positive changes in several areas in Hungary, relative improvement is slowed by the fact that other EU countries are making similar progress in eco-productivity. Hungary's ecological productivity is in line with the regional pattern.[2]

Value added per unit of carbon dioxide equivalent emissions has improved recently, but the EU average has improved even faster. In this respect, Hungary stands at 87 percent of the EU average and 56 percent compared to the average of the TOP5 EU countries.

In terms of material consumption efficiency, Hungary registered a significant improvement from 2020 to 2022, reducing the gap to the EU average. In material consumption, the Hungarian indicator reached 80 percent of the EU average and 46 percent compared to the TOP5 EU countries in 2022. In 2020, the values for Hungary were 72 and 40 percent respectively, i.e. Hungary moved closer to the EU and TOP5 averages for this indicator.

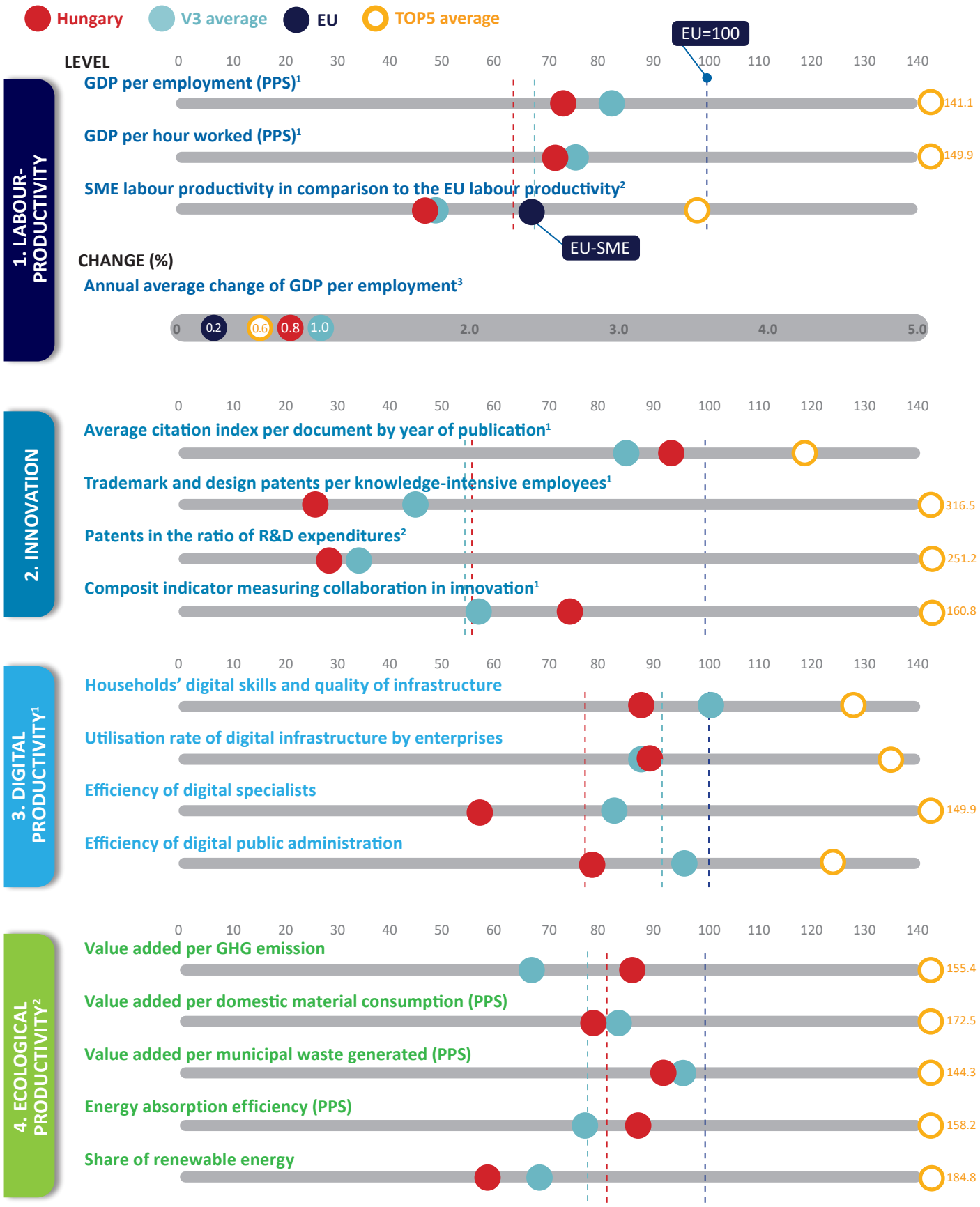
In an international comparison, Hungary lags behind significantly in the recycling of municipal waste. In 2022, the recycling rate of municipal waste in Hungary reached around 33 percent, while the other Visegrád countries all exceeded 40 percent. The average of the TOP5 EU Member States surpassed 61 percent in 2022. In Hungary, the waste management system has been completely restructured and some packaging is now being recycled, which may have a significant impact on future results.

Due to the penetration of renewable energy sources, dependence on fossil fuel fell significantly over the past one and a half decades. The share of electricity from renewables (biomass, hydro, solar and wind energy) has tripled in Hungary over the past decade and a half, accounting for 13 percent of total energy production. On average, renewables accounted for 18 percent in EU countries and 41 percent in the TOP5 EU Member States in 2022.

Overall, Hungary's eco-productivity is improving, but remains below the EU average in terms of levels, and the dynamics as well in some cases. Further significant improvements are needed to achieve sustainability and decarbonisation targets.

2 Bartus (2024).

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



[1] Based on 2023 data. [2]Based on 2022 data. [3]Average annual change of 2020-2023.

Source: MNB-calculations based on Eurostat, European Commission, DIW, WIPO, ScimagoJr databases.

1 Labour productivity

HUNGARIAN LABOUR PRODUCTIVITY IS LOWER THAN THE EU AND REGIONAL AVERAGES; THUS, IMPROVING PRODUCTIVITY REPRESENTS THE LARGEST SOURCE OF GROWTH.

Hungary's average for labour productivity indicators is 64 percent of the EU level and 49 percent of the TOP5 EU countries.

Introduction

Since the Covid-19 pandemic, the fundamental megatrends shaping our world, such as demographic shifts, geopolitical restructuring, rapid technological progress and the green transition, have intensified. The Hungarian economy rebounded quickly from the economic downturn caused by the pandemic in 2021. However, the Russia–Ukraine war that started in February 2022, as well as energy price shocks and accelerating inflation, have set back the recovery. Disruptions in supply chains and high transport costs have led to shortages of raw materials and production line stoppages. The combined effect of these factors reduced real GDP in Hungary and in several other EU Member States in 2023.

The pandemic was also a catalyst that accelerated the pace of digital technology adoption, and new technological solutions are driving rapid business adaptation. The achievements of the 4th industrial revolution and the rapid advance of artificial intelligence are putting companies under enormous pressure. More productive firms have more advanced infrastructure and a more skilled workforce, which helps them to adopt new technologies and thus stay in the market.

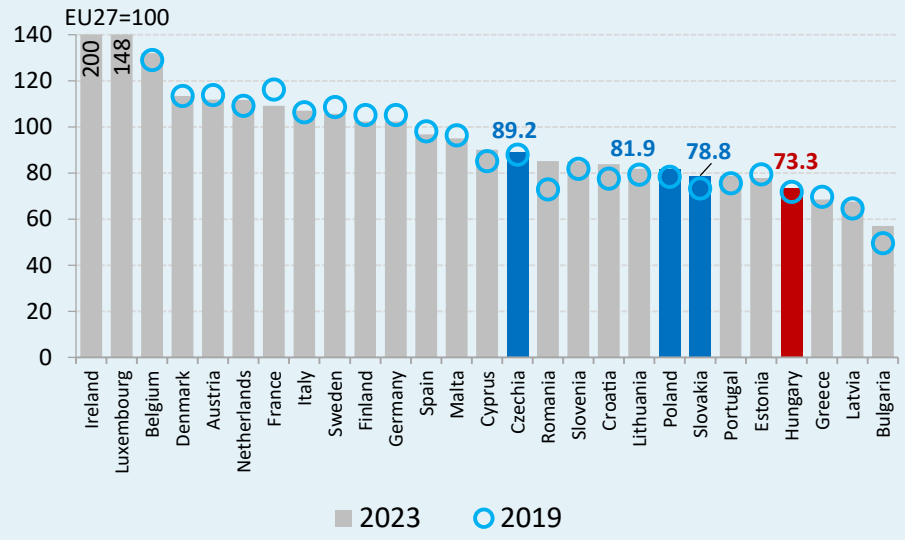
Productivity quantifies the value (added) that an economic unit – be it an enterprise, industry or country – is able to produce using one unit of input. Labour productivity is the most frequently used efficiency indicator, which indicates the value added per employee or working hour.

1.1 Hungary's labour productivity in an international comparison

The value of the pillar obtained from Hungary's various labour productivity indicators for 2023 amounts to 64 percent of the EU countries and 49 percent of the TOP5 EU countries. This indicator is the average of productivity per person employed, per hour worked and the productivity of the SME sector relative to the EU average, adjusted for purchasing power parity.

There is significant growth potential in domestic labour productivity (GDP per person employed): in 2023 this indicator stood at 73.3 percent of the EU average. This is 1.6 percentage points higher than the 71.7 percent recorded in 2019. In 2023, Hungary was still ranked 24th in the EU. The country's relative labour productivity position has increased only slightly, and thus further improvement in this indicator is essential to raise Hungary's economic development (Chart 1-1).

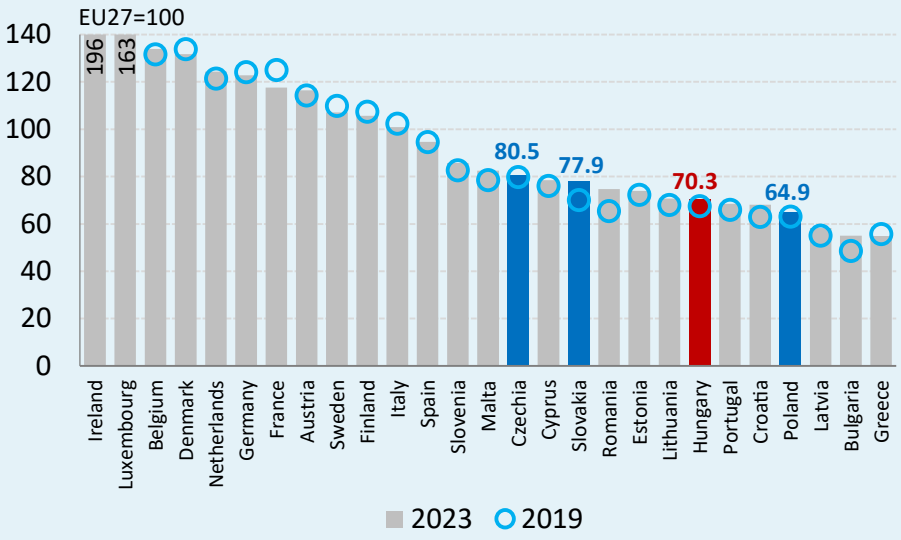
Chart 1-1: Labour productivity in the European Union (2023)



Note: GDP per person employed, in purchasing power parity.
Source: MNB calculation based on Eurostat data

Between 2019 and 2023, the value of GDP per hour worked relative to the EU average increased by 2.8 percentage points in Hungary (from 67.5 percent to 70.3 percent, Chart 1-2). In terms of GDP per hour worked, Hungary was in 21st place in the EU in 2023, ahead of Poland among the Visegrád countries. This indicator shows the value added produced in comparison to the hours worked in a given country, thus filtering out differences due to differences in the hours actually worked. In countries where the share of part-time workers is high and the average working time is shorter, this indicator may result in more favorable relative productivity than the per capita metric. In Hungary, the share of part-time workers was only 4.0 percent in 2023, the 5th lowest in the EU (the EU average is 17.8 percent), ahead of Bulgaria, Slovakia, Romania and Croatia.

Chart 1-2: Working hour-based labour productivity in the European Union (2023)

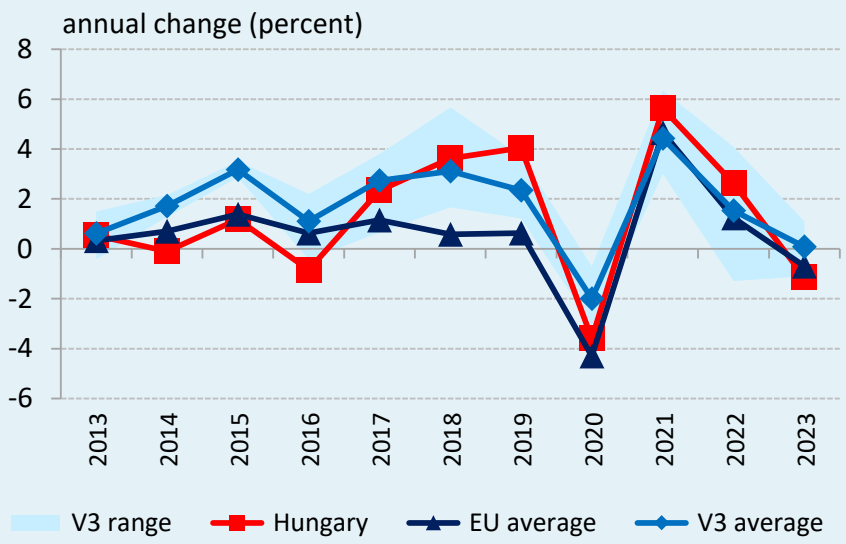


Note: GDP per hour worked, in purchasing power parity. For Belgium, 2022 data.
Source: MNB calculation based on Eurostat data

The evolution of domestic labour productivity can be broken down into three main stages over the past 10 years. First, the turnaround in growth after 2013 led to a period of extensive economic growth with employment expansion. During these years, labour productivity stagnated. Subsequently, in the 2017–2019 period, as the scope for extensive growth

narrowed, labour productivity rose by an average of around 3.3 percent, which was higher than the V3 average (2.7 percent) and significantly above the EU average of 0.8 percent. Productivity growth then slowed in the early 2020s, with domestic labour productivity rising by an average of 0.8 percent per year in the period 2020–2023. By way of comparison, the average for the same indicator in the V3 countries increased by 1.0 percent, while the EU average increased by just 0.2 percent (Charts 1-3 and 1-4).

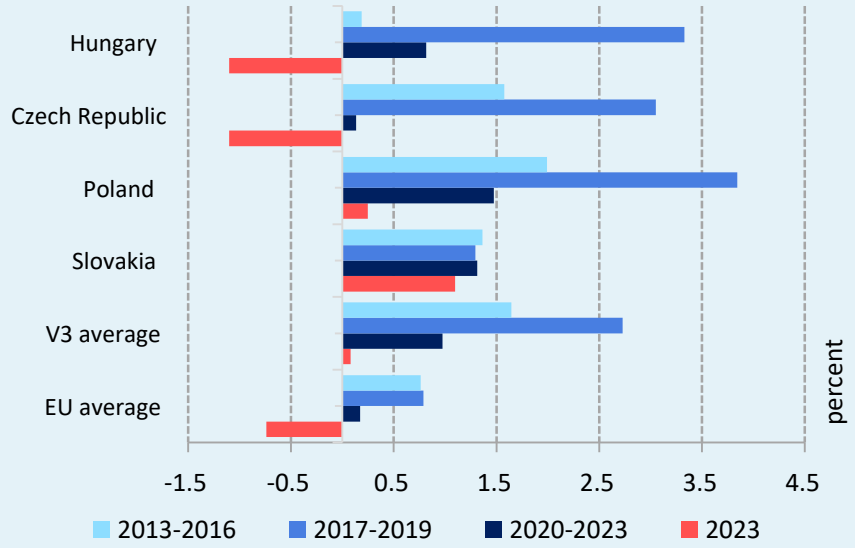
Chart 1-3: Annual change in labour productivity in the Visegrád countries and in the European Union (2013-2023)



Note: Real GDP per person employed. The V3 average is calculated as a simple arithmetic mean.
Source: MNB calculation based on Eurostat data

Measured in GDP per capita, Hungarian labour productivity increased by an average of 0.8 percent per year in the period 2020–2023, with high volatility over time (Charts 1-3 and 1-4). Despite the economic downturn in 2020, employment only dropped slightly thanks to the effective management of the crisis. The MNB increased liquidity by HUF 11,000 billion, which allowed economic policy to mitigate the economic contraction and the labour market reaction in a countercyclical manner. This temporarily reduced labour productivity by 3.6 percent during the pandemic. Thereafter, in 2021, real GDP per capita rose by 5.6 percent, in line with the recovery. In 2022, productivity improved by another 2.6 percent in Hungary, but then fell last year by 1.1 percent in line with economic performance. Employment grew by only 0.2 percent in 2023, but real GDP fell by 0.9 percent, and accordingly labour productivity declined overall. Similar trends can be observed internationally. The average of the V3 countries' indicators in the year of the outbreak of the war (2022) increased by 1.5 percent, and the EU average also increased by 1.2 percent. By contrast, in 2023, real labour productivity in Hungary and in the EU was already decreasing (1.1 and 0.7 percent, respectively), while the V3 average remained stable. Among the Visegrád countries, the Czech Republic recorded a similar decrease as Hungary last year, while Poland's indicator rose slightly (by 0.2 percent) and Slovakia managed to boost its efficiency by 1.1 percent. In Hungary, the exceptionally high inflation period in 2023 caused a major setback in corporate investment, with implications for productivity dynamics in the coming years. If firms have been forced to postpone technological improvements, related infrastructure investments and equipment purchases, this could have a negative impact on Hungary's future productivity.

Chart 1-4: Average annual change in labour productivity in the Visegrád countries and in the European Union (2013–2023)



Note: Real GDP per person employed. The V3 average is calculated unweighted, the EU average is weighted.
Source: MNB calculation based on Eurostat data

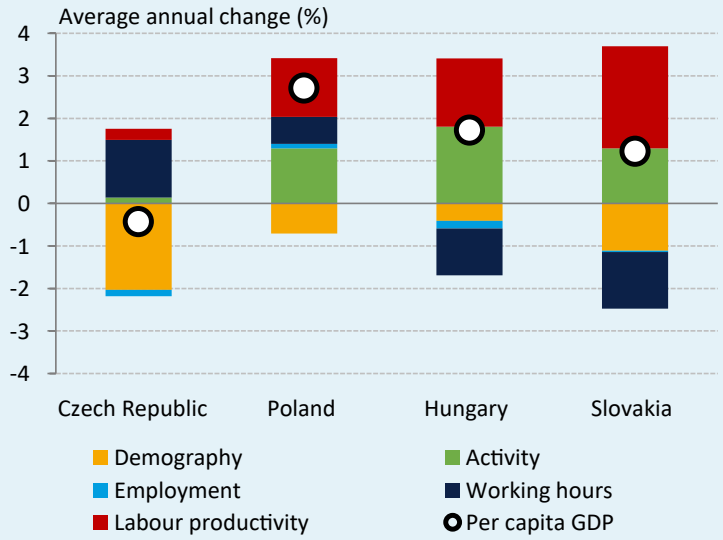
In the Visegrád region, Poland (2.7 percent) and Hungary (1.7 percent) saw the highest average annual increases in real GDP per capita (on a total population basis) over the period 2020–2023 (Chart 1-5). The relationship between GDP per capita and productivity can be described by the following formula.

$$\frac{\text{GDP}}{\text{Capita}} = \frac{\text{GDP}}{\text{Working hours}} \times \frac{\text{Working hours}}{\text{Employees}} \times \frac{\text{Employees}}{\text{Economically active persons}} \times \frac{\text{Economically active persons}}{\text{Working age population}} \times \frac{\text{Working age population}}{\text{Total population}}$$

With this formula, the impact of labour productivity per hour worked, the number of hours worked per person employed, employment, activity and demographic change can be separated in order. The demographic impact indicates the ratio of the working-age population (15–64 years) to the total 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 employed persons to the working-age population, but rather presents the ratio of employed persons to the active population. Similarly to the demographic component, the 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 employed person.

Activity and working hour-based labour productivity contributed to the rise in Hungarian GDP per capita in the period 2020–2023 (Chart 1-5). A long-standing trend in Hungarian society is that the decline in the working-age population exceeds the overall population decline: the demography component shows the impact of this, reducing the improvement in the Hungarian development indicator by 0.4 percentage points on average in the new decade. The increase in the country's activity rate shows that more people of working age (15–64) entered the labour market during the period, offsetting the deterioration in the demographic component by 1.8 percentage points. The employment factor, however, has declined somewhat, with relatively fewer of the higher proportion of the active population taking up work. The fall in the average number of hours worked was the main factor that reduced GDP per capita growth in Hungary (by an average of 1.1 percentage points per year). In Poland, on the other hand, the increase was mainly driven by labour market adjustment and, to a lesser extent, by productivity growth. The demographic factor has pushed back GDP per capita in all the countries of the region, and in the Czech Republic the decline in this factor was responsible for virtually all of the fall in GDP per capita. The patterns observed in Slovakia are very similar to those in Hungary.,

Chart 1-5: Decomposition of average annual change in real GDP per capita (2020–2023)



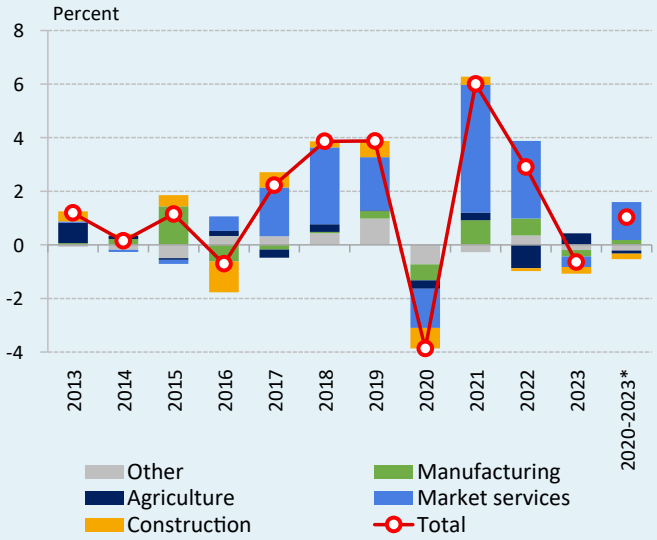
Note: Labour productivity component denotes real GDP per hour worked.
Source: MNB calculations based on Eurostat

1.2 Sectoral trends: services are driving productivity growth

In 2023, the sectors in Hungary generating the highest nominal value added were manufacturing (19.9 percent), trade-tourism-logistics (17.8 percent), and professional, scientific and support service activities (10.3 percent). Together, companies in these sectors accounted for nearly 50 percent of domestic value added last year. The productivity of these industries plays an outstanding role in the performance of the Hungarian economy.

In the 2020s, the modest increase in labour productivity was almost entirely due to the services sectors (Chart 1-6). In the period 2020–2023, developments in the productivity of the Hungarian economy were mainly determined by the productivity of service industries. During this period, market services sectors achieved an average annual increase in real labour productivity of 2.4 percent, while the efficiency of manufacturing firms remained stable. Service providers also accounted for nearly two thirds of the growth in 2017–2019, and the improvement in overall economic productivity in the new decade was almost exclusively due to companies in this sector. In 2023, however, labour productivity in market services firms fell by an average of 2.4 percent, while manufacturing experienced an even larger decline of 3.8 percent.

Chart 1-6: Breakdown of changes in labour productivity by industry across the whole economy (2013–2023)



*Note: *Average annual change. Market services include the following national economy branches: trade, infocommunications, finance and insurance, real estate transactions, professional, scientific and technical activities, and other services. The other group includes water and energy supply, government and mining industries.*
Source: MNB calculation based on Eurostat data

In 2023, the nominal labour productivity of financial intermediation remained outstanding at HUF 31 million per person employed, followed by infocommunications (HUF 17.7 million per person employed) and manufacturing (HUF 14.7 million per person employed) (Chart 1-7). With the shift of orientation towards a knowledge-based economy and digitalisation and current technological trends (see Box 1-1), the market penetration of infocommunications may be decisive for future production. Given its weight, the productivity of manufacturing is a key factor in the production of added value in the economy. At the sectoral level, the lowest productivity was still observed in other services (including, for example, repair of computers and other household goods) in 2023 (HUF 7.4 million per person employed). This was followed by construction and trade-tourism-logistics, with a value added per person employed of HUF 9.4 million and HUF 10.4 million, respectively.

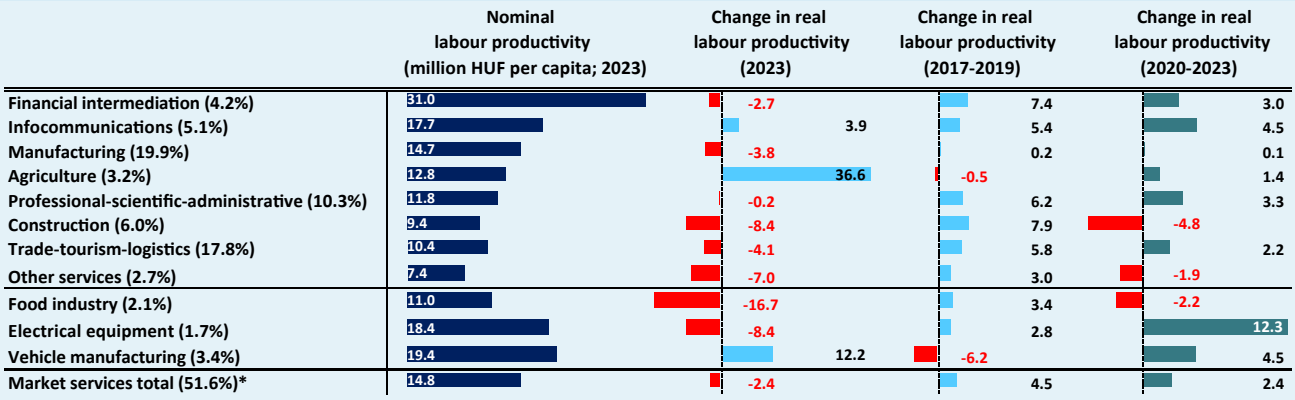
In the 2020–2023 period, all but a few manufacturing sectors and infocommunications experienced significantly lower average real labour productivity growth than in 2017–2019 (Chart 1-7). Average annual productivity growth in the infocommunications sector amounted to 4.5 percent between 2020 and 2023. Accordingly, companies in this sector were able to come close to the combined growth rate of the last three years of the preceding decade (5.4 percent), despite the many economic challenges in the new decade. However, during the successful period 2017–2019, the combined growth of the market services sector (4.5 percent) was still close to the growth of infocommunications (5.4 percent), while in the new decade the technology sector's performance was 2.1 percentage points higher than the average for the market services sector (2.4 percent).

The growth in labour productivity of companies in the infocommunications industry is closely linked to the increased demand for digitalisation (e-commerce, online services) and the rapid spread of digital technological innovations in recent years (see the chapter Digitalisation efficiency for more details). The information and communication sector are particularly scalable, as the digital technology services provided (e.g. software, cloud technology) can be expanded to a very large extent without increasing marginal costs. In addition, infocommunications companies are also highly adaptable to rapidly changing technological trends. The use of infocommunications output as a factor of production significantly increases firms' efficiency in almost every other sector (Anghel – Bunel 2024). Automating or making their processes more efficient, for example, increases the substitutability between labour and capital, and improving data security reduces the risks of operational disruptions.

Labour productivity in the manufacturing sector increased only marginally on average per year in the 2017–2019 period (0.2 percent) and in the 2020–2023 period (0.1 percent), but performance in the individual industries varies strongly (Chart 1-7 and Chart 1-8). Real labour productivity in manufacturing grew by 3.0 percent in 2022 but fell by

3.8 percent in 2023. However, there are significant differences in the performances of different manufacturing industries. Electrical equipment manufacturing, computer manufacturing and vehicle manufacturing were seen as the overall drivers of the modest manufacturing labour productivity growth in the 2020–2023 period. In vehicle manufacturing, which represents the largest value-added weight in manufacturing (16.9 percent), labour productivity rose by 4.5 percent on average during 2020–2023. The manufacturing of electrical equipment, which is also a large manufacturing industry (8.7 percent), saw a 12.3-percent increase in real labour productivity, while computer and electronic products grew by 5.3 percent. However, in the manufacturing of electrical equipment, the indicator fell significantly by 8.4 percent in 2023. The above manufacturing industries produce with a very high share of imports, and thus the share of domestic value added in their output is low: only 15.6 percent in vehicle manufacturing and 19.2 percent in electrical equipment (the manufacturing average is 23.6 percent). By comparison, this rate averages 58.8 percent in respect of the output of companies in the market services sector.

Chart 1-7: Labour productivity characteristics of Hungarian sectors



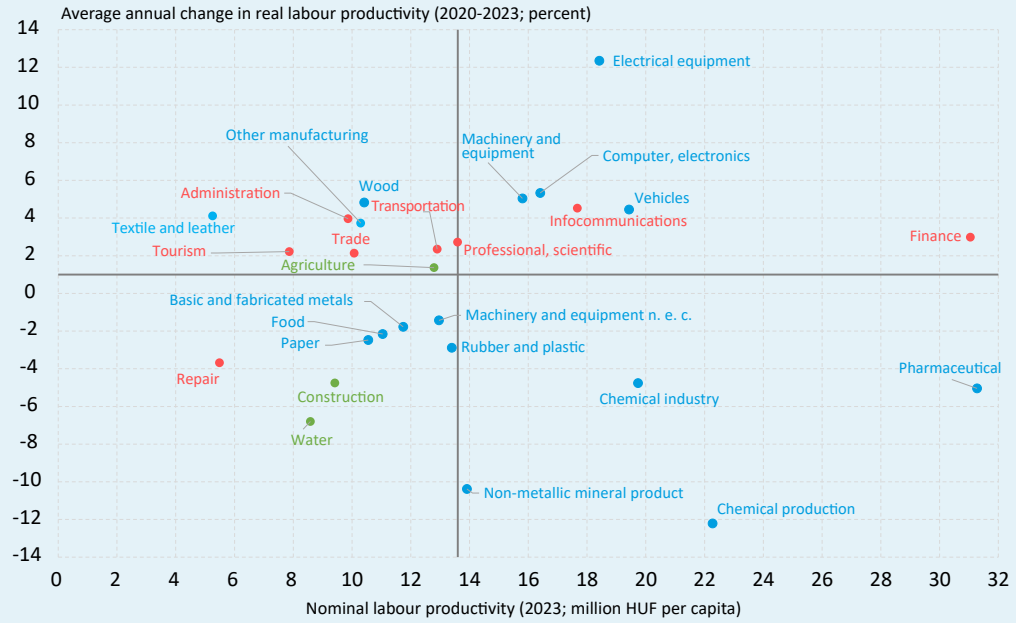
*Note: Changes represent average annual changes. In the first column, the weight of the sectors in (nominal) value added in 2023 is given in brackets. *Market services include the following economic industries: trade, infocommunications, finance and insurance, real estate transactions, professional, scientific and technical activities, and other services.*
Source: MNB calculation based on Eurostat data

In 2023, the value added per person employed indicator for agriculture increased significantly (36.6 percent), and this indicator also expanded in the vehicle manufacturing (12.2 percent) and information and communication (3.9 percent) industries. However, productivity in most sectors fell last year (Chart 1-7). The main reasons behind the change in agriculture are cyclical rather than structural. In July 2022, Hungary was hit by an extreme drought.[3] The worst years for domestic agriculture are typically associated with drought. The surge in 2023 is mainly a correction of this low base. In 2023, the productivity of firms in the market services sector fell by an average of 2.4 percent, while that of manufacturing firms dropped by 3.8 percent. Last year, labour productivity fell by 4.1 percent and 0.2 percent in the largest branches of market services, namely trade-tourism-logistics and professional, scientific and administrative activities, respectively. The infocommunications sector continued to improve, with productivity up 3.9 percent in 2023.

Several high value-added industries were able to increase labour productivity faster than the national average (1.0 percent) in the 2020–2023 period (Chart 1-8). In respect of market services, infocommunications, financial services and professional and scientific activities are among the sectors that were more productive than the whole economy average (HUF 13.6 million per person employed) in 2023 and also increased their productivity during the 2020–2023 period. The productivity dynamics of services sectors were less affected by the crises of the 2020s: only the productivity of the low-weighted other services (repair) declined in this period. Among the manufacturing sectors, as discussed above, electrical equipment, computer and electronic products, vehicle manufacturing, machinery and petroleum refining were the high productivity sectors that also showed above-average growth in the new decade. In the period 2020–2023, the largest productivity losses were suffered by chemical companies (pharmaceuticals, chemical material production, rubber and plastics) with high raw material and energy requirements. The construction and food industries have lower labour productivity levels than the whole economy average and their real productivity has fallen in recent years.

3 In Hungary, the drought of 2022 was the only one since 1992 to reach the moderate drought category according to the Pálfai Drought Index.

Chart 1-8: Level and average change in labour productivity in domestic industries



Note: Value added per person employed. Manufacturing is shown in blue, market services in red and other sectors in green. The solid lines represent the averages of the national economy. Values for sectors not shown in the figure (HUF million/person; percent): Mining: (53.7; 4.8); Petroleum refining: (109.5; 1.2); Energy sectors: (45.0; 15.3).

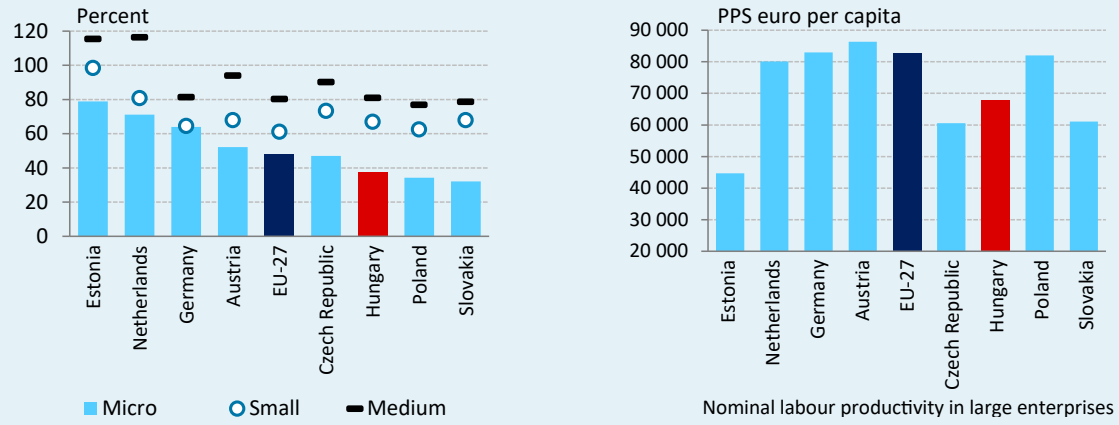
1.3 Comparisons by enterprise size

The labour productivity of SMEs in Hungary reached 54.4 percent of the indicator for large enterprises, compared to 60 percent in the EU. This type of duality decreased after 2012 until 2018 (as the relative productivity of SMEs improved from 47.9 percent to 58.6 percent) and then gradually increased until 2021 (52.2 percent). The productivity gap between SMEs and large enterprises remained significant in Hungary in 2022: the productivity gap of microenterprises relative to large enterprises was 37.8 percent, that of small enterprises 67.0 percent and that of medium-sized enterprises 80.9 percent, respectively (Chart 1-9, left panel). 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 results in the fact that, in its own right, the productivity of large corporations exceeds the indicators of smaller enterprises. The 2022 indicators show that the relative performance of Hungarian SMEs (54.4 percent of large companies) is somewhat better than in the Slovak percentor Polish economies (48.7 percent and 50.9 percent, respectively). Microenterprises achieve 32.1 percent of the efficiency of large enterprises in Slovakia and 34.2 percent in Poland, and 47 percent in the Czech Republic. The relative labour productivity of small firms in these three countries is 67.9 percent, 62.6 percent and 73.4 percent, respectively, compared to large firms. Productivity among medium-sized enterprises is more than three quarters of that of large enterprises in all the economies in the region, coming in at 80 percent in Hungary and 90 percent in the Czech Republic.

Around 99.9 percent of domestic companies are SMEs, forming the backbone of the economy in terms of both value creation and employment. Promoting the efficiency of this segment of companies and – closely related to this – their activity in foreign markets is therefore of key importance for Hungary's competitiveness. Today, only 4.7 percent of SMEs in competitive sectors in Hungary sell abroad (the EU average is 6.8 percent). Increasing this ratio would also increase the share of domestic value added in exports, as their production is less import-intensive than that of large firms. It is important that SMEs remain competitive in the labour market against large companies. If SMEs cannot improve efficiency, they will lose the skilled workforce needed to adopt advanced technologies, for example.

In Hungary, the labour productivity of large enterprises is below the EU average, mainly due to the low share of domestic value added in production. Large enterprises mainly produce for export, and the Hungarian economy has the fourth lowest domestic value added for exports in the EU (54.1 percent), while the Polish economy, for example, demonstrating more successful convergence in recent years, has a much higher domestic value added ratio of around 71.1 percent. Hungary's lower domestic value added ratio can also be attributed to the high import content of goods sold abroad (vehicles, replacement parts, electronic equipment) and the low level that capital inflows are embedded in domestic production networks.

Chart 1-9: Labour productivity as a percentage of large enterprises (2022) and the labour productivity of large enterprises (2022)



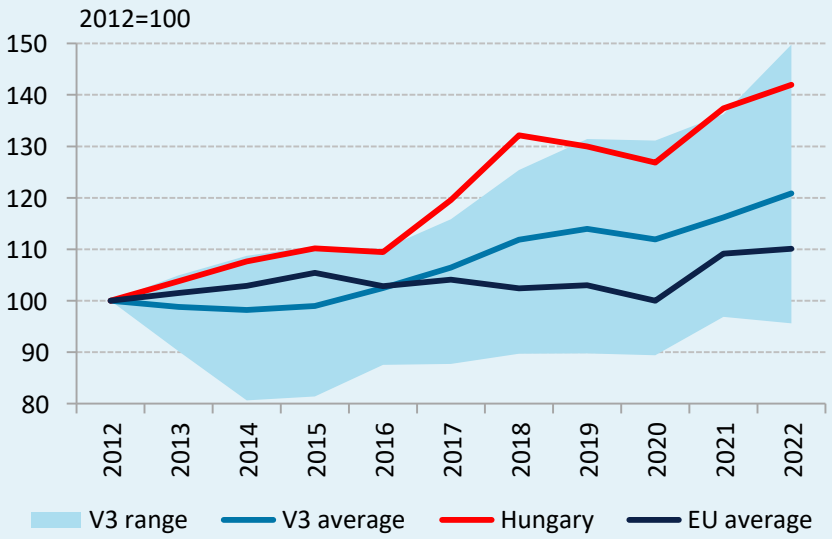
*Note: * 2022 data for Hungary and the Czech Republic, 2021 data for the other countries. The entire SME segment includes all sectors from mining and quarrying to administration (Sections B to N), except financial intermediation (Section K).*
Source: MNB calculation based on Eurostat and DIW-ECON data

The difference between domestic and foreign-controlled companies remains high but has been declining somewhat since the second half of the 2010s. Dual trends in 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 companies.[4] Foreign companies were typically three times more productive than Hungarian-owned companies from 2010 to 2016. This ratio started to gradually narrow from 2017, and in 2021 the gap was two and a half times. The foreign productivity advantage in relation to ownership is closely related to the Hungarian corporate structure, as large manufacturing companies located in Hungary are typically foreign owned. Moreover, all else being equal, foreign subsidiaries typically use higher-quality technology. During the intensive growth phase from 2017, the productivity gap started to narrow due to the performance of the mostly Hungarian-owned SME sector.

Over ten years (2013–2022), the real labour productivity of Hungarian SMEs increased by 42 percent, while the average for the overall economy rose by 16.2 percent over the same period. This growth is more than four times the EU SME average (10.1 percent) and almost double the V3 countries' SME average (20.9 percent) (Chart 1-10). In the period 2017–2019, the annual average growth rate of Hungarian SMEs' productivity was 5.9 percent, while in the V3 countries it improved by 3.6 percent and the EU average for SME productivity stagnated. Only Poland (with average growth of 6.1 percent) outperformed the Hungarian dynamics in this period. In contrast to the trends at the regional and EU levels, the labour productivity dynamics of Hungarian SMEs already started to decline in 2019, and efficiency deteriorated further during the 2020 pandemic. By contrast, the improvement in productivity at SMEs in the V3 countries ended in the year of the outbreak. The average productivity of EU SMEs remained essentially unchanged throughout the 2010s, and then, in the year of recovery in 2021, EU SMEs on average increased their productivity by 9.1 percent, above that of Hungarian firms (8.3 percent). Productivity growth in the narrower region after the pandemic (2021) was less than half of the EU and Hungarian growth (3.8 percent). Overall, thanks to the growth registered between 2012 and 2022, the cumulative productivity growth of Hungarian SMEs was 42 percent, well above the regional average, with only Poland performing better than Hungary (growth of 49.8 percent). The growth phase in 2017–2018 played a key role in this, with average annual efficiency improvements of around 10 percent in the Hungarian SME segment.

4 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 in multiple ownership dimensions, instead of considering only direct ownership subordination.

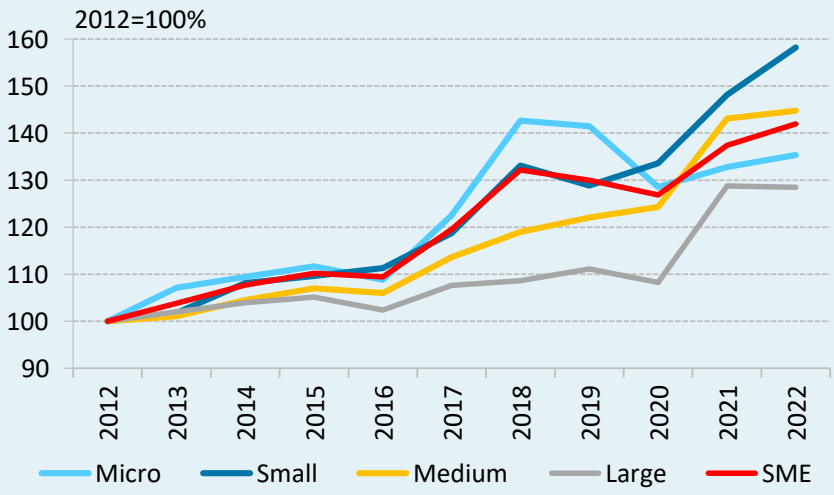
Chart 1-10: Labour productivity of SMEs in a regional comparison (2012–2022)



Note: Real value added per employed person, weighted by employment. Time series by size class have been adjusted by sectoral deflators. The entire SME segment includes all sectors from mining and quarrying to administration (Sections B to N), except financial intermediation (Section K).
Source: MNB calculation based on Eurostat and DIW-ECON data

In the period 2020–2022, productivity growth at SMEs averaged 3.0 percent per year, about one half of the growth rate registered for 2017–2019 (5.9 percent) (Chart 1-11). Productivity growth at large enterprises rose by 2.8 percent and 4.9 percent, respectively, during these periods. The SME and large firm figures exceed the national economy data, because the SME statistics cover only a subset of industries and because data by size category are not yet available for the weak year 2023 (in 2023, real labour productivity in the national economy fell by 1.1 percent). The indicators calculated for SMEs include areas where firms are largely market-based (e.g. public sectors, education, health, public administration are not included), and agriculture, which is highly volatile due to weather fluctuations, is not included. The fastest growing segment in the 2017–2019 period was the micro-enterprise group (annual average of 9.1 percent), with small businesses increasing their efficiency the most in the 2020s (7.1 percent).

Chart 1-11: Evolution of SMEs' real labour productivity in Hungary, by enterprise size (2012–2022)



Note: Real value added per employed person, weighted by employment. Time series by size class have been adjusted by sectoral deflators. The entire SME segment includes all sectors from mining and quarrying to administration (Sections B to N), except financial intermediation (Section K).
Source: MNB calculation based on Eurostat and DIW-ECON data

Box 1-1: Productivity differences between the EU and the US in the light of digital technologies

The US has averaged an annual economic growth rate of 2.2 percent over the past quarter of a century or so, versus 1.5 percent in the European Union. In both of these major economic regions, labour utilisation growth added 0.4 percentage points to GDP growth during the period 1999–2023. The expansion of the capital stock contributed slightly more to economic growth in the US, by 0.8 percentage point, versus 0.6 percentage point in the EU. Thus, the main driver behind the higher economic dynamics in the United States was brisker efficiency improvements, as reflected in total factor productivity (TFP). This factor added almost twice as much to annual average GDP in the US, 1.0 percentage point, compared with 0.6 percentage point in the EU (Table 1-1).

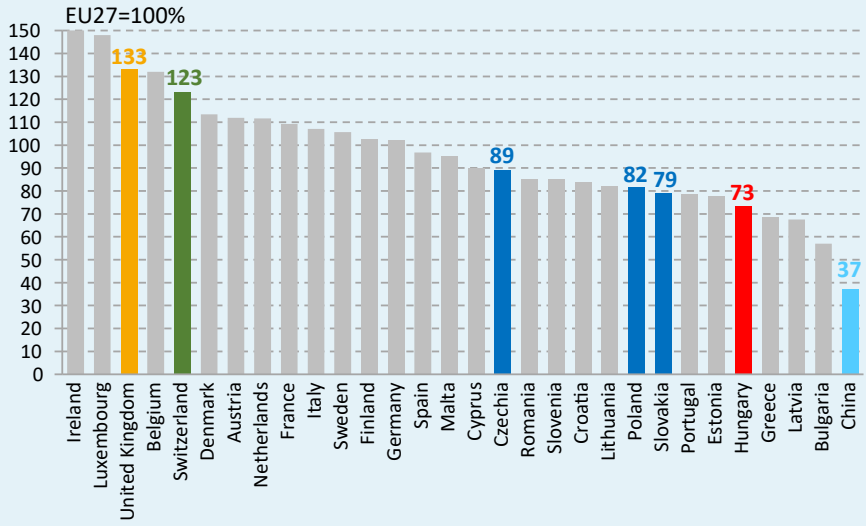
Table 1-1: Breakdown of GDP growth by growth factors (1999–2023)

Growth factors	US	EU27
Labour	0.4	0.4
Capital	0.8	0.6
TFP*	1.0	0.6
Average annual GDP growth (1999-2023)	2.2	1.5

*Note: *Total factor productivity.*
Source: MNB calculation based on Eurostat and OECD data

The US labour productivity level in 2023 was about 33 percent higher than the EU average (Chart 1-12). In purchasing power parity terms, US employment-based labour productivity exceeded that of all EU Member States except Ireland and Luxembourg. However, apart from these two countries, only Belgium comes close to the US productivity performance, with all other Member States lagging behind by at least 20 percentage points.

Chart 1-12: Labour productivity levels in the US, China, Switzerland and EU Member States (2023)



Note: GDP per person employed at purchasing power parity.
Source: MNB calculation based on Eurostat and OECD data

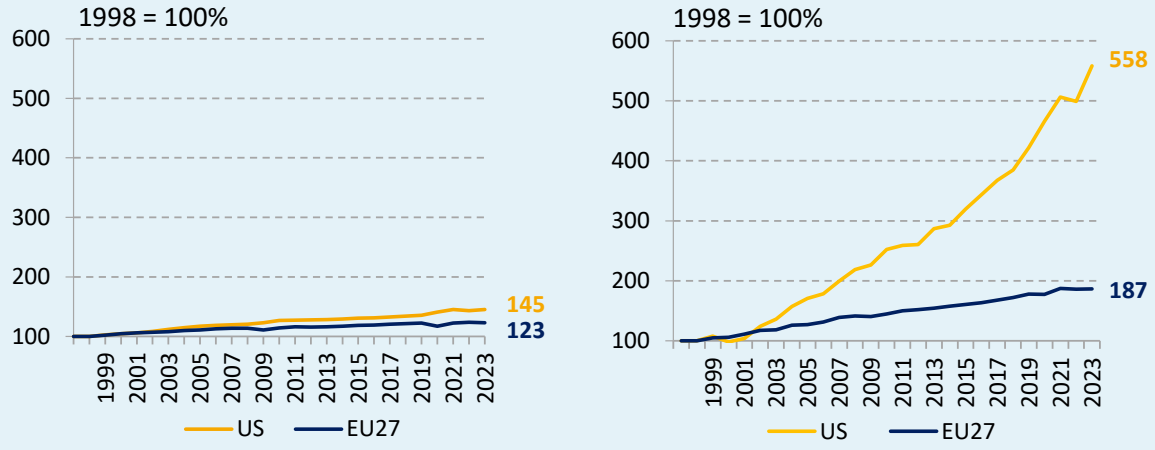
Much of the labour productivity difference is explained by the performance of the ICT sector, where US productivity has more than quintupled over the past 25 years, while in the EU it has nearly doubled. For the economy as a whole, real labour productivity has increased by 45 percent in the US and 23 percent in the EU since 1998. By contrast, the ICT sector experienced a very significant expansion, reaching 558 percent of its 1998 value in the US in 2023 and 187 percent in the EU (Chart 1-13).[5]

5 The EU and US ICT sectors do not fully correspond, as the latter classifies activities according to the North American Industry Classification System (NAICS).

The labour productivity gap between the US and the EU was driven to a lesser extent by capital deepening and to a greater extent by the faster rise in US TFP. The faster growth in efficiency, which is closely linked to the performance of the ICT sectors, contributed 1.0 percentage point to the average annual US labour productivity improvement of 1.4 percent between 1998 and 2023, with the other part of the increase coming from capital deepening.[6] The EU's labour productivity increased by an annual average of 0.8 percent in this period, with the efficiency factor contributing 0.6 percentage point.

Over the past decades, EU companies have been unable to adopt the most advanced technologies in a timely and adequate manner. The link between technological progress and productivity growth is far from clear. For the availability of new technologies to translate into efficiency gains, a number of conditions are necessary. Of these, the availability of the right human competences is of paramount importance. Around 60 percent of EU companies surveyed said they had difficulty finding information and communication technology (ICT) professionals to fill vacancies (DESI 2024). In the EU, 44 percent of 16–74 year olds lack even basic digital skills (DESI 2024). ICT investment as a share of GDP is 2.9 percent in the EU and 3.7 percent in the US. Together, these factors contribute to the lower digital maturity of EU companies, especially SMEs, compared to their US counterparts. Furthermore, the larger average company size in the US is associated with higher corporate digital adoption.

Chart 1-13: Real labour productivity developments in the national economy (left panel) and the ICT sector (right panel)



Source: MNB calculation based on Eurostat, Bureau of Economic Analysis

The European Union lags significantly behind the US in digital technology innovation. In 2023, the US had around ten times as much (0.5 percent) venture capital investment in ICT companies as a share of GDP as the EU (0.05 percent) (OECD). This form of financing plays a significant role in bringing high-risk, game-changing technological innovations to market.

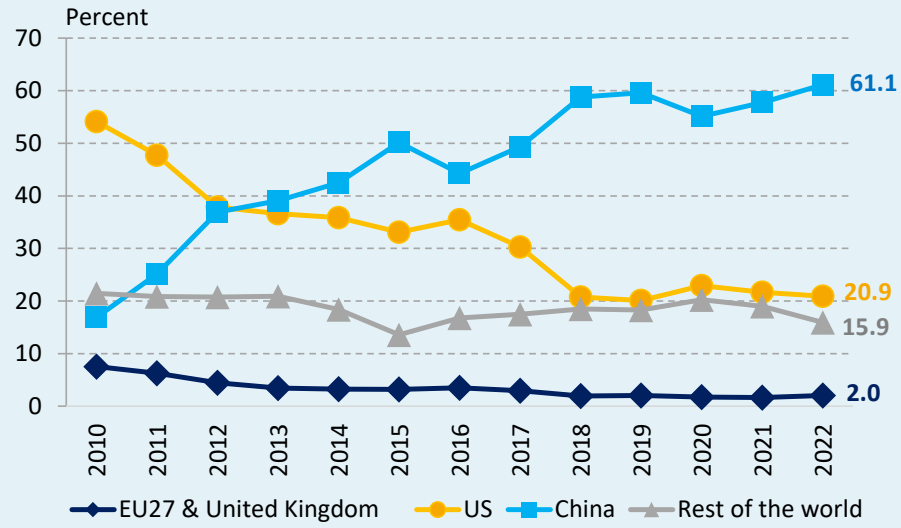
About one half of global venture capital investment originates in the US and only 5 percent in the EU. The share of ICT patents in total patents is 36.1 percent in the US and only 19.7 percent in the EU. The extent of the gap is illustrated by the fact that only three of the world's top 50 tech companies are European.

The EU is steadily falling behind in the latest wave of technology, artificial intelligence (AI). The EU missed out on the efficiency gains from the spread of the internet two decades ago, and then failed to take the lead in the cutting-edge technologies of the last decade (smart devices, blockchain, etc.). AI is spreading very fast: research from the US suggests that the adoption of generative AI is much faster than that of the internet or personal computers (Bick et al. 2024). In addition, the technology is changing and evolving at an extraordinary pace: globally, the number of AI patents granted increased more than twelvefold between 2017 and 2022 (from 5,000 to over 60,000) and the number of scientific publications more than doubled (from 110,000 to over 230,000). China accounts for 61 percent of all AI patents worldwide, the US for 21 percent and the EU for only 2 percent (Chart 1-14). We would note that although China dominates the competition for AI in terms of quantity on a number of metrics, the US still leads when qualitative

6 Capital deepening or capital intensity refers to the increase in capital per employee.

aspects are taken into account. Most of the top AI models are still developed in the US (Maslej et al. 2024). The US still has the edge in the use of venture capital. US venture capital investors, by final owner, accounted for 43 percent of global AI venture capital investment in 2020, China for 20 percent and EU investors for 9 percent, according to OECD data. In 2023, the US invested around five times as much venture capital in AI, as a share of GDP (0.2 percent of GDP) as the EU (0.04 percent of GDP). Globally, 61 percent of venture capital investments in AI startups are from the US, 17 percent from China and only 6 percent from the EU (Draghi 2024).

Chart 1-14: Granted AI patents (% of world total) by geographic area (2010–2022)



Source: Artificial Intelligence Report (Maslej et al. 2024)

The EU will need to play a much more intensive role in the AI revolution if it wants to remain competitive in global markets. For the first time in its history, the EU has reached a stage where it can no longer rely on population growth for economic expansion. The declining population will require a stronger increase in productivity than hitherto. If the EU cannot exceed the average productivity dynamics since 2015 in the future, its GDP will stagnate until 2050 (Draghi 2024).

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2 Efficiency of innovation

THE CRISES OF RECENT YEARS HAVE REDUCED THE REAL VALUE OF COMPANIES' INNOVATION SPENDING, LEADING TO A SLIGHT DETERIORATION IN INNOVATION EFFICIENCY AND A DECLINE IN RESULTS.

Hungary's innovation efficiency is 55 percent of the EU average and 36 percent compared to the TOP5 EU countries.

Introduction

Innovation is a key driver of economic performance and sustainable growth. The Productivity Report 2022 showed that innovation is a key element of economic dynamism, especially in developed countries. Limited human and physical resources are also increasing the importance of innovation in converging countries.[7] Innovation is crucial in the transition from quantitative to qualitative growth models. Continuous and even increasing innovation efforts are therefore needed for the sustainable development and convergence of the economy and to maintain the competitive advantage of developed countries. In addition, it is of paramount importance that R&D expenditure result in economically exploitable outputs (patents, trademarks, know-how or other intellectual products) (Baksay – Matolcsy – Virág 2022, Chapter 4).

In the framework of the MIT REAP programme, the MNB has researched the most promising companies in the domestic innovation ecosystem, which were identified by taking into account the specificities of Hungary. The Hungarian Innovation Driven Enterprises (HIDE) group consists of firms that have some kind of innovation effort or outcome (patent, trademarked brand, R&D expenditure tax credit, or R&D-related government support) and either have a fast-growing (gazelle) status or, although no longer gazelles, have shown strong export performance. According to the research, there are around 1,100 innovation-driven companies in Hungary, which – despite only comprising 0.3 percent of all operating Hungarian companies – accounted for 13 percent of total gross exports and 22.8 percent of the annual incremental GDP growth in Hungary on average for the 2010s.

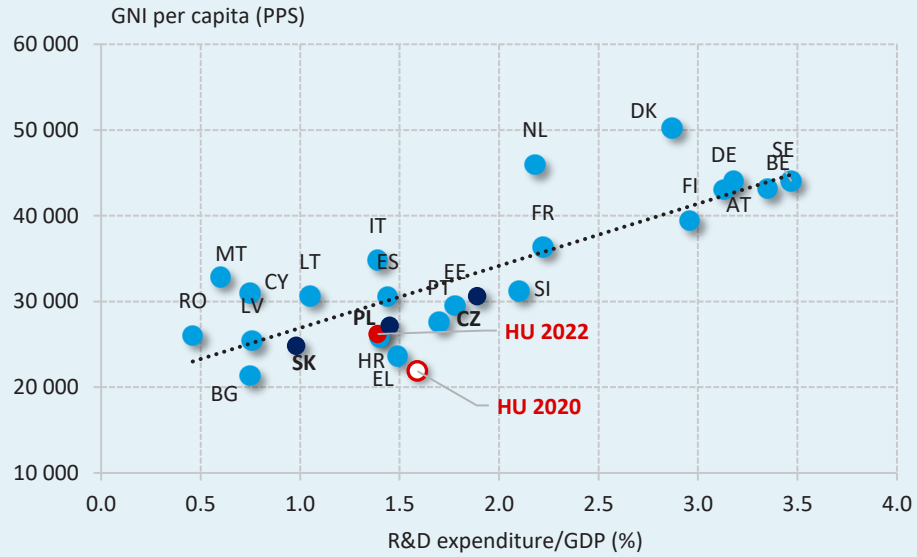
2.1 Innovation spending has fallen as a result of the crisis

In many cases, innovation spending and the resulting outcomes can differ significantly, so we look at the most important indicators for Hungary separately. Innovation is a highly complex process, ranging from the creation of new processes, products or scientific results to the introduction of new organisational structures, packaging and designs. However, in the analysis, it is useful to separate the processes of research, development and innovation and their effectiveness, both for policy design and for efficiency evaluation.

In the 2020s, R&D expenditure as a share of GDP in Hungary decreased but is not significantly different from the regional average. While Hungary's R&D expenditure as a share of GDP fell from 1.6 percent in 2020 to 1.4 percent in 2022, the EU average stagnated at 1.8 percent despite the economic shocks in recent years. Domestic expenditure is thus below the Czech level, but above the Slovak one, and significantly above the Romanian level and close to the Polish one. If we compare R&D expenditure with the level of economic development, we find an increasing relationship among EU countries (Chart 2-1).

7 For more details see Griffith (2000).

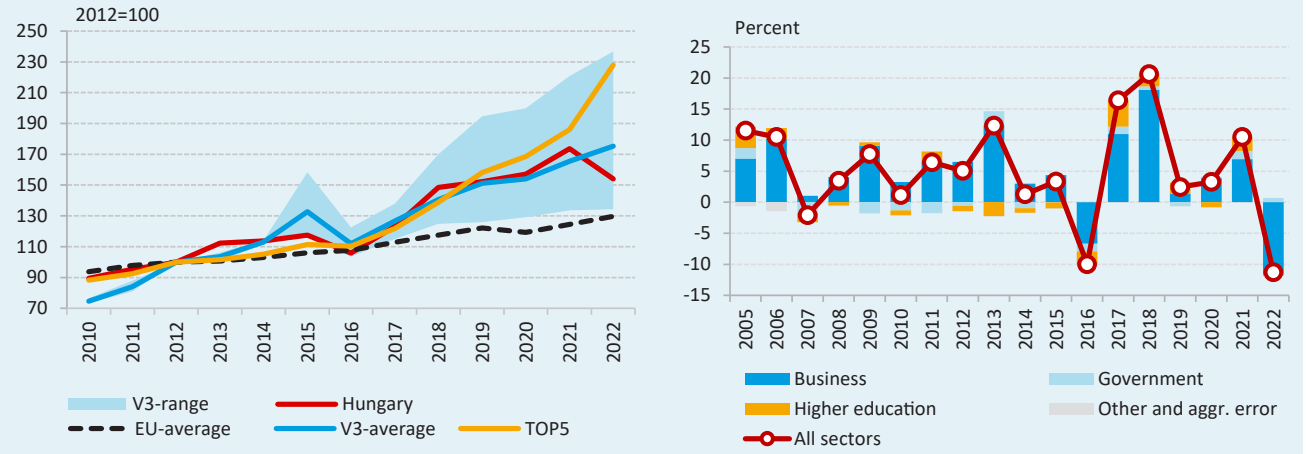
Chart 2-1: Ratio of research and development expenditures and GNI per capita (2022)



Note: Gross national income per capita (GNI) at purchasing power parity (PPS). Due to their specific economic structure, Ireland and Luxembourg, with their high GNI values, are not included in the chart.
Source: MNB calculation based on Eurostat data.

After a sustained rise, the real value of R&D expenditure declined in 2022, mainly due to a fall in business spending. Over the past nearly ten years, Hungary and the Visegrád countries have all outperformed the EU average in terms of real R&D expenditure growth (Chart 2-2, left panel). However, in contrast to the average of the other regions surveyed, Hungary experienced a decline in 2022, bringing real R&D expenditure back to the 2019 level. This decline was driven by a significant reduction in business R&D expenditure, while the decline in higher education and government expenditure was more subdued (Chart 2-2, right panel). The fall in business spending followed the change in the business cycle, which slowed sharply in 2022 due to a sharp rise in European energy prices, rising inflation and falling internal and external demand.

Chart 2-2: Change in real R&D expenditure in the CEE region and in Europe (left panel) and annual change in Hungary's real R&D expenditure by sector (right panel)



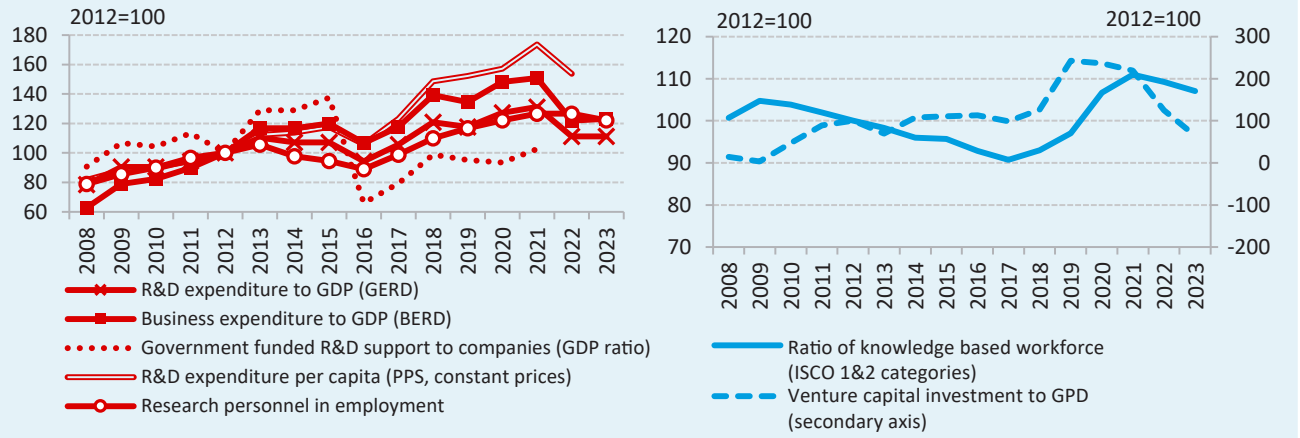
Note: The TOP5 countries were defined based on the data available for last year and were plotted as a simple arithmetic average of the values for the same countries retrospectively. In order, the TOP5 countries were: Ireland, Poland, Croatia, Malta and Cyprus.
Source: MNB calculation based on Eurostat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

On the expenditure side, the upward trend in both R&D and market innovation indicators broke in 2022.[8] The data in Chart 2-3 show that most of the input indicators have increased significantly since 2008, especially after 2016. The 2020 Covid-19 pandemic did not lead to a drop in spending, but the energy crisis and inflation that emerged in 2022 hit

8 For transparency, time series related to R&D processes are shown in red, while indicators reflecting innovation processes are shown in blue. This approach allows a clear insight into the different stages of the innovation chain and a precise assessment of how the links between resources and outcomes are evolving

business R&D spending hard. In Hungary, R&D expenditure in the technical field, especially in the mechanical and automotive engineering sector, accounts for about two thirds of total R&D expenditure, and thus the crisis in the European automotive industry has had a direct impact on R&D expenditure in Hungary.

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

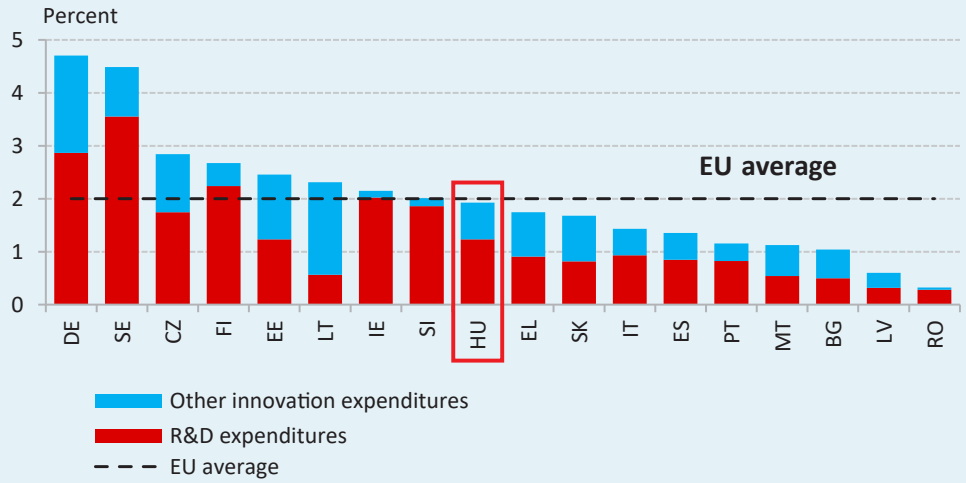


Note: The number of researchers as a share of total employment is an hour-based indicator. The share of knowledge-intensive employees is calculated on the basis of the two employment categories requiring the highest qualification (examples include: economic, administrative, advocacy leaders and legislators, technical, IT and science occupations, health occupations requiring a degree in tertiary education, professors, teachers, management, legal occupations).
Source: MNB, based on HCSO, OECD and Eurostat

Innovation expenditure indicators (marked in blue) have been decreasing since 2021. The share of people in knowledge-intensive jobs declined during the period of extensive labour market expansion but reversed in 2017 and gradually increased until 2021. In 2020, their share already reached 22–23 percent, exceeding the levels before the 2008–2009 financial crisis. During this period, employment in the national economy also grew substantially, with the number of people employed in knowledge-intensive jobs increasing significantly by 271,000 between 2008 and 2021. However, the decline in R&D expenditure after 2021 is accompanied by a moderate decline in the share of knowledge-intensive employment, which may be explained by the cumulative economic crises of recent years. Venture capital investment surged in 2019, followed by stagnation in 2020–2021 and a decline in 2022–2023. As with other indicators, this was mainly due to the deterioration in the economic environment and uncertainty about the outlook. A positive macroeconomic outlook is particularly important for venture capital investments.

In terms of broader innovation-related expenditure, Hungary ranks in the middle of the European field (Chart 2-4). While R&D expenditure is relatively easy for statistical offices to track, so-called 'softer' innovation expenditure – typically related to market innovation – rarely appears in official statistics. To compensate for this, the biannual Community Innovation Survey (CIS) measures other market innovation-related expenditure. This includes capital goods, intangible goods, purchased services and wage-related expenditure related to innovation. The results show that the total innovation expenditure of Hungarian companies amounted to 1.9 percent of GDP in 2022, slightly below the EU average.

Chart 2-4: Corporate innovation expenditure as a percentage of GDP (2022)

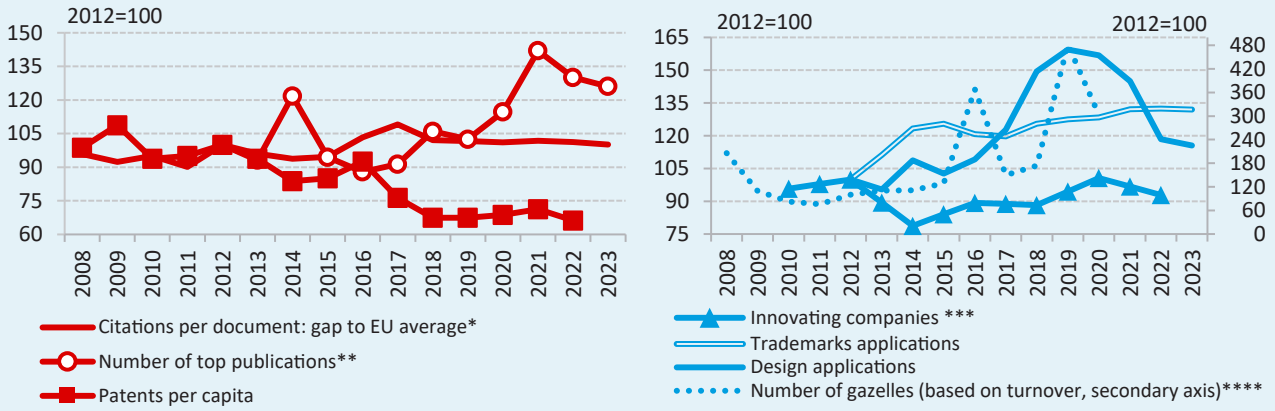


Note: Corporate R&D expenditure is calculated on the basis of the CIS survey, which may differ from the official BERD (Business Expenditure on Research and Development) data. In the 2022 CIS survey release, data are only available for the 18 countries shown in the chart.
Source: MNB calculations based on Eurostat (CIS).

2.2 Innovation results reflect a reduction in expenditure

Most output measures have also been affected by the adverse economic environment (Chart 2-5). Among the innovation output measures (in blue), the number of trademark submissions has stagnated, but design submissions have steadily decreased since 2019, falling to 2017 levels by 2023. After 2020, the share of enterprises engaged in innovation activity decreased in both 2021 and 2022. Among the research and development indicators (marked in red), the substantial increase in the number of Hungarian publications in highly-ranked scientific journals stands out, which despite the decrease in 2022 and 2023 still exceeds the 2020 level.

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

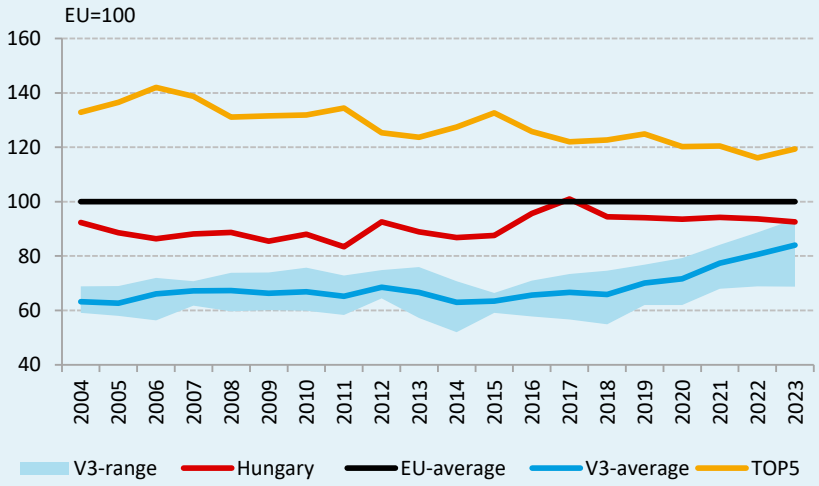


*Note: * Average Hungarian/EU citation index by date of publication. EU weighted average based on the number of citable documents. ** Calculated on the basis of the proportion of publications in the top 10 percent of the world's citations. *** Methodological break in 2016–2018. **** Between 2008 and 2012 MNB estimate based on HCSO time series prepared according to an earlier methodology.*
Source: European Commission (EIS), ScimagoJr, Scopus database

In 2023, the performance of Hungarian scientific journals again exceeded the average of the Visegrád countries and, as in previous years, was close to the EU average, while the average citation rate decreased compared to the EU average (Chart 2-6). As in the 2022 issue, this year we compared the citation rate of journals in each country with the EU average. In 2023, the performance of Hungarian journals was still close to the EU average, but declines were observed in

several areas. In the field of medicine, which accounts for the largest share of publications,[9] Hungary has moved up from 19th to 14th place in the EU in terms of publication volume compared to 2020. In the field of engineering, which accounts for the largest share of Hungarian R&D expenditure, Hungary has improved 5 places to 18th place. In dentistry, on the other hand, Hungary slipped from 1st to 8th place. Outstanding results were achieved in earth sciences (6th place) and physics[10] (8th place).

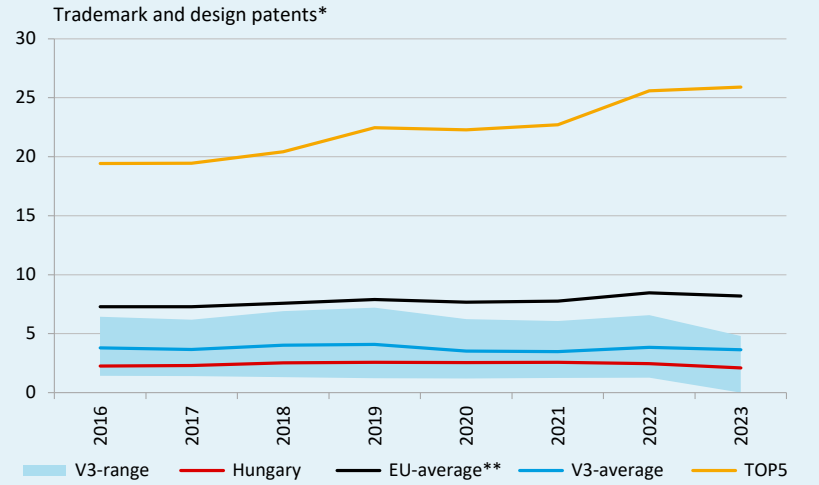
Chart 2-6: Average citation index per document by year of publication



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. In order, the TOP5 countries were: Denmark, Netherlands, Belgium, Ireland and Sweden.
Source: MNB calculations based on ScimagoJr, Scopus.

The number of trademarks and design protections per knowledge-intensive employee in Hungary is below both the EU and regional averages (Chart 2-7). In this respect, there has always been a significant gap between the Central and Eastern European region and the EU average and the best performing countries, and this gap has widened for Hungary. In 2020, the Hungarian indicator was one third of the EU average, but by 2023 it fell to one quarter of the average.

Chart 2-7: Trademarks and design protections per knowledge-intensive employee



*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. In order, the TOP5 countries were: Estonia, Slovenia, Latvia, Lithuania and Bulgaria.*
Source: MNB based on Eurostat and European Commission (EIS)

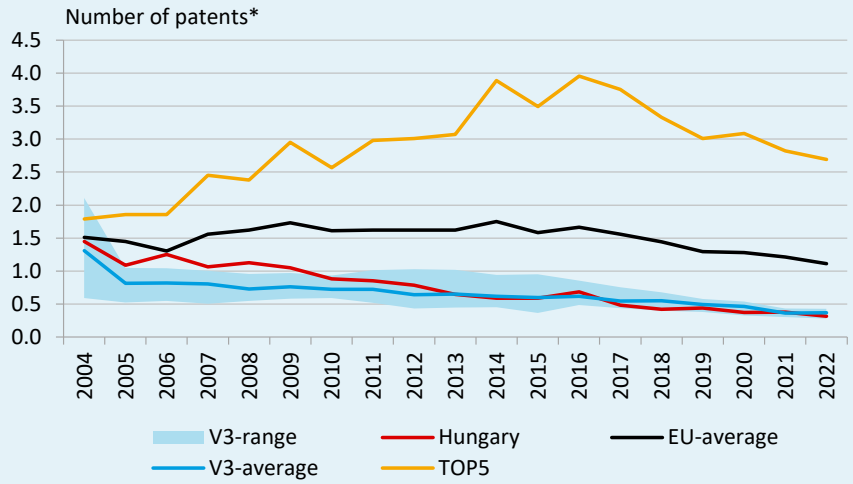
9 In the field of medicine, Katalin Karikó and her colleagues have made significant achievements in recent years, as reflected by the Nobel Prize in Medicine awarded in 2023

10 The award of the Nobel Prize in Physics to Ferenc Krausz in 2023 is a sign of the strength of the Hungarian physics discipline.

2.3 Innovation efficiency in an international comparison

The decrease in the efficiency of R&D expenditure is mainly due to a decline in patenting activity (Chart 2-8). The global decline in patenting is also affecting the region, and Hungary is no exception to this trend. Between 2020 and 2022, the number of patents per R&D expenditure decreased in a wide range of countries (V4 countries and TOP5 countries, as well as the EU average). Between 2018 and 2022, the number of patents filed in proportion to the population size and filed by residents in Hungary remained essentially stagnant (around 55 patents per million inhabitants), compared to 74 in 2016 and 87 in 2009. For the Visegrád countries, the average number of patents rose until 2015–2016 (when the patent output per million people exceeded 90), but then started to decline, falling by around 25 percent in 2022 versus the peak (to around 72 in 2022). This suggests that further action is needed to improve R&D efficiency.

Chart 2-8: Number of patents attributable to research and development expenditures

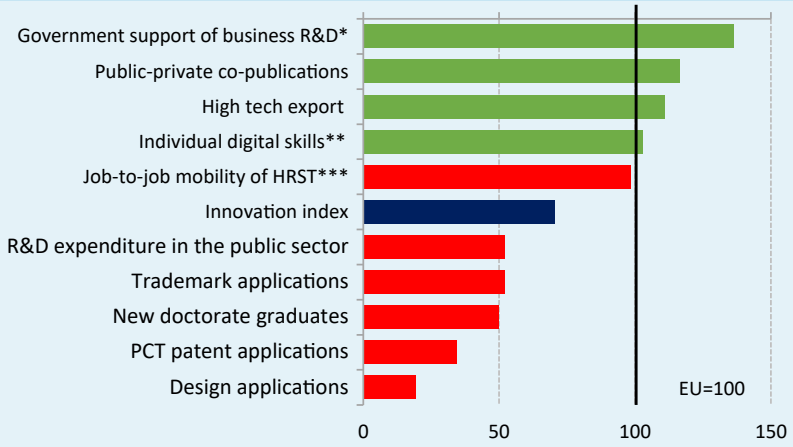


*Note: * The number of patents is expressed as a ratio of R&D expenditure in million PPS per patent. The TOP5 countries were defined based on the data available for last year and were plotted as a simple arithmetic average of the values for the same countries retrospectively. In order, the TOP5 countries were: ** Without Luxemburg, Cyprus and Malta. Luxembourg, Malta, Finland, Sweden and Ireland.*
Source: MNB calculations based on Eurostat and WIPO.

2.4 Factors underlying Hungary's innovation performance

Innovation activity among SMEs in Hungary remains moderate, but the willingness to cooperate has improved, a positive sign of a strengthening innovation ecosystem. Based on the latest European Innovation Scoreboard (EIS) analysis of the Hungarian innovation ecosystem, as in the 2022 report, we highlighted five indicators each in which Hungary performed outstandingly well or poorly (Chart 2-9).

Chart 2-9: Measures of the European Innovation Scoreboard showing the lowest and best results in Hungary (2023)

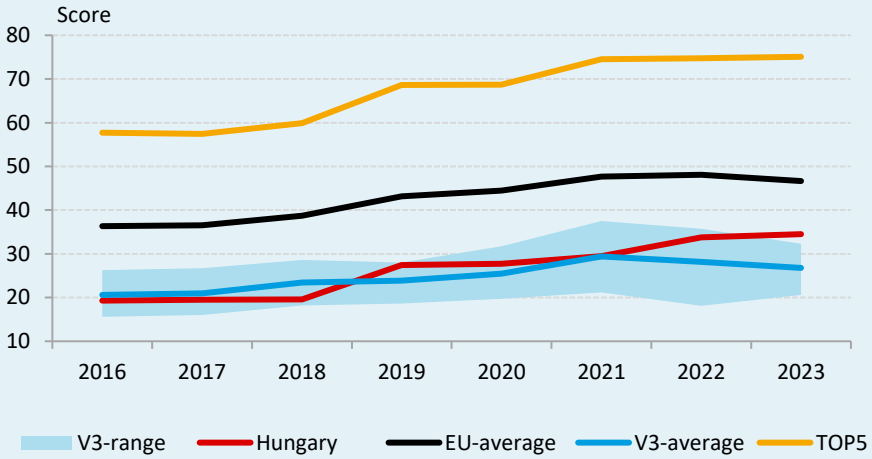


*Note: The EIS indicator set contains 30 indicators, of which the best 5 and weakest 5 are shown in the figure alongside the composite index. We included indicators that are directly relevant for innovation. Accordingly, we omitted a number of indicators related to the general condition of the economy. Indicators that perform better than the EU average are shown in green and those that do not are shown in red. * State aid for business R&D ** Individuals with above-average digital skills *** Labour market mobility in knowledge-based occupations.*
Source: MNB calculations based on European Commission – EIS (2024)

In a European comparison, public support for business R&D expenditure is above average in Hungary. The key to the sustainability of the innovation system is that a high level of public involvement should effectively stimulate innovation and not create a dependency relationship or crowd out market incentives. A positive example of the state's incentive activities is the high number of joint publications of public-private partnerships, which has been growing steadily since 2013. The strength of the Hungarian economy lies in its high share of high-tech exports, mainly thanks to the mechanical engineering sector. However, much of the progress made here is not driven by Hungarian know-how but foreign working capital settled in Hungary. The EIS data indicators also show that the output performance of the innovation system in Hungary is unfavourable by European standards. Among other things, the number of patents, trademark and design protections is low.

Knowledge flows have improved significantly in Hungary (Chart 2-10). The improvement in this composite measure in recent years is mainly due to increased innovation cooperation among SMEs. Although the indicator showed significant improvement, Hungary is still below the EU average. Another important component of the increase in this indicator is the improvement in the flow among knowledge-intensive jobs. Labour force flows between science and technology companies are observed to be closely linked to the promotion of innovation. One of the latest initiatives to foster cooperation is the MIT Regional Entrepreneurship Acceleration Programme (MIT REAP), a collaboration with the US university MIT, which includes MIT and Hungarian actors, such as the MNB, the Budapest University of Technology and Economics, the National Research, Development and Innovation Office and leading market innovators. The aim of the programme is to develop a regional enterprise development strategy based on the promotion of innovation (MNB 2023).

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 an unweighted 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. In order, the TOP5 countries were: Cyprus, Denmark, Finland, Luxembourg and Sweden.
Source: MNB based on European Commission – EIS (2024)

Looking ahead, one positive development is that the participation of Hungarian-owned companies in R&D has increased. 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 remainder is the expenditure of public and non-profit enterprises). As a result, the dual nature of the Hungarian R&D system has eased, albeit only to a small extent, which may also improve the utilisation of innovation in the future.

In the scope of the government innovation support, the focus between 2018 and 2022 was primarily to connect business and higher education actors. This agenda was primarily pursued by the National Research, Development and Innovation Office and the Eötvös Loránd Research Network.

Starting from 2022, the coordination of innovation policy has been the responsibility of the Ministry of Culture and Innovation (KIM), while the number supporting institutions and programmes increased, under the umbrella of the Neumann Janos programme, which was adopted in 2023. The reorganisation of the Eötvös Loránd Research Network resulted the creation of the HUN-REN Hungarian Research Network, which is an independent government body, with the purpose of organising and operating the independent and government-funded network of research institutions. The HUN-REN Network conducts basic and applied research in a wide range of sciences. The network's strategy is to carry out science work with the highest level of academic excellence and to help to link the R&D results into the business value chain. The successful work of the National Research, Development and Innovation Office led to the extension of the institutions with a supporting agency. The newly founded Hungarian Innovation Agency supports the innovation ecosystem, networks participants and spreads innovation culture. Its goals include strengthening the supply of innovative entrepreneurs and researchers, supporting the access of innovative companies and startups to foreign markets, and increasing the international visibility of the ecosystem.

Box 2-1: On the productivity advantage of innovation-driven enterprises

What fundamentally distinguishes innovation-driven entrepreneurs from traditional business entrepreneurs is that their growth strategy is based on innovation, and they take on extra cost (and risk) in the hope of a more promising return. Innovation is often identified with ideas and inventions, but these are necessary, but not sufficient, conditions for the innovations that shape our everyday lives. Developing, producing and distributing a new product/service requires more risky and complex inputs than adapting established production systems in the same market. The founders of innovation-driven companies grow by taking these risks and extra costs.

At the end of the last decade, there were more than 1,100 innovation-driven enterprises in Hungary. The analyses in the MNB's Growth Report (MNB 2023) were produced by linking large databases that consolidate individual firms' reporting data and innovation indicators. Hungarian innovation-driven enterprises (HIDEs) were defined as enterprises[11] that have increased their real turnover by an average of at least 20 per cent annually for at least three consecutive financial years. In cases where this growth has stalled, but the firm has subsequently sold abroad, it is still classified as innovation-driven, as competition in the export market requires continuous innovation.

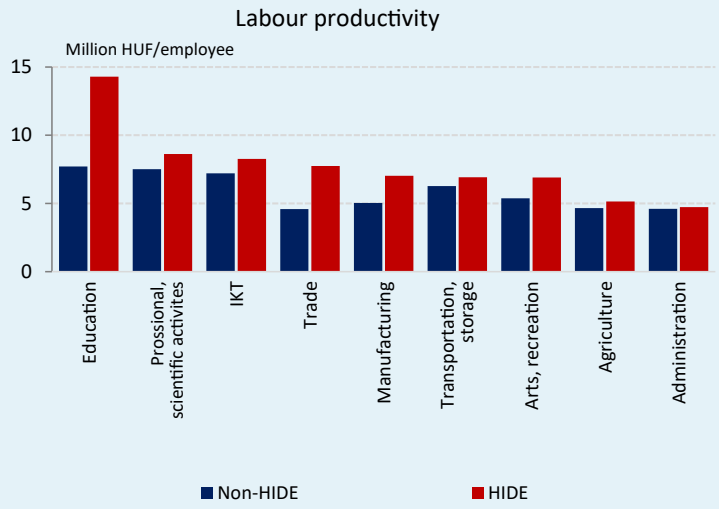
While the growth of traditional businesses is linear and limited by local markets, innovative products provide innovation-driven businesses with exponential growth. Effective scalability enables innovation-driven firms to expand their reach, increase their revenues and compete in larger markets. This is important because these companies play a significant role in the performance and technological development of the Hungarian economy. While scalability through innovation allows HIDEs to gain and maintain a competitive advantage through rapid growth, the growth of companies producing for local markets is constrained by domestic demand. The size of the domestic economy often makes it essential for innovative firms to be present in international markets. To achieve this, firms need to develop products or services that are globally competitive. The ability of firms to adapt to rapidly changing market needs/conditions and to make efficient use of available resources is also essential for business success. To sustain intensive growth based on innovation, companies must work to compete at the international level, which can be facilitated by an advanced, interconnected ecosystem.

The economic importance of Hungarian HIDE firms is that, while they accounted for only 3 thousandths of all partnerships, they accounted for 5.5 per cent of investment, 13 per cent of total Hungarian exports and 23 per cent of the annual average GDP growth increment in the 2010s. In addition to their contributions to growth and external markets, domestic innovation-driven companies employed 1.7 per cent of the workforce, accounted for 5.5 per cent of investment in Hungary and produced 3.6 per cent of total value added.

Typically, the labour productivity of innovation-driven firms is around 44 per cent higher than that of non-innovation-driven firms in the sectors surveyed (Chart 2-11). The labour productivity of HIDEs is higher than that of traditional businesses in that their median number of employees is also several times higher (typically close to three times higher) than that of traditional businesses (Table 2-1). The largest difference was found among enterprises engaged in educational activities: while the labour productivity of a traditional business in the relevant entrepreneurial group was HUF 7.7 million per person, in the IDE group it was HUF 14.3 million per person in 2016.

11 Innovation-driven enterprises were selected according to several criteria. Hungarian IDE companies are corporate taxpayers, operate in the private sector and are not non-profit or special purpose entities (SPE; see Koroknai – Lénárt-Odorán 2011). The construction, real estate, other services and tourism and hospitality sectors were excluded from the sector selection due to the fact that firms in these activities are primarily established to meet domestic demand (MNB 2023, p. 52), and thus their growth potential is limited depending on domestic demand. In addition, the analysis excludes financial intermediation institutions, not including financial firms providing fintech services. The threshold for company size was at least HUF 50 million based on turnover in the innovation-driven group.

Chart 2-11: Labour productivity of non-HIDE* businesses and Hungarian innovation-driven businesses



*Note: *Hungarian Innovation-Driven Enterprise (HIDE). Median values. Due to companies growing in 2016–2019, the comparison is made at 2016 current prices. Non-special purpose companies (SPC) with turnover of at least HUF 50 million. Labour productivity is the median of individual productivity and not the ratio of median values.*
Source: HCSO, MNB, NTCA, NIPO, NRDIO and MNB based on corporate register

The investment needs of innovation-driven enterprises are well above the sector median (Table 2-1). The biggest differences were in arts and recreation (HUF 59.5 million innovation-driven investment versus HUF 3.7 million business investment), transportation and storage (HUF 48.4 million innovation-driven investment versus HUF 9.8 million business investment) and manufacturing (HUF 60.3 million IDE investment versus HUF 7.4 million traditional investment) at the end of the previous decade (2016). External competition, which forces continuous innovation, also boosts investment activation. It is found that while typical non-manufacturing businesses do not sell products (and/or services) abroad, only the median innovation-driven enterprises in the arts, entertainment and recreation sector sell purely domestically. (However, this phenomenon also reflects the difficulties of accounting for foreign demand in services activities, which are typically close to the customer.)

Table 2-1: Economic indicators of non-HIDE* businesses and Hungarian innovation-driven businesses

	Labour productivity (million HUF/employee)		Persons employed		Investment (million HUF)		Export sales (million HUF)	
	Non-HIDE	HIDE	Non-HIDE	HIDE	Non-HIDE	HIDE	Non-HIDE	HIDE
Education	7.7	14.3	5	6	2.3	8.2	0	0
Professional, scientific activite	7.5	8.6	5	12	2.3	15.1	0	40.5
ICT	7.2	8.3	6	18	2.7	18.9	0	16.6
Trade	4.6	7.8	5	13	1.2	12.7	0	48.2
Manufacturing	5	7	13	39	7.4	60.3	0.5	235.5
Transportation, storage	6.3	6.9	8	21	9.8	48.4	0	28.2
Arts, recreation	5.4	6.9	5	13	3.7	59.5	0	0
Agriculture	4.7	5.1	8	35	14.4	35.6	0	78.7
Administration	4.6	4.7	7	19	1.8	13.2	0	0.6

*Note: *Hungarian Innovation-Driven Enterprise (HIDE). Median values. Due to companies growing in 2016–2019, the comparison is made at 2016 current prices. Non-special purpose entities (SPE) with a turnover of at least HUF 50 million. Labour productivity is the median of individual productivity and not the ratio of median values.*
Source: HCSO, MNB, NTCA, NIPO, NRDIO and MNB based on corporate register

As in the previous decade, the outstanding performance of HIDEs can make a significant contribution to the growth of the Hungarian economy in the coming years. Higher labour productivity at innovation-driven enterprises increases the overall efficiency of the economy, and an improvement in this indicator is key to long-term domestic economic growth. The higher productivity of HIDEs allows them to produce more products and services with the same labour force, which increases output and competitiveness. Furthermore, the increase in the number of people employed by innovation-driven businesses – through productivity – increases the income of employees. Higher incomes boost consumption, which generates further economic growth. In addition, the investments of the business community, in addition to labour productivity, increase the stock of capital needed for sustainable production, and also stimulate technological development and general infrastructure improvements. Finally, an increase in export earnings improves the country's external trade balance, and a successful position in foreign markets strengthens international competitiveness and stabilises the economy. Overall, innovation-driven enterprises play a significant role in the sustainable growth of the Hungarian economy, contributing to productivity, investment, employment and export growth.

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3 Digitalisation efficiency

IN HUNGARY, THE COVERAGE OF DIGITAL INFRASTRUCTURE IS ABOVE THE EU AVERAGE BUT UTILISATION IS LOW – HOWEVER, THE GAP HAS NARROWED SIGNIFICANTLY IN THE CORPORATE SECTOR.

Hungary's digitalisation efficiency is 78 percent of the EU average and 59 percent compared to the TOP5 EU countries.

Introduction

Today, every economy depends on digitalisation, which has become a prerequisite for further technological innovation and productivity improvements.[12] At the same time, it requires adjustment by all economic participants, as technological innovation alone rarely leads to efficiency gains if it is not accompanied by investment in business processes, skills and other intangibles.[13]

Hungary's digital infrastructure is among the best in the EU, but there is still room for improvement in the areas under review. For example, 37 percent of Hungarian households have internet access with at least 1 gigabit bandwidth, placing the country in second place in the EU ranking (France is in first place with 52 percent and Greece is in last place at 0 percent). However, advanced digital infrastructure alone is not enough to harness the productivity gains of digitalisation. In several areas, the digital infrastructure is underutilised in Hungary. We have identified a number of opportunities for improvement, which are explained in more detail in this chapter.

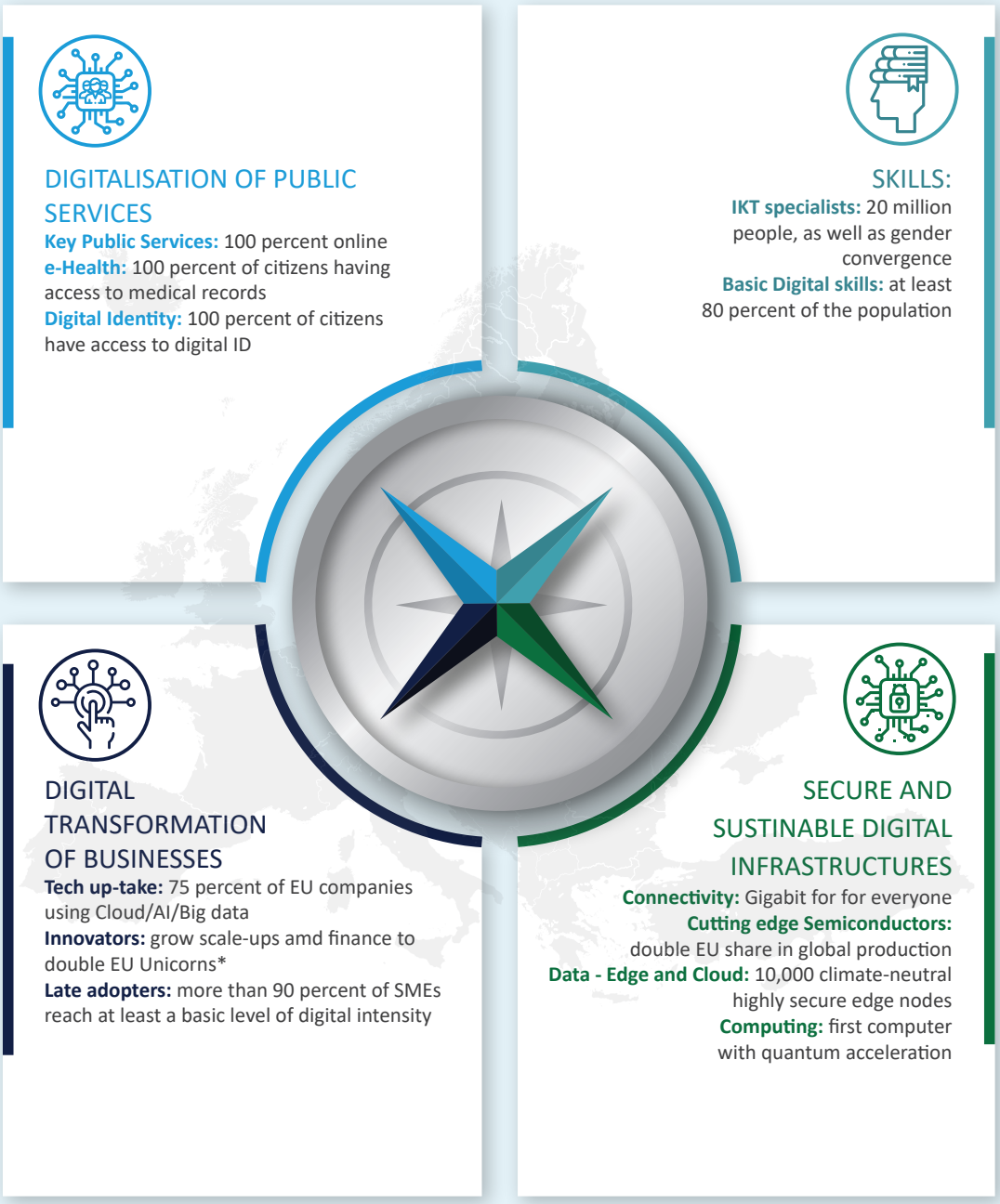
3.1 Digital agenda of the EU and Hungary

The digital transformation is one of the European Union's high priority long-term objectives. Adopted in 2022, the Digital Decade 2030 policy programme set specific targets for 2030[14] in this regard. The digitalisation progress of Member States is monitored by the Digital Economy and Society Index (DESI),[15] which, in line with the policy objectives, includes more than 30 indicators in 4 areas: digital skills, digital infrastructures, digital transformation of enterprises and the digitalisation of public services. In total, the programme sets 12 specific targets in the 4 areas, including more than 20 million employed ICT specialists in the EU, 75 percent of companies using cloud services, artificial intelligence or big data, and all citizens having online access to their health records (Chart 3-1).

Hungary's digitalisation strategy until 2030 is set out in the National Digitalisation Strategy.[16] In 2014, Hungary adopted the National Infocommunications Strategy (NIS), which guided digitalisation efforts in line with the EU Digital Agenda, with a special focus on SMEs. Upon completion of the NIS in 2020, the Hungarian government adopted the National Digitalisation Strategy (NDS), which sets out the goals and actions envisaged for digitalisation in Hungary up to 2030, aligned with the Digital Decade 2030 programme. For example, sector-level digital strategies and action plans have been developed, and the Modern Enterprises Programme has been extended to provide free expert assistance to enterprises for IT and digitalisation development. In addition, tenders and new types of funding programmes (e.g. vouchers, guarantees) in support of corporate digitalisation, as well as targeted programmes to encourage data sharing by enterprises are being developed. The Strategy also includes measures to strengthen the development of digital competencies in public education, vocational training and higher education.

12 Vas et al. (2024).
13 Brynjolfsson et al. (2021).
14 Europe's Digital Decade | Shaping Europe's digital future (europa.eu)
15 DESI dashboard for the Digital Decade (2023 onwards) - Digital Decade DESI visualisation tool (europa.eu)
16 https://www.digitaliskeszsegek.hu/wp-content/uploads/2024/02/Nemzeti-Digitalizacios-Strategia.pdf

Chart 3-1: The European Union's Digital Decade programme (targets to be achieved by 2030)



*Note: * Unicorn startups – startups that reach a valuation of at least USD 1 billion.*
Source: European Commission.

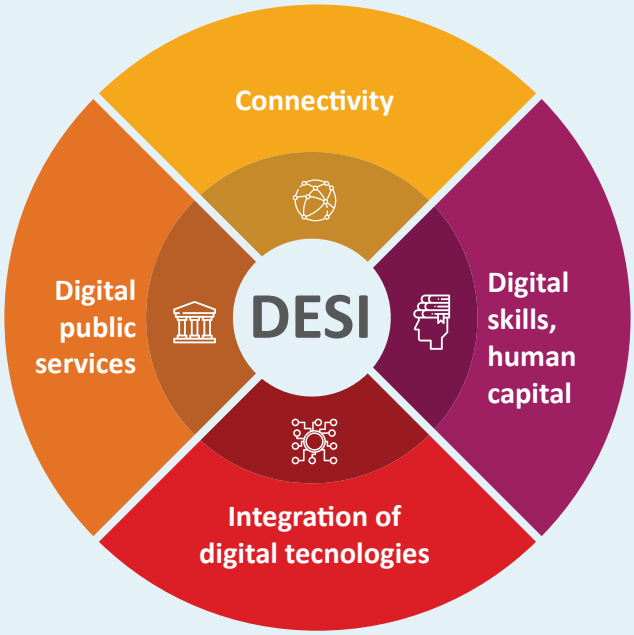
The adoption of the Digital Decade 2030 policy programme necessitated changes to the DESI indicator as well. Until then, DESI had analysed digitalisation progress in the 4 areas using more than 30[17] indicators and then aggregated the results across the 4 areas; in addition, an aggregated composite index was also disclosed, which was obtained from weighting the 4 sub-areas. However, disclosure of the aggregated values was discontinued from 2023, while the indicators used until then are still updated and remain in use. The latter enables us to calculate aggregated values using the previous methodology[18] as indeed, the digital efficiency indicators applied in our analysis use the aggregated values of the 4 domains on the input or the output side (Chart 3-2):

17 The range of the indicators has varied somewhat from year to year.
18 For the purposes of our analysis, we used the 2022 DESI methodology and set of variables in order to ensure better comparability with previous years, with 2023 as the reference year for the data. The calculation thus performed indicates that in 2023, Hungary's overall performance was 58 points on the digitalisation headline index, ranking Hungary 17th in the EU after a 5-point improvement relative to 2020.

- the input side of the productivity indicators includes: digital infrastructure;
- the output side of the productivity indicators includes: digital skills (digital human capital), integration of digital technology by enterprises, and digital public services.

These indices are composed of a combination of additional sub-indices; for example, the Integration of Digital Technology by Enterprises Index, which includes sub-indices related to the digital intensity of SMEs, the penetration of advanced digital technologies and e-commerce at SMEs. 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 this analysis, the digital infrastructure (connectivity) index is on the input side of the indicators, and the following three indices (digital skills / human capital, integration of digital technology by enterprises and digital state) are on the output side.
Source: DESI

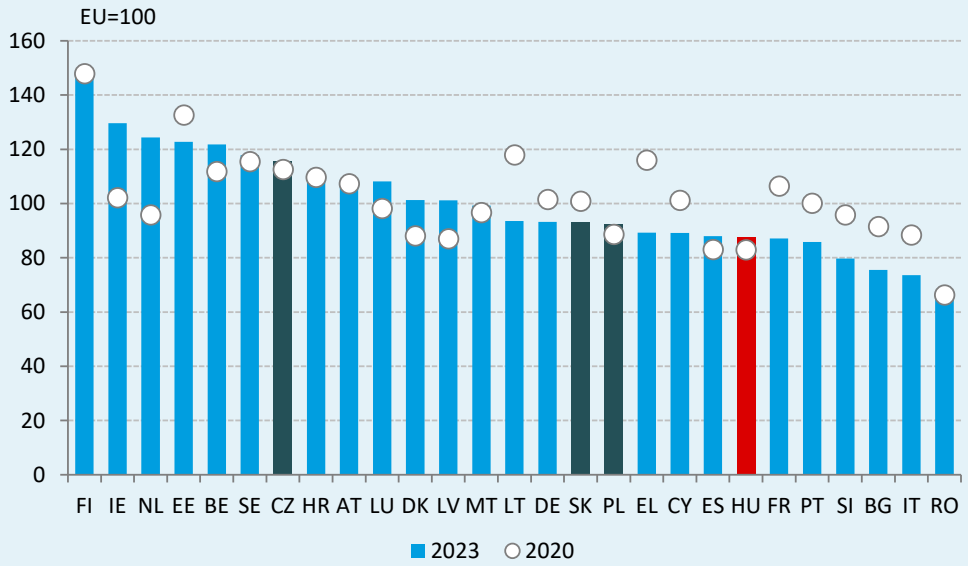
3.2 Digitalisation efficiency of households

In 2023, the efficient use of the domestic population's skills was 88 percent of the EU average and 68 percent of the average of the TOP5 EU countries (in order: Finland, Ireland, the Netherlands, Estonia and Belgium). The indicator is obtained as the quotient of the digital human capital and digital infrastructure quality indices. The efficiency of the Hungarian population's digital skills improved compared to the previous years; accordingly, Hungary climbed to the 21st place in the EU (Chart 3-3). Between 2020 and 2023, Hungary registered an improvement of 4 percentage points compared to the EU average. The Netherlands recorded the largest increase of 29 percentage points, but this change was driven by a sharp relative deterioration in network quality. In the Netherlands, network quality deteriorated by almost 40 percentage points (due to the improving EU average), while in Hungary network quality improved by 3 percentage points relative to the EU average. With 22 percentage points, Germany exhibited the most outstanding improvement in digital infrastructure in the EU.

In 2023, Hungary boasted the 6th best network quality in the EU. As regards landlines, infrastructure was already of good quality by European standards (for example, 37 percent of households use gigabit internet,[19] putting Hungary in second place in the EU behind France), but in the last three years mobile broadband has also improved remarkably, particularly as a result of the increase in 5G network coverage, which surged to 83 percent in 2023 from 17 percent in 2021. The digital skills of household users reached the EU average by 2023, but there is still room to fully harness the high-quality infrastructure.

19 Internet connection with speed of 1000 mbps or higher.

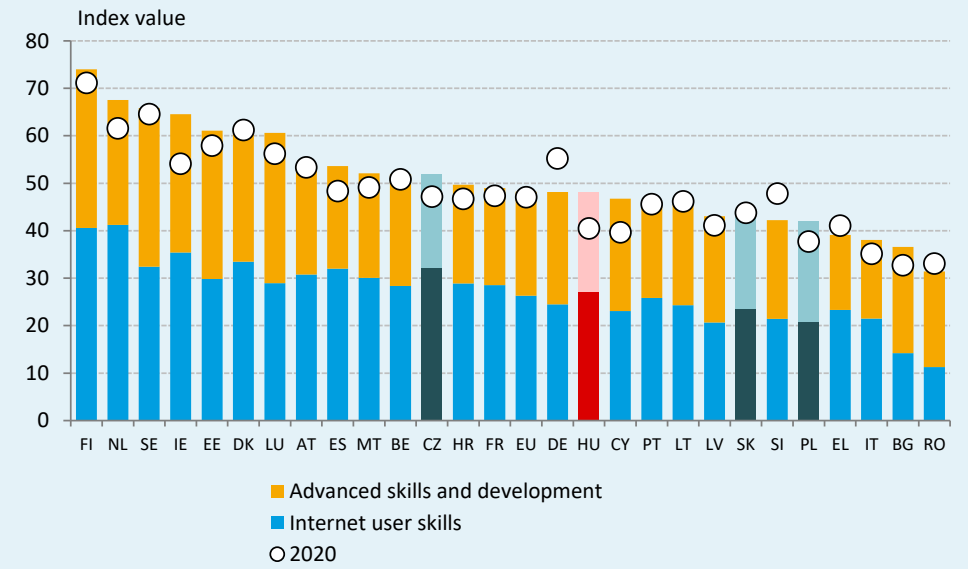
Chart 3-3: Households digital skills efficiency



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

The numerator of the efficiency indicator represents the IT skills of users ('digital human capital'), for which Hungary ranked 16th among the EU countries in 2023 with an index value of 48 points (EU average: 48.3) (Chart 3-4). One of the sub-pillars of this comprises 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 15th. The second sub-pillar measures the penetration of ICT skills, in which Hungary ranks 18th in the EU. Between 2020 and 2023, Hungary's digital human capital improved by 7.5 points, which exceeds the EU average of 1.1 points over the same period. The countries achieving the most remarkable improvement during the period were, in order, Ireland, Hungary and Cyprus.

Chart 3-4: Digital human capital performance in EU countries in 2023 and 2020



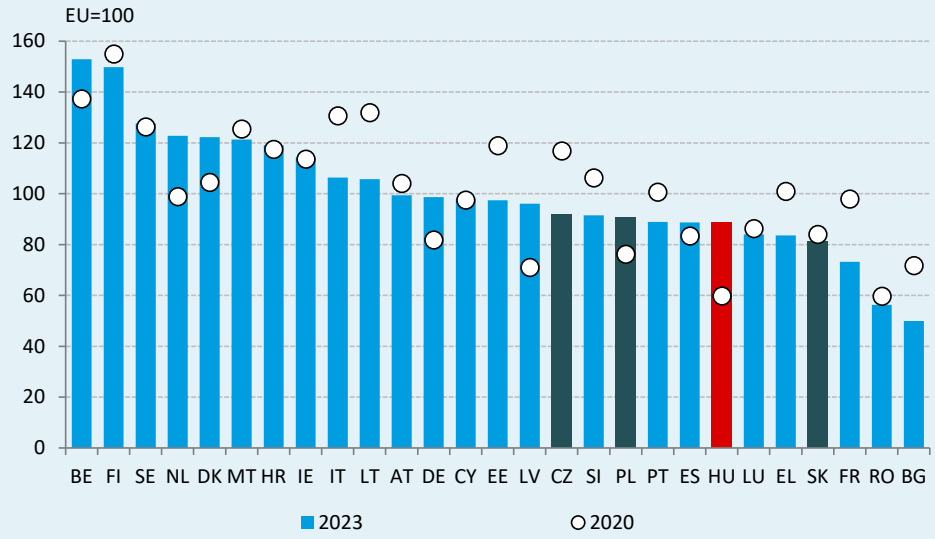
Source: Eurostat, MNB calculation.

3.3 Digitalisation productivity of enterprises

The efficiency of digital technologies in Hungary has increased significantly in recent years: in 2023, it was 89 percent of the EU average (versus 60 percent in 2020) and 66 percent of that of the TOP5 EU countries (versus 44 percent in 2020) (Chart 3-5). This indicator is obtained as the quotient of corporate digital technology usage and digital network quality indices. The countries with the highest corporate digital efficiency are Belgium, Finland, Sweden, the Netherlands and Denmark.

In 2023, Hungary advanced five places compared to 2020 to rank 21st. As seen earlier, digital infrastructure has also progressed in this period, and therefore, the improvement in efficiency implies that the integration of digital technology by enterprises outpaced that progress. The improved results reflect the progress made essentially in all sub-indices of the Corporate Digital Technology Usage Index: the digital technology intensity of SMEs, e-commerce at SMEs and the penetration of advanced digital technologies, such as cloud services and e-invoicing, have all increased. Meanwhile, in several countries (such as France), utilisation has fallen, largely due to rapid improvements in the digital infrastructure.

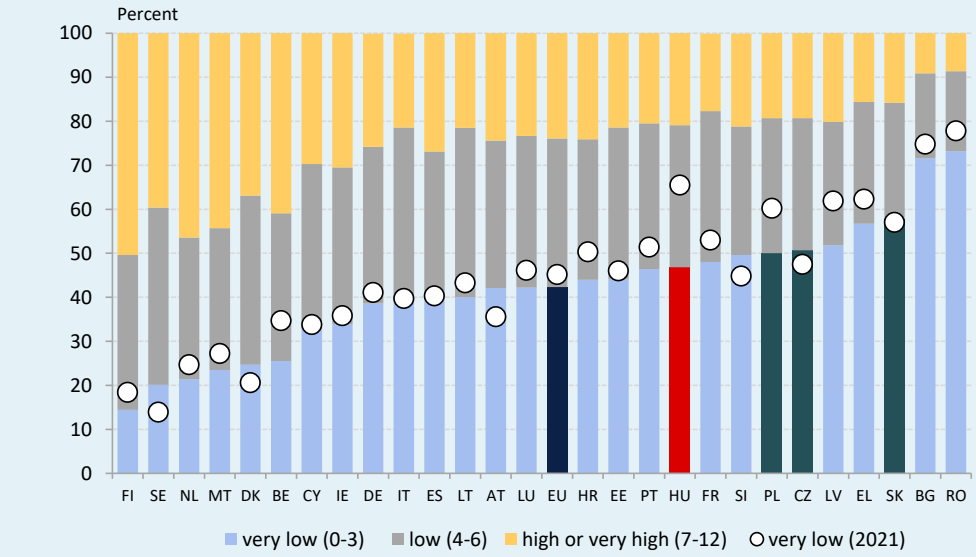
Chart 3-5: Utilisation rate of digital infrastructure by enterprises



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

In 2023, 47 percent of Hungarian small and medium-sized enterprises had minimal digital technology with very low digital intensity (Chart 3-6). According to the enterprise digitalisation sub-index, domestic SMEs invest in digital technology only to a small extent. The digital intensity sub-index shows that 47 percent of enterprises rely on minimal digital technology, which implies that the share of enterprises where technology is underutilised is above the EU average of 42 percent. However, this percentage has improved (i.e. decreased) by 19 percentage points compared to 2021, which has resulted in Hungary overtaking the V3 countries (Poland, the Czech Republic and Slovakia with 50, 51 and 58 percent, respectively) (Chart 3-6). It should be noted that 53 percent of domestic companies use data analytics in their operations, which is the highest proportion in the EU.

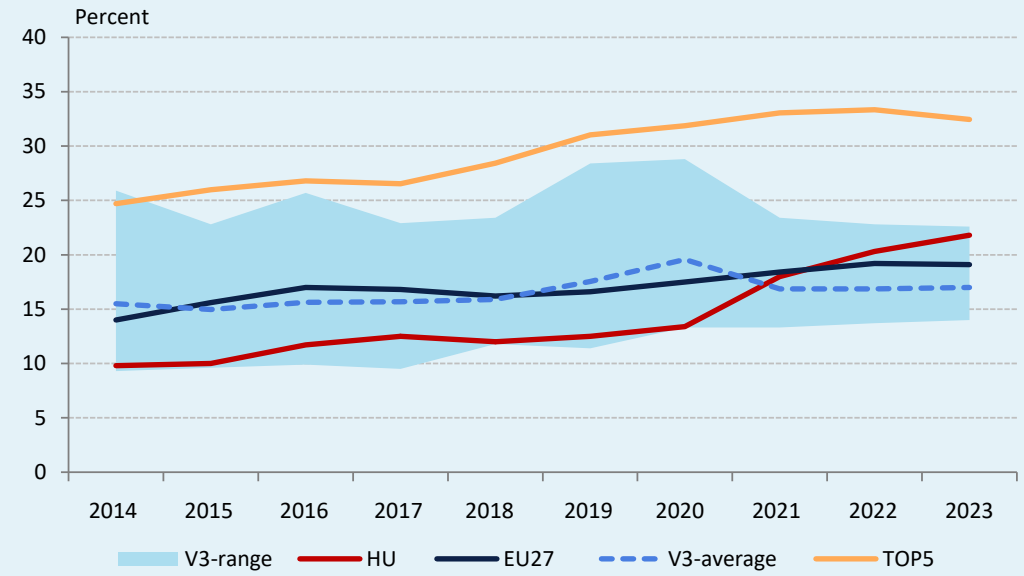
Chart 3-6: Distribution of SMEs based on the Digital Intensity Index (DII) in the European Union (2023 and 2021)



Note: For the measurement of DII, enterprises had to select the applied digitalisation methods from a list of 12 items, such as: use of ICT security solutions, 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 values on the chart show percentages to total SMEs.
Source: Eurostat

In Hungary, small and medium-sized enterprises are performing above the EU average in e-commerce (Chart 3-7). The share of domestic SMEs with at least 1 percent of their turnover coming from e-commerce exhibited accelerated growth after 2020. In 2023, this ratio was close to 22 percent, reaching the level of the best performing Visegrád country, the Czech Republic (22.6 percent), and exceeding the EU average (Chart 3-7).

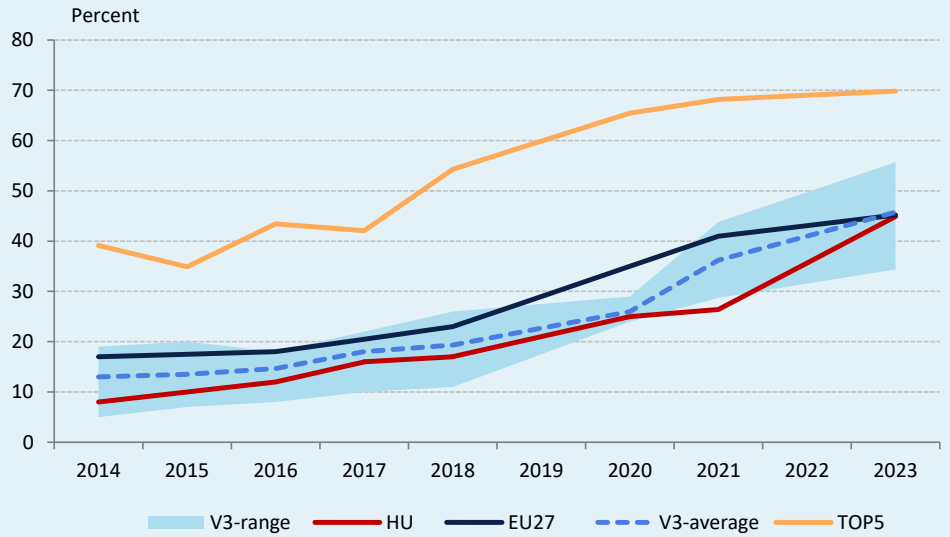
Chart 3-7: Proportion of SMEs with at least 1 percent of their turnover coming from e-commerce



Note: In order, the TOP5 countries in 2023 were: Denmark, Sweden, Malta, Lithuania and Ireland.
Source: Eurostat

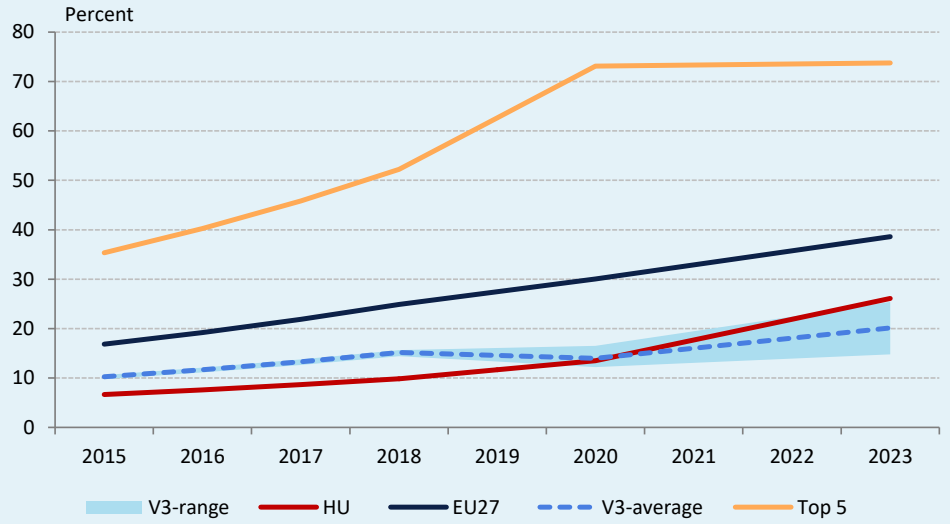
Between 2020 and 2023, the ratio of Hungarian corporations using cloud-based services rose from 25 to 45 percent (Chart 3-8). After 2020, the use of cloud-based services by Hungarian enterprises grew faster than before, with 45 percent of the enterprises purchasing cloud-based services in 2023, which is consistent with the average of both Visegrád countries and the EU. Improvement was also observed in the use of e-invoicing. In Hungary, 13 percent of enterprises used e-invoices in 2020, doubling to 26 percent in 2023 (Chart 3-9). Despite the increase, the current value is still significantly below both the EU average (39 percent) and the average of the TOP5 countries (74 percent).

Chart 3-8: Percentage of enterprises purchasing cloud computing services



Note: For 2019 and 2022, no data were available for any of the countries under review; for some countries, data for a year were missing and are substituted by estimates. In order, the TOP5 countries in 2023 were: Finland, Sweden, Denmark, Malta and Ireland.
Source: MNB calculation based on Eurostat data

Chart 3-9: Percentage of enterprises issuing e-invoices that can be processed automatically



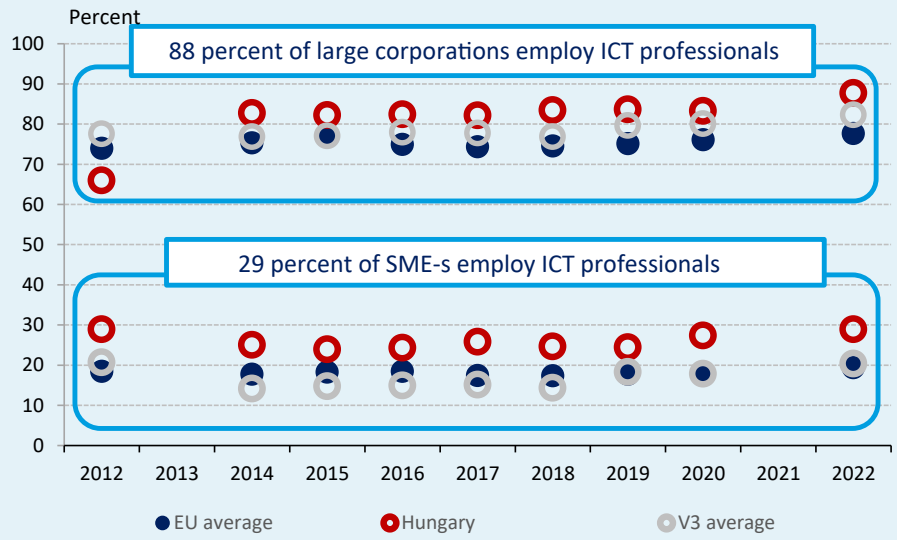
Note: Data were not available for 2019, 2021 and 2022; consequently, we applied estimates for the missing years. The TOP5 countries were defined based on data available for last year and were plotted as a simple arithmetic average of the values for the same countries retrospectively. In order, the TOP5 countries in 2023 were: Italy, Finland, Slovenia, Sweden, Estonia.
Source: MNB calculation based on Eurostat data

3.4 Efficiency of digital specialists

ICT specialists play a key role in the building of a digitalised economy. Enterprises may choose to employ ICT specialists or outsource the tasks to external partner companies. However, the continuous education and availability of IT specialists is essential for the digital transition and growth of the economies.

In 2022, on average, 29 percent of Hungarian SMEs and 88 percent of Hungarian large corporations employed ICT professionals (Chart 3-10). Evidently, larger enterprises are much more likely to employ ICT specialists. In addition, large corporations recorded robust growth. At large corporations, the frequency of employment rose from 66 percent in 2012 to 88 percent in 2022, whereas SMEs recorded no change overall. Hungarian ICT employment indices exceeded both the regional and EU averages.

Chart 3-10: ICT specialists in employment, by size category



Note: Data for 2013 and 2021 are not available.
Source: Eurostat, MNB calculation

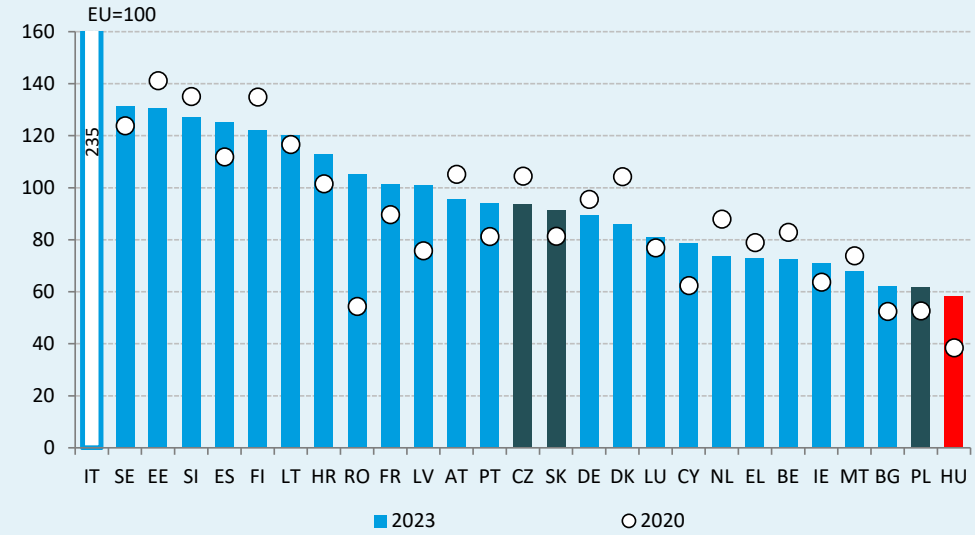
Companies employing ICT specialists in Hungary are less likely to use modern enterprise resource planning (ERP) software, cloud-based applications, Internet of Things (IoT) solutions and e-invoicing than their peers in the EU and in the rest of the Visegrád region. One of the measures of the digital 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. Therefore, it provides valuable assistance to enterprises by making their operations more efficient. Moreover, significant productivity gains may be achieved by cloud-based, IoT applications and the introduction of e-invoicing.

In terms of their processes, Hungarian enterprises are less digitalised relative to the number of specialists employed. In this regard, the efficiency index was 58 percent in 2023 compared to the EU average and 39 percent relative to the TOP5 countries. Hungary's efficiency indicator lags behind that of the V3 countries, as well (Chart 3-11). The numerator of the indicator includes the share of companies that use ERP software, IoT, cloud solutions or e-invoicing, while the denominator includes the share of companies that employ ICT specialists. The countries with the highest efficiency are, in order: Italy, Sweden, Estonia, Slovenia and Spain. Italy's extremely high score can be attributed to the almost 100 percent penetration of e-invoicing and the small percentage of ICT specialists employed. Hungary is ranked last, namely, the 27th, in the EU.

One reason for the low penetration of modern enterprise resource planning applications may be the fact that, from the perspective of businesses, the majority of the costs associated with the implementation of digitalisation technol-

ogies such as ERP and customer relationship management (CRM) systems are, in many cases, not related to the purchase of hardware and software devices. Instead, these costs are more related to the training of other non-ICT specialist employees and the restructuring of internal processes.[20] Therefore, the employment of ICT specialists alone does not necessarily lead to the use of more advanced digital technologies.

Chart 3-11: Efficiency of digital specialists



Note: The uptake of cloud applications, IoT, e-invoicing and ERP divided by the share of companies employing ICT specialists.
Source: MNB calculation based on Eurostat data

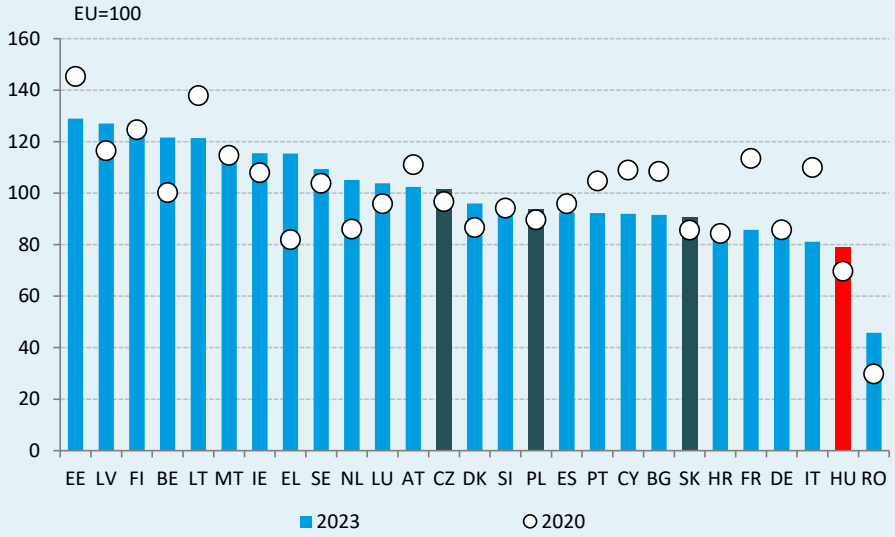
3.5 Digital efficiency of the state

The digitalisation projects carried out by the government may provide a more efficient framework for the economy. By way of electronic public administration (e-governance) households and enterprises can save time and money, while government expenditures also decrease. By setting a good example and boosting entrepreneurship, digital developments in the public sector may stimulate the digital innovations of enterprises. Electronic administration is faster, since connecting public administration data systems reduces waiting times and there are fewer personal identification steps. In Hungary, such developments include the option to outsource VAT returns to the tax authority and, more recently, eSzemélyi, which provides the means, for example, for electronic signatures and electronic identification in the online space, as well as the storage of digital transport tickets and passes.

In 2023, the efficiency of digital public administration in Hungary was 79 percent of the EU average and 64 percent of the TOP5 EU countries. The indicator is obtained as the quotient of the usage of digital public administration systems and the digital network quality indices. For the former, Hungary was ranked 22nd in the EU in 2023. The five most advanced countries in terms of the digital efficiency of the state are: Estonia, Latvia, Finland, Belgium and Lithuania. 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. Hungary's 2023 position in the ranking remained unchanged versus 2020. In the EU ranking, the efficiency of Hungary's e-governance is in 26th place (Chart 3-12). The Digital Citizenship Programme, under which the Digital Citizenship mobile application was launched in September 2024, may help increase the efficiency of digitalisation in public administration. With the application, users can access to a growing number of services, such as proof of identity, requesting a certificate of good conduct, booking an appointment, and in the future, the app will also support the administration required for vehicle purchase and sale.

20 Brynjolfsson – McAfee (2016).

Chart 3-12: Efficiency of digital public administration



Note: Digital public administration systems and network quality (DESI indices).
Source: MNB calculations based on Eurostat

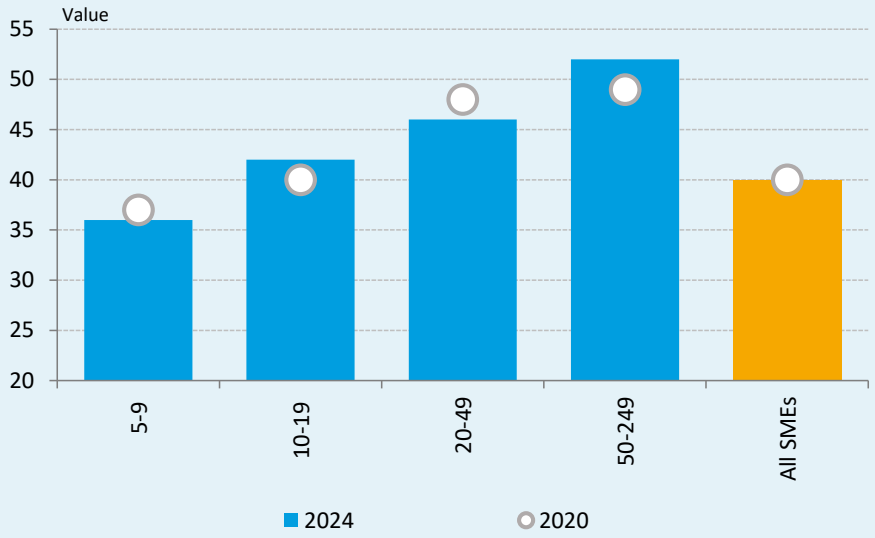
Box 3-1: Digital maturity of Hungarian SMEs based on the Digiméter survey

In addition to Eurostat's Digital Economy and Society indicators,[21] the Digiméter survey[22] can provide additional information on the digitalisation of Hungarian SMEs. Since 2020, the survey regularly examines the digital characteristics of businesses in six areas: digital finance, IT security, digital presence, digital everyday life, business management and finally sales and marketing. Up to 100 points can be achieved in each topic. An aggregate indicator is also provided, weighted by the scores of the six topics.

In the Digiméter survey, the digitalisation of Hungarian SMEs in 2024 scored 40 points (out of a maximum of 100 points). The survey shows that there has been no significant change in recent years (the outcome was 40 points in 2020 as well). This result stands in apparent contradiction to the information that can be obtained from the DESI indicators, which show that the digitalisation of businesses in Hungary has improved substantially in recent years. The reason for the discrepancy is that the Digiméter gives a very high weighting to smaller businesses. Digiméter looks at enterprises with 5 to 249 employees, while Eurostat looks at SMEs with 10 to 249 employees and large enterprises. Thus, due to the representativeness of the sample, many companies with less than 10 employees were included in the Digiméter survey, which lowers the average values registered here (Chart 3-13). Some of the indicators in the DESI do not apply to SMEs, but to all companies with more than 10 employees, including large companies, which on average perform better. According to our calculations, the Digiméter core index excluding companies with less than 10 employees has increased from 42 to 45 since 2021. At the same time, there is not much difference in the value of the indicators directly comparable in Eurostat and Digiméter *(Pintér 2024)*. For example, Eurostat's Data Analytics Indicator put the proportion of companies using data analytics at 53 percent of domestic SMEs in 2023, while the Digiméter survey found that 63 percent of companies "regularly monitor data generated by their operations in order to use those to prepare decisions" *(Digiméter 2024, p. 54)*.

21 This includes the indicators of the Digital Economy and Society Index (DESI), which monitors the digitalisation progress of EU Member States.
22 Digiméter (2024) https://digimeter.hu/wp-content/uploads/2024/04/Digimeter_2024_tavasz_tanulmany_20240418.pdf

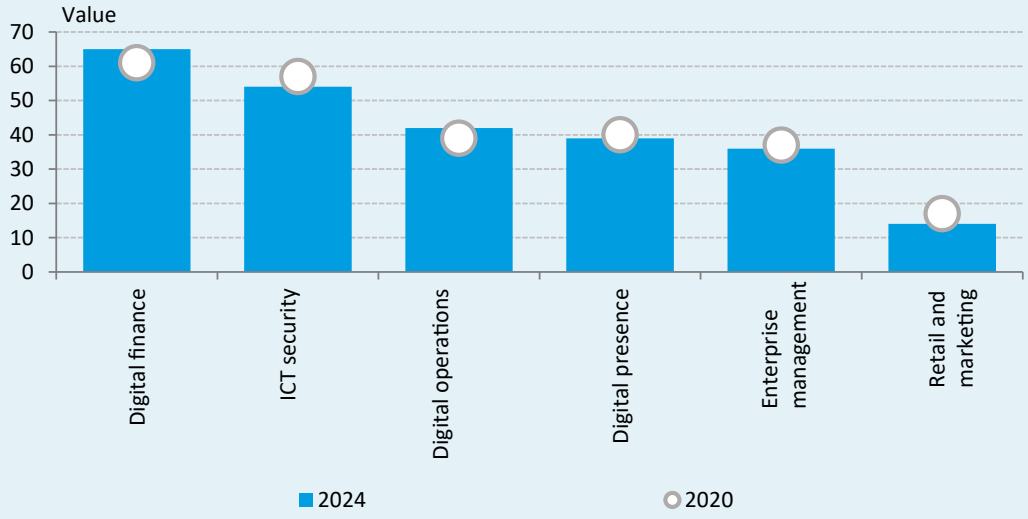
Chart 3-13: Digiméter Index by company size (2020 and 2024)



Note: The most recent data collection date is February 2024.
Source: Digiméter 2020 and 2024

In 2024, Hungarian SMEs scored highest in digital finance and lowest in sales and marketing (Chart 3-14).

Chart 3-14: Digiméter survey results for 2024 and 2020



Note: For Digiméter 2024, the data collection date is February 2024.
Source: Digiméter 2024 and 2020

In 2024, and in recent years, from among the areas under review, Hungarian SMEs performed best in the area of digital finance (with the score increasing from 61 to 65 in the period). In 2024, 82 percent of Hungarian SMEs used invoicing software. Within this, the share of businesses using cloud-based billing systems increased from 19 to 26 percent. There has been a significant increase in e-invoicing in recent years, with the share of SMEs receiving and issuing e-invoices rising to 67 percent in 2024 from 48 percent in 2021.[23] In these areas, we can identify similar trends in indicators with similar content in EU surveys. Only 38 percent of domestic SMEs use accounting and finance software. The difference between the average and the best performing domestic companies has narrowed to a certain extent: in the 2024 Digiméter survey, the top 20 percent are 24 points ahead of the average, compared to 27 points in 2020. There were no differences in the value of the financial index by sector or region (Table 3-1).

23 No data are available for 2020 for this indicator.

Hungarian SMEs achieved a score of 54 points in IT security in 2024, 3 points below the 2020 result. There is a large heterogeneity to be observed among the surveyed firms: small firms (between 5 to 10 employees) performed below average, while firms with more than 10 employees performed above average. In terms of turnover, the picture is similar: companies with a turnover of less than HUF 100 million achieved below average results. There are differences between regions, with the highest average score (60) achieved in Budapest and the lowest (44) in Central Transdanubia.

In the categories of digital presence, digital everyday life and business management, Hungarian businesses scored around 40 points both in 2024 and in previous years. Progress has been seen in some areas: the share of businesses with a Google Business Profile account has increased (34 percent currently, compared to 16 percent in 2020), the option to work from home is increasing[24] (23 percent in 2020 and 31 percent in 2024) and the share of businesses using teleconferencing software increased to 45 percent during the period. By 2024, the share of companies that update their website at least monthly fell to 15 percent, from 19 percent in 2021.[25] Here again, there is still room for improvement in the use of high-quality domestic digital infrastructure by businesses.

In sales and marketing, the 2024 figure of 14 even shows a slight deterioration compared to previous years. In 2024, 12 percent of the SMEs surveyed had some form of customer relationship management (CRM) system in place, reflecting no significant change versus previous years (11 percent on average). At the same time, the survey shows that CRM use among companies with 50 to 249 employees fell to 16 percent by 2024 from 30 percent in 2022. According to Eurostat data on CRM applications, 15 percent of SMEs used such software in 2021 and 20 percent in 2023. The share of companies with a webshop or offering the possibility to order/purchase items on their website has decreased: it was 13 percent in 2024, down from 17 percent in 2021 and 21 percent in 2022.[26] Heterogeneity is also observed in the sales and marketing index by category of company by number of employees, with an index value of 12 for companies with fewer than 10 employees and an average of 20 for companies with 50 to 249 employees.

The same pattern can be observed in several areas of the Digiméter survey: on average, SMEs achieve the highest scores in the capital city and the lowest in Central Transdanubia (Table 3-1). By sector, companies in trade and services scored higher on average in the Digiméter survey than those in industry and agriculture (Table 3-2).

Table 3-2: Regional distribution of Digimeter subindex

	Digital finance	IT security	Digital everyday life	Digital presence	Business management	Sales and marketing	Mean
Budapest	66	60	51	46	39	16	46
Pest county	67	54	42	39	37	15	42
Western Transdanubia	66	56	43	38	38	13	42
Central Transdanubia	61	44	31	35	29	10	35
Southern Transdanubia	62	46	33	35	33	15	37
Northern Hungary	68	51	32	34	34	13	39
Northern Great Plain	65	48	36	35	36	15	39
Southern Great Plain	60	49	35	35	34	12	38
All SMEs	65	**54**	**42**	**39**	**36**	**14**	**40**

Forrás: Digiméter 2024.

24 The survey defines support for working from home as having at least one person working from home at least one day per week in the given company (Digiméter 2024, p. 46)

25 Among companies with a website, data for 2020 is not known.

26 Among companies with a website, data for 2020 is not known.

Table 3-3: Sectoral distribution of Digimeter subindex

	Digital finance	IT security	Digital everyday life	Digital presence	Business management	Sales and marketing	Mean
Agriculture	54	46	34	28	34	12	35
Industry	66	48	37	31	35	11	38
Trade	64	55	42	44	39	20	44
Services	66	57	46	44	36	14	44
All SMEs	65	54	42	39	36	14	40

Source: Digiméter 2024.

Box 3-2: The contribution of smart capital to growth

One important element of economic convergence is a high, sustainable investment rate, as current investments provide the basis for future production. Empirical research demonstrates that the success and persistence of convergence is not only determined by the volume of investment projects, but also by their structure and quality (van Ark et al. 2009; Corrado et al. 2013). Viewed in purely quantitative terms, investment rates mask their impact on efficiency and the prices of capital goods. Recent experience in Hungary also suggests that high investment rates alone are not sufficient to increase productivity and efficiency in the long term. The quantitative and qualitative characteristics of capital accumulation together determine the impact of investment on growth, making the role of 'smart capital' increasingly important (Várnai 2022).

Smart capital plays an important role in economic convergence and productivity growth. ICT assets (computer hardware, telecommunications devices) and intangible assets (research and development, computer software and databases, licences, know-how, original copies of entertainment, literary and artistic works) are referred to as 'smart capital'. ICT and intangible projects are assumed to complement one another, as development requires the tools (ICT capital) and software that facilitate digitalisation together with organisational change and research and development (intangible assets) (Corrado et al. 2017). Digital transformation can improve the productivity of all sectors of the economy in the longer term through automation, data analytics and more efficient innovation (Brynjolfsson – McAfee 2014).

Between 2013 and 2019, smart capital accounted for only around one twentieth of growth in gross value added in Hungary, while in the EU countries[27] it made up more than one tenth of annual growth on average. During the period, the share of smart capital investment accounted for 3.6 percent of GDP on average, which is also below the EU average (4.7 percent). Using the EU KLEMS[28] database of growth accounting data,[29] we examined the contribution of smart capital to growth in gross value added: between 2013 and 2019, smart capital accounted for around one tenth of annual growth in the EU countries[30] on average (more than one fifth in Austria and Belgium, which boasted the highest share), while in the United States it made up one sixth of total growth. In Hungary, the contribution of smart capital to annual average GDP growth is 0.25 percentage points, which is above the EU average, but when expressed as a percentage of growth, smart capital contributed only 6 percent of growth, less than the EU average (with an annual average GDP growth of 3.8 per cent) (Chart 3-15). One of the limitations of growth accounting is that it is unable to

27 Data were not available for Cyprus, Poland, Malta and Slovakia.

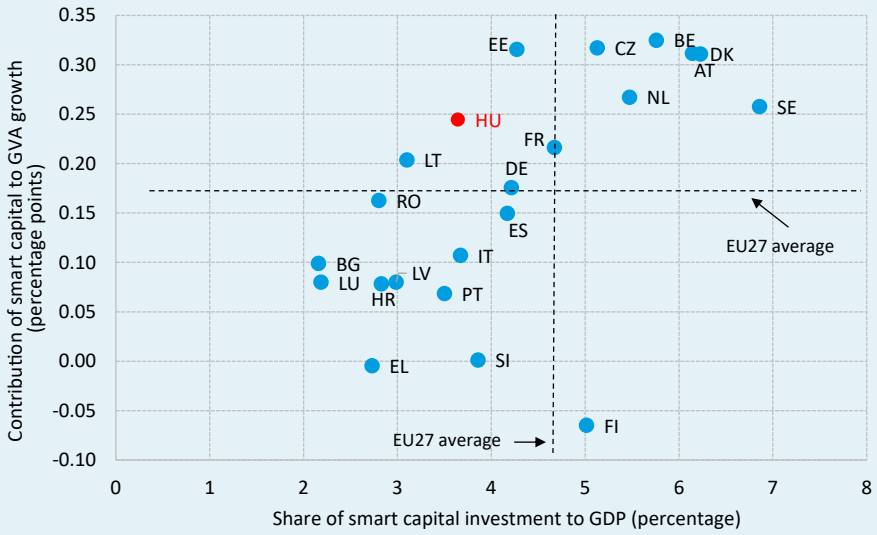
28 The EU KLEMS database contains detailed sector-level growth and productivity data for the countries of the European Union, the United Kingdom, the United States and Japan. In the database, capital is broken down into different types (ICT capital, non-ICT capital and intangibles), which are recognised with the application of a single harmonised methodology, which ensures the comparability of countries using different accounting rules (Bontadini et al. 2023).

29 Growth accounting explains the growth in gross value added by the growth rate of labour and capital employed, while total factor productivity (TFP) is obtained as a residual. The method supports the decomposition of growth into changes in labour, capital and TFP. In the calculation, the growth rates of labour and capital are weighted by their share in value added (Hulten 2010).

30 Data were not available for Cyprus, Poland, Malta and Slovakia.

quantify the spillover effects of the factors of production; it is only suitable to estimate the direct effects. Presumably, smart capital may have an indirect effect on growth through the better digitalisation and hence, efficiency, of enterprises, as well as through a faster pace of the appearance of innovations. Between 2013 and 2019, the share of smart capital investments accounted for 3.6 percent of GDP on average, with no significant change in 2020. For the EU, this value increased somewhat from an average of 4.7 percent in 2013–2019 (the average value for 2022 and 2023 amounted to 4.9 percent). Hungary still has room for improvement in terms of investment in ICT capital and intangible assets.

Chart 3-15: Share of smart capital and contribution of smart capital to growth (2013–2019)



Note: Data are not available for Cyprus, Malta, Poland and Slovakia.
Source: Eurostat, EU KLEMS, MNB calculation.

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4 Ecological productivity

HUNGARY'S ECOLOGICAL PRODUCTIVITY IS MORE FAVOURABLE THAN ITS OTHER PRODUCTIVITY FACTORS, BUT THERE IS STILL ROOM FOR IMPROVEMENT, E.G. BY INCREASING THE SHARE OF RENEWABLE ENERGY SOURCES.

Hungary's ecological productivity is 81 percent of the EU average and 51 percent compared to the TOP5 EU countries' average.

Introduction[31]

Since the first industrial revolution, the historically unprecedented growth in the world's economy and population has 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).

In many countries around the world, the ecological footprint exceeds the country's biocapacity, meaning that they use more of their natural resources than they have in a renewable way. To meet current needs, in the absence of areas with higher biocapacity, a lower, more efficient use of ecological resources is needed to ensure sustainable economic growth (Baksay – Matolcsy – Virág, 2024).

Overuse of natural capital has several causes: change of land use, material flows and climate interference. Increased land use reduces the proportion of natural areas and increases the proportion of artificial land cover where ecosystem services are no longer formed. Material flows negatively impact nature through increased material extraction, pollution and waste generation. Artificial interference in the planet's weather poses additional risks through negative impacts on the ozone layer, acidification of seawater and large fluctuations in average temperatures. By depleting natural capital, we risk compromising the availability of natural factors for future production.

Ecological productivity means the efficiency of using the environmental resources (or emissions of air pollutants 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 emissions of greenhouse gases, energy consumption and material use in the economy. With economic policy taking on an active role, it may greatly foster the shift in attitude necessary to curb the presently unsustainable process, and may become the driver for a turnaround. An example of this is the introduction of a deposit fee in July 2024 to encourage a higher recycling rate of certain plastic, metal and glass packaging in Hungary. It can be regarded as a milestone that the mandate of the MNB also includes fostering environmental sustainability since 2021. The MNB is an active player in the green transition through its Green Programme (Matolcsy, 2024).

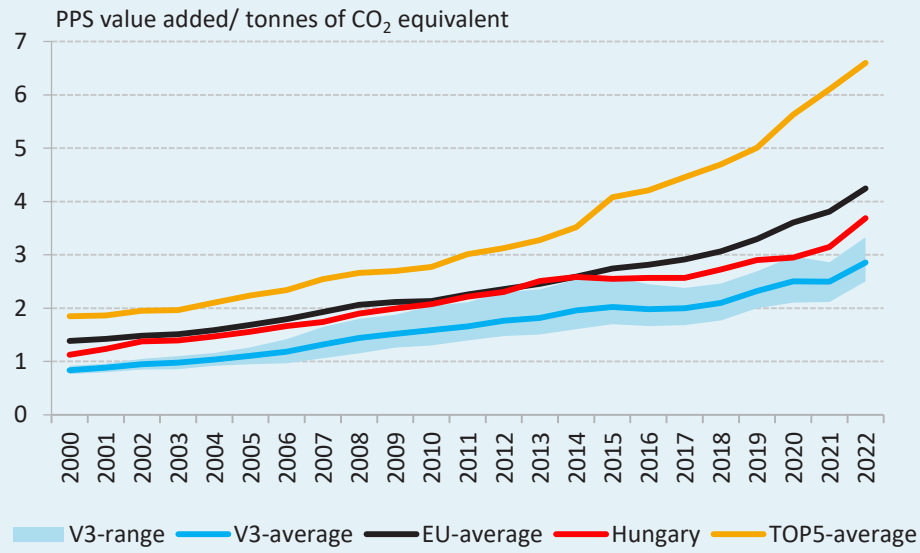
Hungary's ecological productivity is 81 percent of the EU average and 51 percent compared to the TOP5 EU countries. Ecological productivity measures how much of a product or service is produced using a unit of natural resources, and the environmental burden of production. There are several possibilities of quantifying ecological productivity depending on the approach, which are discussed in more detail in the following subsections. The composite index of eco-productivity is the arithmetic average of 5 indicators: value added per unit of CO2 equivalent emissions; value added per unit of domestic material consumption; value added per unit of municipal waste generation; energy absorption efficiency; and the share of renewable energy sources.

31 We received assistance in writing this chapter from Dr. Gábor Bartus, Secretary of the National Council for Sustainable Development, and we thank him for his help also this way.

4.1 Emissions of greenhouse gases

Hungary ranks first in a regional comparison in terms of value added per unit of CO2 equivalent emissions but is increasingly lagging behind the average of the TOP5 EU Member States. The indicator has tripled since 2000 in Hungary (Chart 4-1). This means that the Hungarian economy can produce three times as much goods and services as previously at the same level of emissions. Despite the significant improvement of the indicator, the Hungarian figure is still below the EU and TOP5 average in 2022. In this respect, Hungary stands at 87 percent of the EU average, while compared to the average of the TOP5 countries this value is 56 percent.

Chart 4-1: Value added per unit of CO2 equivalent emissions



Note: Ratio of value added at purchasing power parity and CO2 equivalent GHG emissions. The TOP5 countries were defined based on most recently available data and were plotted as a simple arithmetic average of the values for the same countries retrospectively. In order, the TOP5 countries were: Sweden, Malta, Ireland, Denmark and France.
Source: MNB calculation based on Eurostat

In Hungary, greenhouse gas emissions have decreased significantly over the past two decades. Between 2000 and 2022, greenhouse gas emissions in Hungary fell by nearly 23 percent. Structural changes in the chemical industry, the modernisation of buildings and lower use of fossil fuels have contributed to the reduction in greenhouse gas emissions. In addition to carbon monoxide, particulate matter (PM 2.5) and various nitrogen oxides showed the largest reductions.

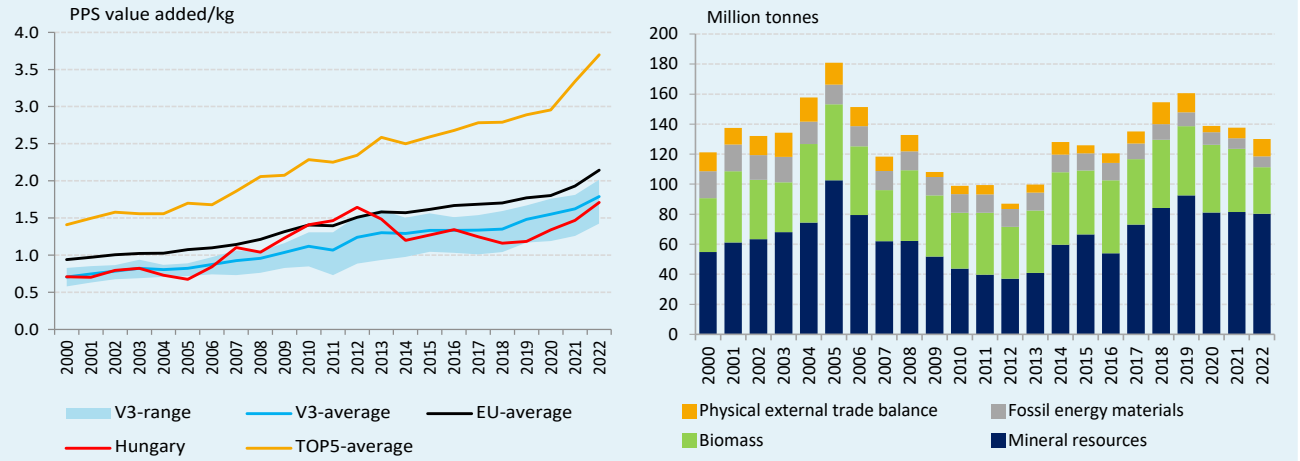
4.2 Material consumption efficiency

Hungary's material consumption efficiency is close to the regional average (V3), but still below the EU average. Material consumption efficiency is defined as the value added per unit of domestic material consumption. A country's efficiency improves when it can produce the same value added with less material inputs, or when the economy grows faster than its material consumption. Relatively speaking, the economy detaches itself from its raw material demand when it is able to produce higher value added along with a specific material demand. Domestic material consumption per capita is 13.5 tonnes per year, similar to the EU average (14 tonnes) and lower than the OECD average of 17.7 tonnes (based on 2022 data).

The evolution of material consumption efficiency in Hungary fits into the regional pattern. As a consequence of a worsening trend, by the end of the 2010s the Hungarian value increasingly lagged behind the regional average, but then started to improve again in the 2020s and approached the regional average by 2022 (Chart 4-2, left panel). The fluctuations in domestic material consumption in Hungary 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 panel). The demand for mineral extraction is largely determined by the development of infrastructure (e.g. motorway construction). Based on an international comparison, a higher share of industry in the economy is accompanied by a higher material requirement,

and thus material consumption efficiency is a more important consideration in these countries. In Hungary, the value added of industrial production doubled from 1995 to 2022 (compared to an increase of one and a half times in the EU), but its share in value added has decreased compared to 2015. In an international comparison, there is a general improvement in material consumption efficiency, which may have been driven by recent efficiency improvements in response to Covid-19 and the energy crisis. Domestic material consumption efficiency in Hungary reached 80 percent of the EU average in 2022, compared to 46 percent for the TOP5 EU countries. Despite the improvement versus 2020 (72 and 40 percent respectively), there is still significant room for improvement.

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



Note: Ratio of value added at purchasing power parity and domestic material consumption. The TOP5 countries were defined based on most recently available data and were plotted as a simple arithmetic average of the values for the same countries retrospectively. In order, the TOP5 countries were: the Netherlands, Italy, Luxembourg, Malta and Ireland. The category of mineral resources includes metal ores and non-metallic mineral raw materials.
Source: MNB calculation based on Eurostat

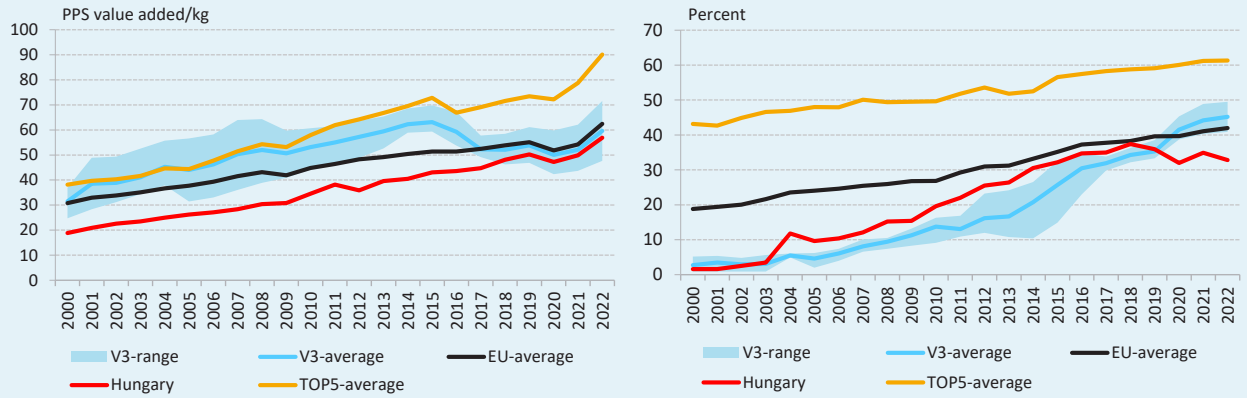
Ecological productivity can be raised by increasing material consumption efficiency. Increasing the life cycle of products and recycling materials has a beneficial effect on the environment. The degree of environmental burden may be reduced, not only by improving material efficiency, but also by including the positive role of waste management and 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 reversed via green investments, more intensive waste collection and increased recycling. Municipal waste generation per capita was 400 kg per year in Hungary (in 2022), well below the EU average (530 kg in 2021) and the OECD average (530 kg in 2022). In everyday practice, this means that on average a person generates less than 8 kilograms of municipal waste per week in Hungary and 10 kilograms in the EU. On the positive side, the per capita generation of municipal waste in Hungary decreased by 9 percent from 2000 to 2022, while the EU's per capita generation of municipal waste increased by 3.3 percent during the same period. The rate of municipal waste generation started to decouple from the growth rate of the economy, i.e. the expansion of waste generation is lagging behind economic growth. In Hungary, GDP grew by more than 70 percent in real terms between 2000 and 2022, while the amount of waste generated decreased by 14 percent.

There is an improving international trend in the efficiency of waste management, as measured by the value added per unit of waste generated, in which the trends observed in Hungary fit well (Chart 4-3, left panel). The efficiency of waste management in Hungary tripled over the past two decades, and thus by 2022 Hungary approximated the EU average. By 2020, the Hungarian indicator reached 91 percent of the EU average and 63 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 generated.

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



Note: Ratio of value added at purchasing power parity and municipal waste generation. The TOP5 countries were defined based on most recently available data and were plotted as a simple arithmetic average of the values for the same countries retrospectively. In order of municipal waste generation, the TOP5 countries were: Luxembourg, Sweden, the Netherlands, Romania and Estonia. In order of recycling rate of municipal waste, the TOP5 countries were: Germany, Austria, Slovenia, the Netherlands and Belgium. The EU average is defined as a simple arithmetic average of the countries. Data for 2022 is not available for the Czech Republic, Greece and Ireland.
Source: MNB calculation based on Eurostat

Separate collection and recycling of municipal waste can reduce the economy's demand for raw materials. Proper waste management and recycling is one of the key elements of sustainability.

The share of recycled waste in Hungary increased rapidly until 2018 and approached the arithmetic average of EU Member States, but after that a temporary decline was observed. In 2022, 33 percent of municipal waste was recycled in Hungary, while the arithmetic average for EU Member States in 2022[32] was 41 percent, and the Hungarian data is below the level of the other Visegrád countries, whereas a few years ago it exceeded them (Chart 4-3, right panel). In recent years, the decline in the proportion of waste recycled has mainly been driven by a decline in the volume of recycled waste in its material.[33] The adoption of consumer habits consistent with the circular economy and the increasingly active use of the deposit-refund system are expected to support an improvement in the indicator.

Several international and national regulations are intended to channel users towards a circular, sustainable economy. From July 2024, the mandatory deposit-refund system (DRS) for certain packaging materials was launched in the EU Member States. The deposit fee – set at HUF 50 in Hungary – motivates consumers to take empty packaging (bottles, jars, cans) to the point of return after consuming the product and receive a refund for it. In Hungary, more than 400 million bottles, jars and cans were returned in the first months of the deposit-refund system's implementation and one million users are already using the REPONT app.[34] MOHU, the operator of the deposit-refund system in Hungary, has committed to achieving a 70 percent refund rate for the first year after launch and 90 percent for the third year. By way of comparison, the refund rate only reached 30 to 40 percent based on data from the previous separate collection system in Hungary. The change in approach not only increases the recycled amount of municipal waste in the economy, it also contributes to reducing the volume and improving the efficiency of the economy's material consumption. The stated aim of the EU legislation is to contribute to the achievement of a circular economy through this incentive.

4.4 Energy absorption efficiency

Recent geopolitical tensions place particular emphasis on making the most efficient use of available energy, diversifying resources and storing energy. The efficiency of energy absorption is also a key point in ecological productivity also because of its land use, material flows and climate impacts. It shows how much value can be added per unit of

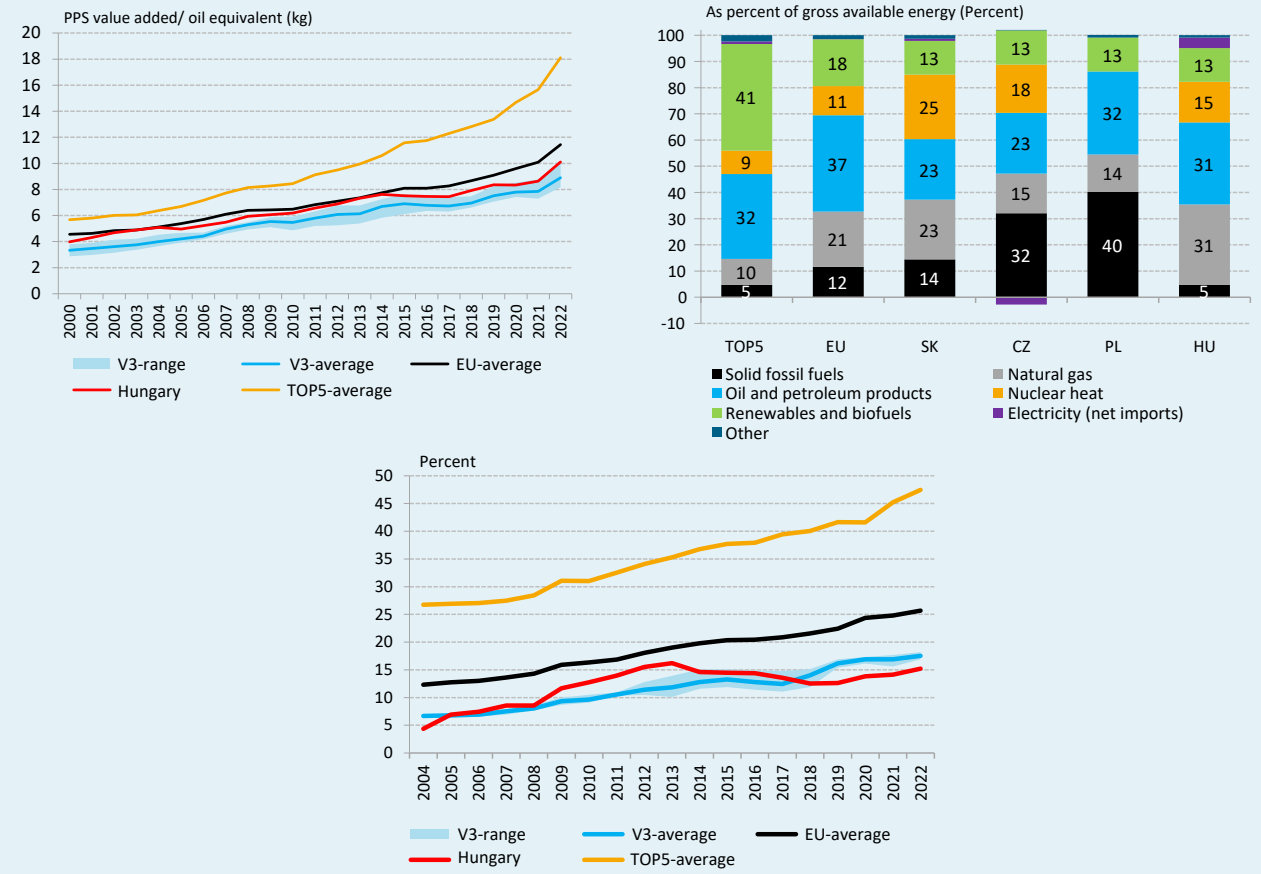
32 Data for 2022 is not available for the Czech Republic, Greece and Ireland.
33 Recycling is a recovery operation by which waste materials are reprocessed into products or materials, either for their original use or for other purposes. This includes the processing of organic materials, but excludes energy recovery and reprocessing into materials used for backfilling operations (Act CLXXXV of 2012 on Waste).
34 MOHU: One million people are already using the MOHU REPONT app: https://mohu.hu/hu/mar-egymillioan-hasznaljak-a-mohu-repont-applikaciojat

energy used. 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 panel). Similar to the energy absorption efficiency of the Hungarian economy, the international trend is also positive. By 2022, the Hungarian indicator reached 88 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 has declined, but there is still considerable unutilised potential in this area. Like most countries, the Hungarian economy also currently relies heavily on fossil fuels, which accounted for two thirds of the total primary energy supply in 2022. Due to the penetration of renewable energy sources, dependence on fossil fuel fell significantly over the past one and a half decades. The share of electricity generated from renewables (biomass, hydro, solar and wind energy) has tripled in Hungary over the last decade and a half, but is lower than the EU average, accounting for 13 percent of total energy generation (Chart 4-4, upper right panel). The EU average is 18 percent and in the TOP5 EU Member States around 41 percent of the energy consumed came from renewables in 2022. On the consumption side, renewable energy in Hungary accounted for 15 percent of energy consumption in 2022, compared to the EU average of about 26 percent and the average of the EU TOP5 countries of over 47.5 percent (Chart 5-4, bottom panel). Utilising the potential inherent in this factor would greatly contribute to further improving Hungary's ecological productivity. The above differences in the structure of energy production and energy consumption are due to the fact that imported or exported energy deflects the proportion of the energy mix used from the proportion of domestic production.

Chart 4-4: Energy absorption efficiency (upper left panel), distribution of energy sources (upper right panel), share of renewable energy (bottom panel)



Note: Quotient of value added at purchasing power parity and energy consumption. The TOP5 countries were defined based on most recently available data and were plotted as a simple arithmetic average of the values for the same countries retrospectively. In order of energy absorption efficiency, the TOP5 countries were: 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. In order of the renewable energy ratio, the TOP5 countries were: Sweden, Finland, Latvia, Denmark and Estonia.
Source: MNB calculation based on Eurostat

Nuclear energy is not considered renewable, but it features low CO2 emissions compared to the use of fossil fuels. On average, nuclear energy accounts for 11 percent of the energy mix in the EU member countries, but European society is divided on the use of nuclear energy. In 14 EU Member States, nuclear power is not used at all, and in Germany, for example, the share of nuclear power has fallen from 10 to 12 percent in 20 years to 3.2 percent in 2022. In France, on the other hand, it accounts for almost 35 percent of the energy mix. Hungary ranks 21st in the EU in terms of the share of renewable energy sources, but if low-carbon nuclear energy is also taken into account, it ranks 11th. Sweden has the highest share of low-carbon energy sources in the EU, at over 75 percent.

The decrease in dependence on fossil fuels has a number of benefits. On the one hand, it reduces Hungary's dependence on imported fuels, and on the other hand, it reduces environmental pollution. As the energy sector is responsible for a significant portion of emissions, the use of renewables instead of fossil fuels can substantially reduce emissions of greenhouse gases.

Box 4-1: The increasing role of battery storage

As the world economy expands, so does its energy demand. For sustainable development, the energy efficiency of production and the diversification of resources needs to be increased, while greater emphasis is being placed on the issue of energy storage. Renewable energy sources (as a share of gross available energy) are gaining ground worldwide. In 2000, their global share was 18 percent, rising to 30 percent by 2023. The expansion of renewables is helping to reduce dependence on fossil fuels and move towards a more sustainable, more diversified energy mix.

Renewables[35] are highly exposed to weather conditions, which makes their seasonal and intraday availability show a fluctuating tendency. Energy storage can be a solution to stabilise energy supply. When a household, company or other economic operator produces more energy than it consumes (or sells) at a given moment, it becomes important for it to be able to store and use (or sell) the extra production at a later point of time. In this way, a current oversupply can be avoided and higher future demand can be met.

By making energy storage as widespread as possible, the economy's emissions can be reduced by moderating demand for fossil fuel power plants. It can also reduce peak-loads on the grid, enable more efficient energy use, provide back-up energy for periods of power outages and increase energy independence. Energy storage also contributes to maintaining the reliability of the grid, increasing its resilience and has a moderating effect on energy prices in the medium term.

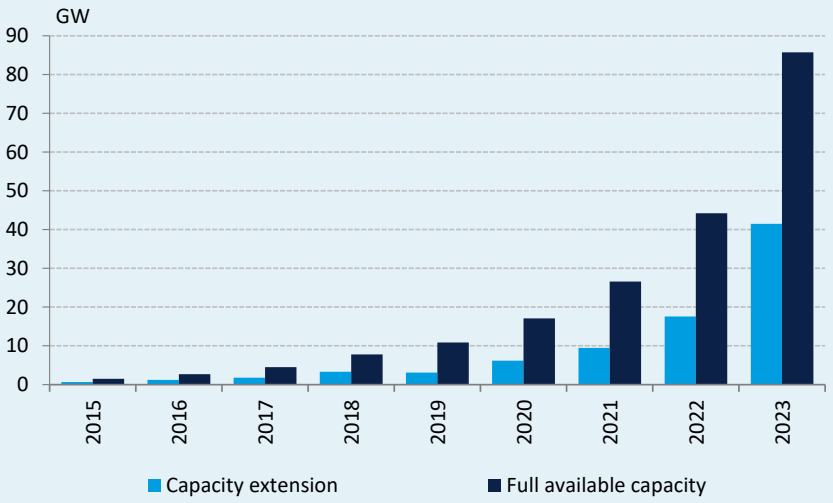
There are many ways and techniques to store energy. In this box, we distinguish between two types of batteries: the low-capacity lithium-ion battery, which allows for large charging and discharging, and the high-capacity battery storage, which can store energy for longer periods of time. The former is mainly used by households, while the latter is typically used in industrial and power plant environments.

The global stock of low-capacity lithium-ion batteries, which can store energy for short periods, increased fourfold from 2020 to 2023.[36] Worldwide, the available capacity exceeded 2,400 GWh, which is used for 40 million electric cars and thousands of battery storage systems. At present, lithium-ion batteries are predominantly (90 percent) associated with electromobility. However, the future may see an increase in the share of behind-the-meter consumer and utility-scale energy storage.[36] The average price of lithium-ion batteries has fallen by 90 percent since 2010 as technology has advanced.

Global battery storage capacity has expanded exponentially in recent years (Chart 4-5). While only 0.7 gigawatts of new capacity was installed globally in 2015, this figure rose to more than 6 gigawatts by 2020 and 40 gigawatts by 2023. As a result, the available capacity exceeded 85 gigawatts by 2023. China, the European Union and the US together account for nearly 90 percent of global capacity. According to a study by the International Energy Agency[37], the trend increase may continue in the future.

35 Typically hydro, wind and solar energy.
36 IEA (2024a): Batteries and Secure Energy Transitions
37 EA (2024b): World Energy Investment 2024

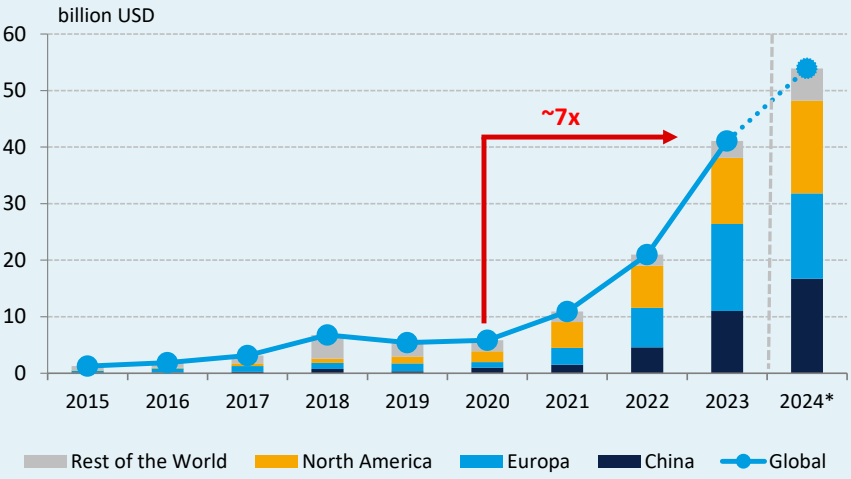
Chart 4-5: Evolution of global battery storage capacity in the energy sector



Source: IEA

The scale of global investment in battery storage has increased from USD 6 billion in 2020 to USD 41 billion in 2023, representing a nearly seven-fold increase (Chart 4-6). According to a study by the International Energy Agency[37], by 2024 investments in this area could exceed USD 50 billion, and by 2030, in the net zero emissions scenario, it could reach USD 138 billion.

Chart 4-6: Evolution of global investment in battery storage

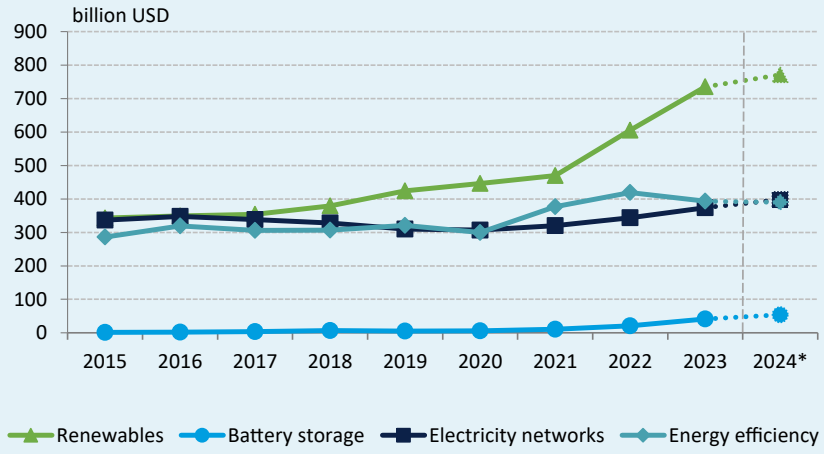


*Note: * The 2024 value is estimated.*
Source: IEA

Investment in battery storage is on a rising trend, but still lags significantly behind other energy efficiency investments. Currently, for every dollar spent on renewables, nearly 60 cents is invested in the electricity grid and battery storage systems.[38] In 2023, global investment battery storage (USD 41 billion) was significantly lower than the amount invested in improving the electricity grid (USD 374 billion), investment in energy efficiency improvement (USD 393 billion) and the amounts invested in renewables (USD 735 billion) (Chart 4-7). Investment in global battery production capacity for electric cars reached USD 115 billion by 2023.

38 IEA (2024c): World Energy Outlook 2024

Chart 4-7: Trends in global investment in energy improvements, by type



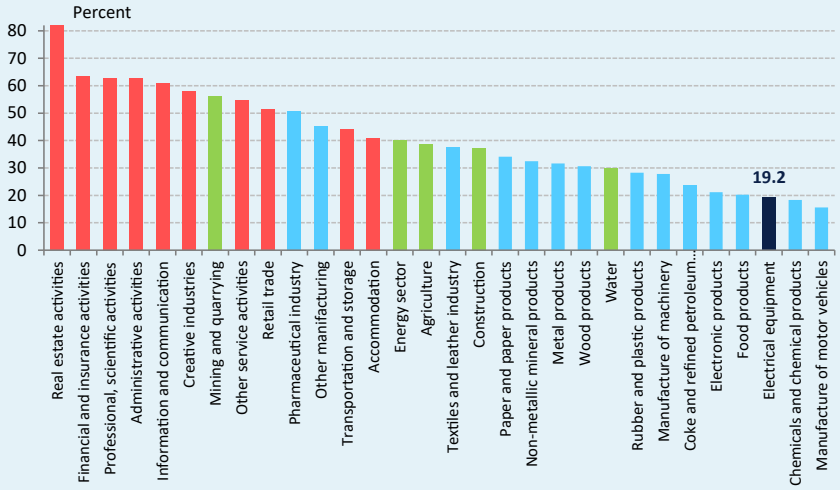
Note: The 2024 value is estimated.*
Source: IEA

At the 2023 UN Climate Change Conference (COP28), representatives from nearly 200 countries agreed to triple global renewable energy capacity and double energy efficiency improvements by 2030. To meet these targets, a further increase in the development of energy storage is essential. With the targets set, global energy storage should reach 1,500 gigawatts by 2030, of which battery storage capacity would account for 1,200 gigawatts, a 14-fold increase from the current level of 85 gigawatts.

In recent years, Hungary has received a number of foreign investments related to battery production, with reported investments exceeding HUF 6,000 billion. Some of these investments have already been completed and are in production, while others are still under preparation, with investment in progress. It is expected that production capacity will exceed domestic demand, thereby increasing the amount of exports.

In Hungary, the labour productivity of the electrical equipment sector is above the national economy average, but its share of value added in output is significantly below the level of most other sectors. Labour productivity in the electrical equipment sector, which includes battery production, was HUF 18.4 million per person in 2023, above the national economy average of HUF 13.6 million per person. However, it does not come close to the labour productivity of the deeply embedded pharmaceutical industry (HUF 31.3 million/person) and financial services (HUF 31.0 million/person). By contrast, the value added characteristic of the sector as a share of output is rather low. In the electrical equipment sector in Hungary, this indicator was 19.2 percent in 2023, below the manufacturing industry average (23.6 percent) and only one third of the 58.5 percent for market services (Chart 4-8).

Chart 4-8: Value added content of gross output by industries in Hungary



Note: Based on 2023 data. Manufacturing is shown in blue, market services in red and other manufacturing in green.
Source: MNB calculation based on Eurostat data

The embeddedness of the electrical equipment sector in the national economy is low compared to most producing sectors, and the lowest in Hungary compared to Europe. Embeddedness is measured by the so-called indirect effect, which shows how much indirect domestic value added is generated in the economy through the production chain for every HUF 100 billion of output in a sector. Based on 2021 data from Input-Output tables (IOT), the embeddedness of electrical equipment in Hungary is 12.5 percent. The indirect impact of total manufacturing is 15.1 percent and that of market services is 20.7 percent. Among the market services sectors, tourism stands out, with more than double the embeddedness of the electrical equipment sector at 29.2 percent. The embeddedness of the domestic electrical equipment sector is also low by international standards. According to the available 2018 international OECD IOT, the average level of embeddedness of electrical equipment in the EU is 22.2 percent, which is almost double the Hungarian value.

The boom in battery production has been accompanied by an increase in energy intensity and energy demand in the sector. Battery production requires significant additional energy that is not covered by current domestic energy production capacities. This also points to an increase in the capacity of renewables, while the role of energy storage will be enhanced.

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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.

Table 1: 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)	2023
GDP per hour worked (PPS)	GDP (PPS)	Hours worked	2023
SME labour productivity in comparison to the EU labour productivity	Labour productivity of SMEs (PPS)	EU-27 labour productivity (PPS)	2022
II. INNOVATION			
Average citation index per document by year of publication	Citations per document HUN	Citations per document EU-27	2023
Trademark and design patents per knowledge-intensive employees	Number of trademark and design patents	Number of knowlede-intensive employees	2023
Patents in the ratio of R&D expenditures	Patent applications	National R&D expenditures (PPS)	2022
Composit indicator measuring collaboration in innovation	Composit indicator		2023
III. DIGITAL PRODUCTIVITY			
Households' digital skills and quality of infrastructure	Digital skills, human capital (DESI index)	Connectivity (DESI index)	2023
Utilisation rate of digital infrastructure by enterprises	Integration of digital technology (DESI index)	Connectivity (DESI index)	2023
Efficiency of digital specialists	Proportion of companies using ERP, IoT, cloud computing services and e-invoices	Proportion of companies employing ICT specialists	2023
Maturity of digital public administration	Digital public services (DESI index)	Connectivity (DESI index)	2023
IV. ECOLOGICAL PRODUCTIVITY			
Value added per GHG emission	Value Added (PPS)	CO2 Equivalent GHG Emission	2022
Value added per Domestic material consumption	Value Added (PPS)	Domestic Material Consumption	2022
Value added per Municipal waste generation	Value Added (PPS)	Municipal Waste Generation	2022
Energy absorption efficiency	Value Added (PPS)	Total Energy Supply	2022
Share of renewable energy	Renewable Energy Supply	Total Energy Supply	2022

Source: MNB compilation.

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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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