FINANCIAL AND ECONOMIC REVIEW

September 2023
Vol. 22 Issue 3

Financial and Economic Review

Scientific journal of the Magyar Nemzeti Bank

Publisher: Magyar Nemzeti Bank
Publisher-in-Charge: ESZTER HERGÁR
H-1013 Budapest, Krisztina körút 55.
https://en-hitelintezetiszemle.mnb.hu/
ISSN 2415–9271 (Print)
ISSN 2415–928X (Online)

Cover design: MARIANNA IZSÓNÉ BIGAI

3 FINANCIAL AND ECONOMIC REVIEW

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Published regularly every three months.
HU ISSN 2415–9271 (Print)
HU ISSN 2415–928X (Online)

Page setting and printing:
Prospektus Kft.
H-8200 Veszprém, Tartu u. 6.

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Start-Up Ecosystem: Proposals for Fuelling the Hungarian Start-Up Scene

András Havas – Levente Jánoskuti – Márta Matécsa – Tamás Vecsernyés – Kata Hörcsig

The essay examines the role of the start-up ecosystem in the economy. It offers an international outlook to analyse the features of the Hungarian system, points out areas for development and reviews international best practices. The examination shows that overarching cooperation among economic actors could engender a start-up scene where not only 30,000 new high value-added jobs would be created, but also around EUR 1.3 billion in direct funding would appear in the economy.

Journal of Economic Literature (JEL) codes: C10, G23, G24, J20, M13, O30, O40

Keywords: start-up ecosystem, competitiveness, skilled employees, innovation

1. Introduction

The world economy is contending with several challenges: rising inflation, an unclear recovery from the pandemic, war in Ukraine and a cost-intensive energy transition in Europe. In this light, most experts and analysts agree that a marked and persistent deterioration of macroeconomic conditions is on the horizon.

Start-ups also face these challenges, but of course diamonds are formed under pressure. Many of the world's greatest start-up successes were born and built during economic downturns: one need only mention Airbnb, Uber, Slack or Square. Challenging times force entrepreneurs to take risks and establish, test and fully develop innovative business models. Average firms tend to be cautious during economic downturns, while more ambitious risk-takers, especially start-ups, recognise the opportunities, and their successes benefit the economy as a whole

* The papers in this issue contain the views of the authors which are not necessarily the same as the official views of the Magyar Nemzeti Bank.

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The essay was written with support from McKinsey's company helping start-ups based on the article entitled *Fuelling the Hungarian start-up ecosystem* (*Bacsó et al. 2023*) and the study that served as the basis for it, supplementing them by incorporating the reviewer's comments. The authors wish to thank Gábor Dános, Nóra Epelley, Tamás Kökény, Natália Madarász and Zsigmond Varga for their contributions to this paper.

The first version of the Hungarian manuscript was received on 16 June 2023.

DOI: https://doi.org/10.33893/FER.22.3.5

through innovations, product development and job creation. At a time when governments seek to soften the impact of a slowdown with all means possible, catalysing a start-up ecosystem is a highly promising option.

In the Central and Eastern European (CEE) region, start-ups can face dilemmas in acquiring the necessary resources. Several studies analyse the peculiar features of CEE start-ups. The institutional environment of the individual countries has a major impact on the propensity to start a business and the migration of existing start-ups. The CEE region is experiencing an outward migration of start-up founders (*Szennay 2019*). While in recent years some start-ups financed with venture capital in the Central and Eastern European countries became very successful unicorns, the size of venture capital funds lags far behind the European average, and the state plays an extremely large role in financing (*Karsai 2022*). *Békés and Muraközy* (*2012*) examined the features of high-growth gazelle firms and found that the businesses in a better financial position which employ young, skilled workers are 10 per cent more likely to become gazelles. The results also show that overall an economic policy that facilitates economic growth and supports new companies can be effectively developed. Supplementing this, *De Nicola et al.* (*2021*) looked at how gazelles affect the Hungarian economy and concluded that they are positively correlated with the productivity growth of the businesses around them. This holds true for those that operate in the same industry as the gazelles, and even for those that are suppliers in an industry with many gazelles. This may be due to two factors: 1) other firms can learn from the leaders and workers at gazelles about effective management and marketing; 2) the presence of gazelles increases the demand for suppliers' goods, which can be manufactured at a larger scale, potentially more efficiently.

Since start-ups mostly rely on workers skilled in software development, research and development and product management, increasing the number of start-ups could serve as a solid basis for retaining such experts and even attracting the professionals currently working abroad to return home. The start-up ecosystem is crucial in fostering the next generation of top (digital) talent and increasing the talent pool, thus ultimately benefitting not only start-ups but also other corporations in realising their innovation and development goals.

2. The research – Data and assumptions

The research presented in the essay relied on various economic and financial databases and public sources. Company data are based on the Dealroom database, adjusted as necessary based on input from local experts.

Dealroom's Hungarian start-up database contains firms that were established in Hungary but are currently headquartered outside Hungary. Dealroom classifies companies as start-ups based on two conditions. First, the product or the business model (or both) needs to be innovative. In most cases, such companies are tech enabled: proprietary technology and software or business processes are heavily enabled by tech, so these companies can achieve high growth by leveraging their platforms. The second condition is rapid scaling or scalability. This means that the start-up should develop a solution to an existing local or even global economic problem that can be easily transposed to other markets, thereby ensuring quick growth for the firm. Due to inconsistencies in the database, the data was reviewed at the different start-up stages and adjusted as necessary if they were inconsistent with the expert view (for example, a start-up considered Series B in the database might have been adjusted, with expert input, to Series A[1]). The average net salary, around EUR 1,450 per month (adjusted across maturity stages) was based on an expert report from Startup Hungary.

The following main assumptions were made during the analysis:

- The impact (both in funding and employment) of certain start-ups was excluded in the cases listed below to ensure a conservative approach. 1) Pre-seed: excluded as a result of incomplete data on Hungary (for instance, funding data were available for only 4 per cent of pre-seed start-ups). 2) Exit: excluded as a result of the limited availability of data on funding in Hungary. 3) IPO: excluded because IPOs would disproportionately increase the funding and employment impact and because the main beneficiaries of a more active ecosystem are start-ups in earlier maturity stages (in other words, the additional impact for start-ups with a potential for IPOs was lower).

- The impact of the assumed measures was estimated for the period between 2025 and 2030.

For some start-ups, funding and employment data are limited for certain stages of maturity (the authors only had access to the funding data of 20 per cent of all start-ups and employment data of 32 per cent of them, albeit this includes the very large number of pre-seed start-ups for which data was available for only 4 per cent of them, so as previously mentioned they were excluded from the impact analysis).

[1] The terms Series A, B and C refer to the rounds of financing from venture capital investors, structured by start-up life cycle and the amount of funding. However, the international literature does not have a consensus definition about classifying a given capital raising into one of the rounds. Dealroom uses the following classification for European start-ups based on the amount of capital raised: (1) Pre-seed: under EUR 1 million; (2) Seed: EUR 1–4 million; (3) Series A: EUR 4–15 million; (4) Series B: EUR 15–40 million; (5) Series C: EUR 40–100 million.

3. The state of Hungary's start-up ecosystem

Hungary now has around 3,000 start-ups, according to data from Dealroom, a global provider of information on start-ups and venture capital (VC) activity.[2] Collectively, these start-ups employ some 10,000 to 15,000 people and have raised over EUR 1,400 million in funding.[3] Certain strengths of the Hungarian economy, such as a culture of scientific innovation, skilled talent and the proximity to large European markets could help create a thriving start-up scene. Combining the existing strengths with the best practices of other countries would allow Hungary to considerably increase the competitiveness of its economy.

However, an international outlook reveals that Hungary may lag behind the CEE region currently. Hungary was only placed 50th in the Global Startup Ecosystem Index by StartupBlink,[4] behind most countries from the CEE region (Estonia 14th, Poland 33rd, the Czech Republic 35th and Romania 42nd). The report also mentions that Hungary increasingly lags behind Europe (while it was placed 25th within Europe in 2020, it is 31st in 2023). This is mainly due to the lack of internationally successful start-ups, attributed by the authors of the report to economic challenges and the migration of talent.

To determine the development opportunities for the Hungarian start-up ecosystem, key metrics were compared across Hungary and the most successful start-up ecosystems from the CEE region and the world (including value creation, financing and the number of start-ups per capita). The results showed room for improvement in almost all dimensions (*Table 1*).

[2] The data in the table is as of 2021, Dealroom mentions "more than 1,500" Hungarian start-ups in a report published in 2022, suggesting that the figure may have been reviewed since
[3] Does not include the headcount data and the capital raised by pre-seed and exited firms and those that have had an IPO.
[4] *Startup Ecosystem Report 2023:* https://lp.startupblink.com/report/

Table 1
Start-up metrics in Hungary and selected countries

	Central Eastern Europe						Leading ecosystems in EMEA			
	Bulgaria	Czechia	Hungary	Poland	Romania	Slovakia	Estonia	Germany	Israel	Netherlands
Financing										
Venture capital funding per capita, EUR	60	80	**45**	48	116	29	1,967	440	n/a	614
R&D										
Investment in R&D as a share of GDP, %	0.9	2.0	**1.6**	1.4	0.5	0.9	1.8	3.1	4.9	2.3
Talent										
Universities in top 500 for STEM	0	5	**2**	6	3	0	1	32	5	10
Universities in top 500 for business	0	0	**1**	4	1	0	0	13	3	11
Start-up activity										
Number of start-ups*	1,949	3,315	**2,977**	7,949	3,413	1,292	2,765	51,296	11,277	45,088
Start-ups per 1 million population	281	310	**305**	209	177	237	2,077	616	1,224	2,585
Average valuation per start-up, EUR million**	1.6	6.9	**2.0**	5.4	7.5	0.8	11.9	8.2	37.8	6.3
Number of unicorns	0	4	**1**	11	1	0	7	58	91	21

*Note: Data for 2021. * As of February 2022. ** Conversion rate: USD 1 = EUR 0.85*
Source: Dealroom; OECD; QS Quacquarelli Symonds World University Rankings 2021; McKinsey analysis

Hungary is on a par with the region as a whole in many factors that form the basis for a successful start-up ecosystem. It produces a number of start-ups comparable to that of the other CEE countries, is similar to Poland in venture funding (an estimated EUR 45–50 per capita) and has a largely matching talent pool. In some areas, Hungary is ahead of its peers; for example, it has the region's highest share of ICT (information and communication technology) experts, 3.6 per cent of the total workforce, compared with an average of 2.8 per cent in the CEE as a whole (*Havas et al. 2018*).

Human capital is key in the success of Hungarian start-ups focusing on developing and implementing the latest technologies, such as artificial intelligence and biotechnology. In Hungary, the digital infrastructure basically ensures the growth of the tech ecosystem, and funding, which is vital for start-ups, and the interest of venture capital investors are growing (*Goreczky 2021*). The largest Hungarian companies were able to raise around EUR 400 million in 2021, in various financing rounds. Most of the funds came from foreign private investors, who typically focus on more mature start-ups. A review of the life cycle of top Hungarian start-ups (based on Dealroom funding data) shows that initial funding usually came from Hungarian sources, while a larger round, typically a Series A, involved European investors, and the firms only attracted the interest of American venture capital investors in Series B rounds with tens of millions of euros in funding.

Table 2
The 10 largest Hungarian start-ups on the basis of the total venture capital raised

	Company name	Total capital raised, EUR million	Main activity
1	Bitrise	101	Software development
2	SEON	92	Online fraud prevention
3	Aimotive	68	Automated driving
4	Turbine	26	AI-powered oncology drug R&D
5	LMDoki	26	Mobile application for booking appointments
6	Sharp3D	19	3D modelling
7	Craft	18	Document management system
8	CodeCool	13	Programming training
9	Commsignia	10	Vehicle communication
10	Antavo	10	Loyalty programme management

Note: April 2022 data
Source: Forbes

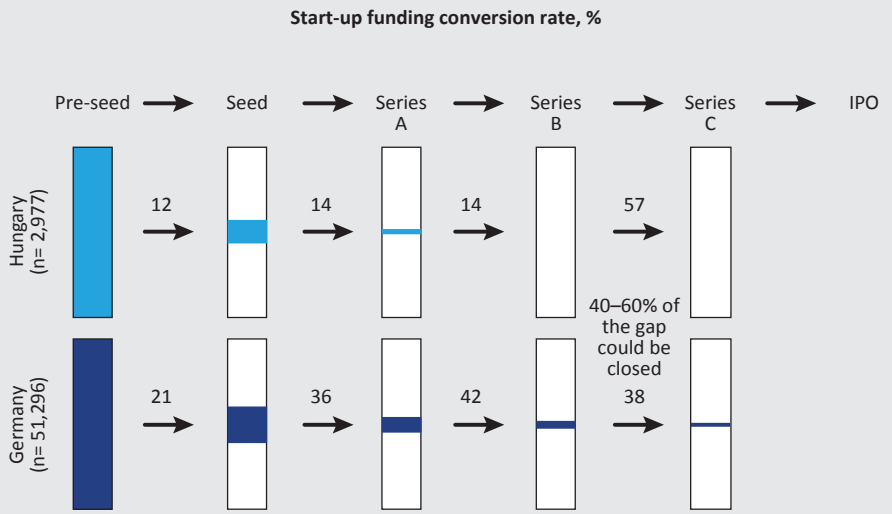
However, a start-up ecosystem's health is generally measured by high-valuation exits (the acquisition or IPO of a start-up), both in number and in value. The analysis pointed out that Hungary lags behind its neighbours in the number of so-called unicorns:[5] there have been 4 and 11 unicorns in the Czech Republic and Poland, respectively, and LogMeIn was the only one from Hungary to reach that level.[6] This also means that up-and-coming Hungarian entrepreneurs have few truly good role models, on both the investing and the start-up side, unlike their counterparts in more successful start-up nations. In particular, Estonia and, most recently, Romania have been able to build on their internationally successful unicorns: the trailblazing examples include Skype from Estonia (sold for USD 8.5 billion in 2011) and UiPath from Romania (with an IPO valuation of USD 31 billion in 2021). According to *Startup Genome's Global Startup Ecosystem Report 2023,*[7] the total value of the Hungarian start-up ecosystem is only EUR 1.7 billion (measured between the second half of 2020 and 2022, signalling an approximately 1 per cent decrease from the previous 2-year period), and there was no recent unicorn exit.

Szennay (*2019*) pointed out another important characteristic of the CEE region. The author examined the migration of existing start-ups, and found varying results across the Visegrád countries: Poland and the Czech Republic have positive net start-up migration, while Hungary and Slovakia are experiencing substantial outward migration. Since institutional transformation usually takes a long time, the solution in the short and medium term could be the incubation of start-up ideas and appropriate training and mentoring. Another study summarising expert interviews about the factors influencing the survival and growth of Hungarian start-ups also concluded that internationalisation and acquisitions are crucial in the success of start-ups (*Csákné Filep et al. 2020*).

Looking at conversion rates across the "start-up maturity funnel" can help further illuminate opportunities to advance the start-up ecosystem (*Figure 1*).

[5] Start-ups reaching USD 1 billion in valuation.
[6] LogMeIn was first valued over USD 1 billion after its IPO in the US in 2009, so experts are divided whether it is a unicorn or even a Hungarian start-up.
[7] https://startupgenome.com/report/gser2023

Figure 1
Start-up life cycles in Hungary and Germany



Source: Dealroom

When comparing the statistics of Hungary's maturity funnel with that of Germany, which has one of the top three European start-up ecosystems (*EC 2022*), it can be seen that Hungary has less than half as many start-ups (proportionally to population) at the beginning of the funnel: 305 start-ups per million people in Hungary, versus 616 in Germany. There are significant gaps in conversion rates, which show when firms advance from one stage of maturity to the next one, at almost all further stages of maturity.

Overall, these ratios indicate that Hungary has room for improvement: it should be focusing on factors that increase the number of start-ups founded and improve the start-up scaling success rate.

4. What does this mean for the economy?

Our analysis indicates that over the coming decade, a more advanced start-up ecosystem could help buoy Hungary's economy in three ways.

4.1. Economic and financial value added

Increased maturity along the start-up funding funnel (for instance, an increase in the share of start-ups converting from the pre-seed to the seed stage) could generate EUR 2.5 billion–EUR 5.0 billion in additional funding for the sector. Much of that, around EUR 0.6 billion–EUR 1.3 billion would be used as additional direct local

spending in the economy. The resulting job creation could generate up to some EUR 2.2 billion in employment taxes between 2025 and 2030.[8] Other tax revenues are also projected to rise.

In a recent study, *Bisztray et al.* (*2023*) looked at how quickly growing firms affect productivity growth. The productivity of companies that rapidly increase their revenue typically expands as well, and usually (in 70 per cent of the cases) they make a positive contribution to productivity growth in the industry. The authors also showed that rapid growth is often an extraordinary period in the life of a business: there is positive correlation between productivity growth in a sector and the ratio of young firms, but there is no strong link between the amount of contribution such companies make and industry-specific features.

4.2. Talent development

A more advanced start-up ecosystem would generate almost 30,000 high value added new jobs in Hungary. Such a well-functioning entrepreneurial community offers appropriate opportunities for Hungarian professionals and may also help attract skilled labour to Hungary from abroad. For digital start-ups, this positive effect could be even greater, not only for the businesses in question but also for the economy as a whole.

4.3. Digitalisation

McKinsey's report *Digital challengers on the next frontier in Central and Eastern Europe* (*2022*) includes a deep dive on digitalisation in Hungary. An important finding of the analysis is that a more advanced start-up ecosystem that mainly seeks to commercialise and advance new digital solutions can promote digitalisation at a nationwide level, and the potential economic and development benefits could amount to as much as EUR 9 billion in additional GDP by 2025.

Ambitious firms are especially important for the competitiveness of a country, and a digital entrepreneurial ecosystem can provide significant assistance in the creation of a digital unicorn (*Torres – Godinho 2021*). Besides boosting innovation and entrepreneurship across the economy, digitalisation could reinvigorate traditional industries, allowing them to leapfrog to state-of-the-art technologies by collaborating with local start-ups that can design products and services for those industries' specific needs. Many great examples already exist. For example *Turbine*, based in Hungary, is using AI to develop new digital platforms that streamline the oncology R&D process globally. *Starschema* provides data-warehousing, business intelligence and big data services to many Fortune 500 companies.

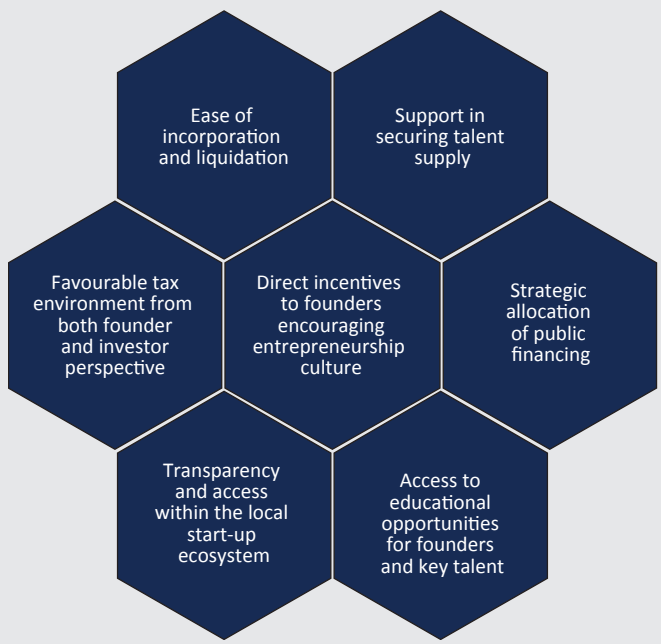
[8] All figures are nominal as of 2021 and thus do not account for inflation. The nominal values for future years could be higher than indicated.

A successful start-up ecosystem is also a sustainable one. It has a positive scale effect when successful founders create, reinvest in and spread their knowledge to new start-ups. Early signs of this effect can already be observed in Hungary, where data from a recent survey by *Startup Hungary* (*2021*) suggested that about one in four founders have had previous start-up experience.

5. Attributes of successful start-up ecosystems and the tools for developing them

To find the common attributes and underlying ways in which countries fuel their start-up ecosystems, the authors interviewed a broad range of global start-up experts, as well as several stakeholders in local ecosystems. These discussions helped identify the seven key attributes of most successful start-up ecosystems (*Figure 2*).

Figure 2
Seven common attributes of successful start-up ecosystems



Source: McKinsey & Company

Related to the seven attributes mentioned, specific tools and avenues of development that countries can use to increase both the number of start-ups founded and the success rate of such companies were revealed (*Figure 3*).

Figure 3
Improvement of successful start-up ecosystems with the seven common characteristics

Source: McKinsey & Company

5.1. Ease of incorporation and liquidation

Globally renowned, successful start-up ecosystems operate in countries where regulations not only help founders, the operation of firms and investment, but also give them incentives to adopt the right policies and approaches. Laws and administrative processes are constantly adapted to evolving economic conditions.

One core element of establishing a successful start-up ecosystem is a transparent and simple yet fraud-resistant system for incorporating and liquidating ventures. Overly complex, time-consuming incorporation processes may hinder ambitious start-up founders, while a highly bureaucratic liquidation process can prevent founders of failed start-ups from moving on to the next venture without excessive delay. Very few founders get it right on the first try, and experiences of past failures can often be crucial in creating a unicorn.

Hungarian corporate law, and therefore Hungarian practices, are not yet in line with international best practice: Hungary was ranked 87th in the World Bank's

2019 *"Starting a Business"* ranking.[9] The stakeholders in the Hungarian start-up ecosystem face two main challenges: finding opportunities for launching a new business after the previous one was liquidated, and navigating the administrative challenges entailed by the process (*Jáki et al. 2019*). The bureaucratic hurdles are one of the key reasons why more than 25 per cent of Hungarian start-ups are registered abroad. These companies hope to benefit from a more transparent regulatory environment, simplicity and better access to funding, according to a Startup Hungary survey.

In addition, excessive red tape can keep away foreign investors: according to Dealroom's data, only around 16 per cent of total start-up funding in Hungary comes from foreign investors, versus an average of 40 per cent in Europe as a whole and up to 70 per cent in leading ecosystems, such as those of Germany or Israel. In Estonia, the government has acted as a catalyst for the ecosystem by launching a number of legal and administrative initiatives, such as those for e-government, simplified administrative processes, electronic incorporation and e-residency. Initiatives of this kind can increase both the number of start-ups founded and their success rate.

To facilitate the adoption of the most suitable regulatory principles, several countries have put in place so-called start-up committees, which act as independent coordinators between local and national decision-makers and the stakeholders in the start-up ecosystem and advocate on behalf of start-ups when new regulations are formulated. Aiming to improve the framework for high-growth companies, the Austrian Federal Ministry for Digital and Economic Affairs established a start-up committee comprising five experts. The independent body's main task is to provide professional support to decision-makers by giving content-based advice on regulatory steps that could support the ecosystem's growth.

5.2. Support in securing talent

Once a start-up is up and running, it needs to attract top talent: people who are ambitious, live and breathe the start-up's mission, and capitalise on their experience to help the company scale toward international success. In the global race for talent, most successful countries have initiatives that simplify the hiring of employees by start-ups.

One way of doing this is to facilitate the employment of international digital talent. Truly ambitious start-ups must generally hire foreign tech and business specialists from the outset who, thanks to their market knowledge and language skills, can help start-ups expand into new markets and scale up on a global level.

[9] *"Starting Business"* World Bank. https://archive.doingbusiness.org/en/data/exploretopics/starting-a-business

In many cases, even a simplified start-up visa process can go a long way in recruiting international talent. A good example for this is the French "tech visa", which is actually a simplified and fast-track visa scheme. It helps start-ups grow by assisting employees from outside the European Union in obtaining a residence permit. Between 2017 and 2021, 1,150 start-ups used this opportunity.[10] The visa, valid for four years, is renewable and degree-agnostic. It automatically covers spouses and minor dependent children. Eligible companies must be registered in France (not necessarily as their headquarters) and meet one of the following conditions: 1) Young Innovative Enterprise (JEI) status (a package of tax credits and social contribution exemptions for R&D-heavy start-ups); 2) state funding for innovation within the past five years; 3) French VC backing; 4) membership in a partner accelerator or incubator.

Experts and founders in the survey said that another key tool for hiring talent at start-ups was the ability to give employees stock options. Obviously, start-ups can hardly compete with the salaries of large corporations. They can only offset this problem by involving employees in the future success of the business, the achievement of which depends heavily on the employees, too, so this is a win-win solution.

5.3. A favourable tax environment

International examples show that the appropriate tax policies can ease the initial financial burden on start-ups, encourage better conversion throughout the funding funnel (for example, through the tax benefits offered to start-up investors) and create incentives for successful entrepreneurs who exit to reinvest in the ecosystem. Direct tax benefits to start-ups could come through income tax reductions or through cuts on taxes paid on the salaries of employees, as the Netherlands has done with a 30 per cent tax cut. The latter is a tax benefit offered to skilled employees who relocate to the Netherlands for a specific employment role. When the necessary conditions are met, the employer can grant a tax-free allowance equivalent to 30 per cent of the gross salary subject to Dutch payroll tax.

Tax policies to encourage investment can take the form of income tax benefits tied to venture capital investment. One example comes from France, where exiting founders receive tax relief on the proceeds they use to fund other start-ups, potentially through holding companies. The UK Enterprise Investment Scheme offers tax relief to individual investors who buy new shares and allows those investors to claim an individual income tax deduction of 30 per cent of investments in the start-up. Similar systems exist in Belgium, Germany, Ireland, Italy, Portugal, Spain and Sweden, among other countries.

[10] According to data from the French Ministry for the Economy and Finance

So far, Hungary has granted no benefits to founders or employees via income tax reductions. Corporate tax deductions for corporate start-up investors are capped at HUF 20 million (around EUR 50,000) over a four-year period. In accordance with Section 7(1)(m) of the Hungarian Act LXXXI of 1996 on Corporate Tax, pre-tax profits are reduced by three times the historic cost of the shares acquired in start-ups (with respect to a capital increase following the acquisition, including the growth of the historic cost) in the year of obtaining the shares and the next three tax years, in equal instalments, but only up to HUF 20 million per tax year and start-up.

5.4. Direct incentives to encourage an entrepreneurship culture

McKinsey's earlier research (*Berger-de León et al. 2021*) has confirmed that in some cases people from non-traditional backgrounds have a higher interest in founding a company, but are less able to act on their intent. This is also true for mid-career founders (ages 35 to 45), who are more likely to have the right combination of experience and knowledge but may be risk-averse as a result of their comfortable corporate jobs and family priorities. Many successful ecosystems have support programmes targeting such founder segments and help increase the number of new start-ups.

Who starts companies in Hungary? *Jáki et al.* (*2019*) showed that typical start-up founders were middle-aged men from Budapest, with experience at international corporations or in an earlier business, and around half of the founders had some experience with start-ups. There are very few women in the Hungarian ecosystem, partly because much of the start-ups are related to the ICT sector, where most experts are male. However, a similar gender gap can be observed in Hungary and Europe in terms of the owners of start-ups, 80 per cent of whom are male (*Kézai – Konczos Szombathelyi 2021*).

The gender gap is significant: only around 25 per cent of start-ups created between 2010 and 2020 had at least one female founder (*Startup Hungary 2021*). Yet as noted before, according to *earlier research by McKinsey*, women have a higher interest in founding a company, but rarely do so due to various reasons. Two approaches might make a positive contribution towards eliminating hurdles and closing this gender gap: encouraging mentoring programmes targeting females and increasing public awareness of unconscious bias in funding processes. A positive example for this from the past five years is an Australian initiative for female founders: to help female entrepreneurs overcome disadvantages in gaining finance and support, Australia's government started the Boosting Female Founders Initiative programme, which offers grants of AUD 25,000–AUD 480,000. The programme provides not only targeted support for scaling in domestic and global markets but also expert mentoring and advice. For this project, Australia's government has allocated a total

of AUD 52.2 million in grant funding, over multiple rounds, and AUD 35 million of that has been granted to start-ups in the past three years.[11]

5.5. Strategic allocation of public financing

Public funding for the start-up ecosystem is a powerful tool, but one that requires efficient, well-monitored distribution. In successful ecosystems, grants (e.g. R&D grants) are given to sectors that are strategically important to the economy, and equity funding from public sources is granted in a way ensuring that the state's position is equal to that of any other investor, with strict due diligence and investment KPIs. In CEE countries, there are several areas that are in need of development. *Karsai* (*2022*) pointed out that in the CEE region state funds (including EU transfers) offer a large supply of capital to a wide range of start-ups, but the selection of the companies is not based solely on market considerations. This can lead to the emergence of a dual market, where start-ups that do not receive funding try to survive on the market.

In practice, start-up funding varies across the CEE countries. In Central and Eastern Europe, the development of venture capital's institutional structure has been imbalanced: 1) among the Baltic states, Estonia and Lithuania chose to liberally regulate the market, and as digitalisation increased, a vibrant venture capital market emerged, producing internationally renowned success stories; 2) in Hungary and Poland the market was divided into two: one group comprised start-ups supported by funds from the European Union and the national budget, while the other included internationally successful and innovative firms that emerged locally with the cooperation of private fund managers; 3) in the other EU countries of the CEE region the strengthening of the market economy is facilitated by EU funds, and the related institutional transformation is well under way; 4) in the countries outside the European Union, VC remains embryonic (*Karsai 2020*).

Two key tools were identified during the investigation of best practice examples of efficiently allocated public funds. First, research grants for areas in strategically important sectors are a proven way of supporting both the domestic start-up ecosystem and the national capacity for innovation. Targeting research grants to strategic sectors has two key benefits: a higher likelihood of success for start-ups that can operate in strong domestic markets and an improvement in the international competitiveness of a nation's key industries. Second, experts agreed that the most efficient way of allocating public funds to the start-up sector was for the government to establish a "fund of funds" that, rather than investing directly, invests through reputable and professional VC funds that already have a track record of strong returns. This approach is generally perceived as more efficient than direct

[11] Official site of the Australian Government: https://business.gov.au/grants-and-programs/boosting-female-founders-initiative-round-3

government involvement in venture funding, because professional VC funds have the necessary experience and rigorous, market-oriented KPIs for returns that ensure the efficient allocation of investors' money.

Although this type of funding has no strings attached, venture capital funds need clear and transparent reporting on the way they allocate resources they receive from the "fund of funds". A successful example is the Polish Growth Fund of Funds, with over EUR 3 billion under management, intended to stimulate equity investments in growth-focused enterprises in Poland with the help of the professional VC sector.

The importance of innovation in strategic industries is also exemplified by Israel. Israel's population is almost the same as Hungary's (at around nine million), but has a GDP of nearly USD 500 billion, more than 2.5 times that of Hungary. Its economic success is fuelled by both its start-up ecosystem and the strength of its strategic industries, including biotech, cybersecurity, pharma, specialised engineering and technology. To help start-ups, the Israeli Innovation Authority runs a variety of research grant programmes,[12] ranging from general all-access grants to grants for companies founded by minorities.

The Israeli Innovation Authority provides specific research grants for start-ups in sectors that are strategically important to the Israeli national economy:

- The Ideation Incentive Program provides grants of up to USD 30,000 in the initial development stages. It is generally open to start-ups in all industries, but allows for higher grants in biotech and other specialised engineering sectors.
- The R&D Fund's programme provides product development grants to start-ups younger than five years. The recipients innovate in areas with high development risk, such as communications, cyber, hardware, medical equipment and software.
- A programme specifically for cybersecurity provides grants of about 50 per cent of a company's R&D budget (up to about USD 600,000).

5.6. Transparency and access

Leading start-up ecosystems ensure top-notch transparency and credible reporting, typically through databases and digital platforms that serve as the single source of truth on a nation's start-ups and provide guidance on founding and scaling. When the research was conducted, no digital platform served as a single source of truth on Hungary's start-ups, or provided practical guidance for those who might wish to found such companies.

[12] The details of the programme can be found at the Israeli Innovation Authority's official website: https://innovationisrael.org.il/en/program/ideation-tnufa-incentive-program

Stakeholders in the current start-up ecosystem could work jointly to create a platform that would, among other things, provide information and services for start-up founders and investors, as well as structured mentoring and networking for entrepreneurs. The platform's goals would be to enable access to experience and capital and, ultimately, to increase the number of start-ups founded and scaled. An example for this is Startup Estonia, a government initiative with an allocated amount of EUR 7 million. It aims to enrich the start-up ecosystem by mobilising start-ups, incubators, accelerators, other private sector actors and relevant public entities. It covers four main areas: community activation, training programmes for young companies, investor support and the facilitation of administrative processes. It also provides a database of start-ups and relevant service providers, and as of 2022, the database included more than 1,300 start-ups and was catalysing the whole Estonian start-up conversion funnel.

5.7. Access to educational opportunities

Established investors and successful founders in Hungary say that its entrepreneurs have generally low levels of risk-taking and lack the willingness to internationalise. A 2018 Oxford University study found that Hungary was ranked the fourth lowest out of 77 countries on a risk-taking index (*Becker et al. 2018*). To quote the CEO of a Hungarian start-up, Hungary is the "country of inventors", it has a strong cohort of technically proficient entrepreneurs, but when it comes to business development, they appear to lack the drive and motivation of their counterparts in other CEE countries. As pointed out by *Békés and Muraközy* (*2012*), in line with international literature, business growth could be facilitated by trainings improving business management skills, innovation activities and the strengthening of companies' international ties. This is all the more important because growth is largely determined by the idiosyncratic features of the company's management and strategy.

Successful ecosystems use three main tools to ensure that potential founders of start-ups and their employees have the right skills. First, founders get free access to digital, coding and business courses through a start-up platform or subsidised courses at existing local providers. There are examples for this in Hungary, in the form of a programme sponsoring digital education at existing coding schools.

Another typical trait of successful start-up ecosystems is the promotion of an entrepreneurial culture in academia, usually by supporting nation-wide digital entrepreneurship curricula at universities and other academic institutions. Hungary offers an example for this, too: the Hungarian Startup University Programme (HSUP) kicked off in 2020, with more than 2,000 participating students. This was the country's first unified adult education curriculum in start-up entrepreneurship.[13]

[13] Source: HSUP website, https://hsup.nkfih.gov.hu/

Finally, Hungary could utilise the international networks and know-how from the collaboration with start-up-focused foreign universities, such as Stanford in the United States and the University of Aachen in the European Union. Higher education institutions could be encouraged to create incubators or research departments; for example, the Stanford Technology Ventures Program (STVP) forms partnerships with universities around the world to develop programmes and curricula for entrepreneurship education. The programme is designed to maximise the impact that partner universities create in their respective countries.[14]

If Hungarian universities and other education institutions can not only continue but also expand their efforts to educate entrepreneurs, promote entrepreneurship and build international networks, it could promote the founding of several Hungarian start-ups.

6. Conclusion

Although the Hungarian start-up ecosystem lags behind the world's leading ecosystems and the CEE region, it can definitely catch up by capitalising on the internationally renowned Hungarian scientific innovation. The success rate of Hungarian firms could be improved by catalysing the foundation of more start-ups and improving the conversion rate across the maturity funnel.

The present research identified seven main attributes that could boost both the number of start-ups founded and their success rate. In connection with the seven attributes, the avenues of development were determined that could promote the continued development of Hungary's start-up ecosystem.

The basis for ease of incorporation and access to financing is a transparent yet fraud-resistant system for incorporating and liquidating ventures, with much less red tape than today, and a direct advisory committee comprising stakeholders from the ecosystem that could help keep start-up regulations up to date.

Having access to skilled labour and a talent pool is a crucial, or perhaps even the most important, feature. In this respect, the international competition is intensifying by the year, with several countries introducing various initiatives to attract international talent to their own start-up scene. To allow Hungarian start-ups to access the appropriate talent, a transparent stock option scheme or a special visa targeting start-up workers could go a long way.

[14] "Global partnerships": Stanford Management Science and Engineering.

Furthermore, the countries with successful start-up systems offer a favourable tax environment to firms. This can take the form of direct tax credits tailored to start-ups or even "reinvestment" benefits, in other words incentives for investor and entrepreneurs after a successful exit to reinvest their profits in the start-up ecosystem in exchange for preferential taxation.

Direct incentives to bolstering entrepreneurship are justified because in successful ecosystems the "mystery" of launching a business is not necessarily associated with the archetype of a risk-taking young male. International studies have found that an ecosystem can benefit greatly from encouraging incorporation with subsidies and mentoring programmes targeting various groups (e.g. female founders, mid-career professionals).

Strategic allocation of public financing is a key attribute that determines the differences between various countries. This paper found the most successful models with two types of state funding. Grants exert the largest impact if they target strategically important industries to encourage innovation, and with public equity investment the "fund of funds" method proved to be the best. This means that the state, similar to any other private investor, invests in professional private equity funds with strict KPIs, thereby indirectly financing the start-up ecosystem.

Transparency and knowledge sharing can be ensured through databases and digital platforms that serve as the single source of truth on a nation's start-ups and provide practical guidance on founding and scaling.

Finally, the seventh key attribute is the training of founders and professionals, which can be implemented through free access to digital, coding and business courses, the continued strengthening of the curricula relevant for digital businesses in higher education institutions, and international scientific partnerships.

If progress can be made in the identified areas through the close cooperation among the stakeholders in the sector, Hungary has a chance to create a thriving start-up scene that can help buoy the economy as a whole.

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Inflation Shocks and Disinflation: Stylised Facts from the Past 50 Years*

Balázs Spéder – Balázs Vonnák

In our study, we examine the circumstances under which major inflation shocks lead to persistently high inflation. For our analysis, we use macroeconomic data from a broad sample of countries for the past fifty years or more. We identify several cases where inflation rises from the single-digit range to above 20 per cent, followed by successful disinflation within two years. Similarly, there are many examples where inflation remains high after an initial shock. The former cases are characterised by more pronounced increases in interest rates during inflation shocks, more disciplined fiscal policy and favourable commodity price developments. Examining the same sample, we also show that the disinflation after a period of persistently high inflation was not typically accompanied by a significant slowdown in the real economy and instead was often followed by higher economic growth. In the disinflationary episodes we identified, the size of the real cost of disinflation is negatively correlated with the central bank independence, suggesting that a disinflationary commitment played a positive role.

Journal of Economic Literature (JEL) codes: E31, E63, N10

Keywords: inflation, stabilisation, monetary policy, central bank independence

1. Introduction

By the end of 2022, global inflation had risen to unprecedented levels as a result of successive shocks, with annual rates exceeding 10 per cent in nearly half of the world's countries and more than three quarters of the world's countries showing inflation rates above 5 per cent (*Figure 1, left panel*). Over the past half century, there were several periods when inflation caused a global problem (*Figure 1, right panel*). In the 1970s, inflation came in several waves. As a result of the two oil price shocks during that decade, inflation rose to double digits in most economies between 1973–1975 and 1979–1982. With the end of the Cold War

* The papers in this issue contain the views of the authors which are not necessarily the same as the official views of the Magyar Nemzeti Bank.

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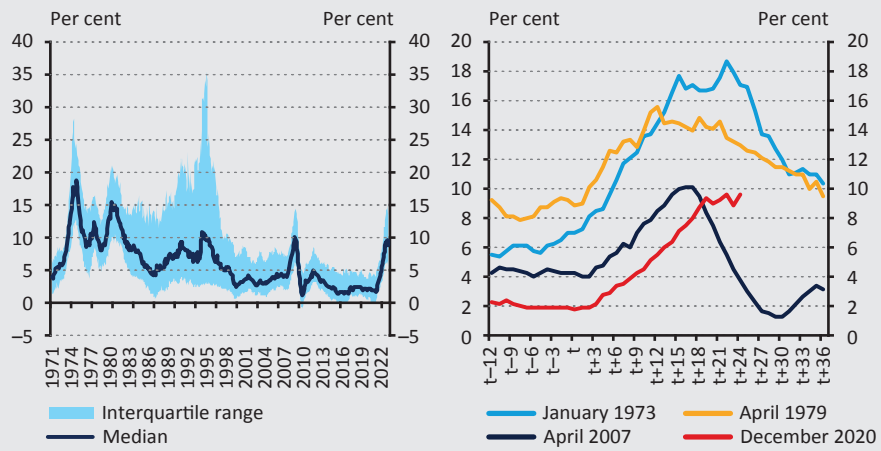
The first version of the Hungarian manuscript was received on 28 June 2023.

DOI: https://doi.org/10.33893/FER.22.3.26

and the transition from the socialist central planning system to a market economy, accelerating inflation occurred in many countries around the world in the first half of the 1990s, but it remained limited in geographical scope. The economic growth before the global crisis of 2008–2009 was also accompanied by a substantial rise in inflation and, for many countries, double-digit price index increases.

Figure 1
Evolution of global year-on-year inflation 1971–2022 at monthly frequency: quartiles over the whole time horizon (left panel) and medians around major global inflation periods (right panel)



Note: The panel on the right shows the courses of the four largest inflation shocks shown in the panel on the left. The start dates of these shocks (t) were considered as January 1973, April 1979, April 2007 and December 2020.

Source: Based on World Bank data

Today, inflation is persistently stuck above the target and is once again posing a major monetary policy challenge for the world's central banks. It has become a key question whether the shocks of recent years are causing temporary or permanent inflationary pressures. A summary of the experience of past inflation shocks can help answer this question.

In our study, we use a database of data from 201 countries from 1970 to 2022 to investigate the macroeconomic conditions under which inflation rose to high levels and in which cases disinflation occurred. A distinction is made between temporary surges in inflation and inflation dynamics that remain high over the longer term. We examine the relationship between high inflation and growth, and the evolution of output during disinflation. Finally, we turn to the issue of central bank credibility and independence.

Over the past half century or so, there were a number of successful and unsuccessful episodes of disinflation after major inflation shocks. Successful cases of disinflation are usually characterised by a tighter economic policy stance and more favourable commodity price developments. In these cases, economic growth did not typically slow down in the two years following the shock, in contrast to the episodes where inflation remained high. The latter has also proven to be true in general, not only in the case of quick breaks of inflation shocks: disinflation after periods of persistently high inflation was "painless" in most cases.

Our research, which is essentially a collection of stylised facts rather than a causal analysis, connects to the literature on inflation spanning several decades from a number of directions: high inflation and its stabilisation, the real cost of stabilisations, and the role of the central bank in stabilisation are all relevant to our analysis.

Research so far is divided on the impact of stabilisation on the real economy. The classic articles by *Sargent* (*1982*) and *Dornbusch – Fischer* (*1986*), using the European hyperinflation episodes of the 1920s and 1940s, argue that under rational expectations there is no real cost of the stabilisation. Sargent's earlier argument is confirmed by *Kiguel – Liviatan* (*1988, 1992a*) with examples from Latin American countries and by V*égh* (*1995*) with examples from several other countries. They stress, however, that the periods of hyperinflation have special characteristics and that the real impact of the stabilisation of high or even chronic inflation crises is estimated to be substantially negative. *Taylor* (*1979*) and *Fischer* (*1988*) argue that the real costs of inflation may be the result of past price and wage indexing fiscal policies and of not credible policy commitment. In the Hungarian literature, *Darvas* (*1999*) carries out similar analyses using selected European countries as examples. *Reinhart – Végh* (*1994*) go further and compare exchange rate and money-based stabilisation and find that exchange rate-based stabilisation attempts lead to a boom in the economy first and a slowdown later, while money-based stabilisation attempts lead to a recession first and a recovery later. Examining the disinflation periods of 19 developed countries between 1960 and 1990, *Ball* (*1994*) finds that the so-called sacrifice ratio, i.e. the ratio of the cumulative GDP loss during disinflation to the decline in trend inflation, is positive in almost all cases and mostly significant. In contrast, *Easterly* (*1996*) and *Bruno – Easterly* (*1998*), examining high (over 40 per cent) inflation periods between 1961–1994, find no trade-off in the "recession now or later" question: their results show that high-inflation periods are associated with low growth, while inflation stabilisation is associated with high growth, i.e. they find a negative sacrifice ratio. A part of the literature estimates the sacrifice ratio using structural VAR models, such as *Cecchetti – Rich* (*2001*) for the United States in the 1959–1997 period and *Durand et al.* (*2008*) for the euro area in 1972–2003. Their results show that reducing inflation leads to a loss for the real economy. *Katayama et al.* (*2019*) also specify that the longer the duration of the disinflation

process, the higher the sacrifice ratio. The comparability of structural VAR models with our results is limited, since we do not specify what causes the disinflation. More recently, *Tetlow* (*2022*), using Bayesian averaging to evaluate the results of 40 models, finds that the sacrifice ratio is positive and, additionally, increasing in time. The underlying reasons of these real economic effects of inflation crises stabilisation are largely absent in the literature.

As the most important components of stabilisation programmes, the literature pays particular attention to the role of monetary and fiscal policy. *Bruno – Fischer* (*1990*), *Kiguel – Neumeyer* (*1995*) and *Fischer et al.* (*2002*) stress the role of seigniorage, i.e. the monetary financing of fiscal deficits in the case of chronic inflation, and highlight the role of fiscal consolidation in the success of stabilisation. Similarly, *Dornbusch et al.* (*1990*) and *Sargent et al.* (*2009*) highlight the need for fiscal consolidation in stabilisation. *Dornbusch – Fischer* (*1993*) stress the importance of abolishing backward-looking wage indexation as a key to breaking the wage-price spiral in the context of a sustained reduction of moderately high inflation rates of between 15–50 per cent. The importance of the exchange rate as a credible nominal anchor is also stressed by *Kiguel – Liviatan* (*1992b*) and *Végh* (*1995*), who argue that exchange rate-based stabilisations are associated with minimal output reduction. *Fischer et al.* (*2002*) find that exchange rate stabilisations are expansive. The role of the inflation targeting system in inflation developments is presented in *Ábel et al*. (*2014*). According to *Fraga et al.* (*2003*), the introduction of inflation targeting significantly contributed to the inflation stabilisation of emerging market economies, while *Driffill – Miller* (*1993*) highlight the introduction of the ERM exchange rate regime in the inflation convergence of European countries, and *Kremers* (*1990*) shows the role of the EMS design specifically in the inflation stabilisation of Ireland. *Garber* (*1981*) emphasises, in the context of large external shocks, the elimination of centrally distorted allocations and the normalisation of intersectoral allocation with reducing the role of the state in it. *Bareith – Varga* (*2022*) use the example of Hungary to show how the introduction of inflation targeting has had an impact on reducing core inflation, while the volume of papers edited by *Cottarelli and Szapáry* (*1998*) discusses the disinflation experiences of the transition countries of Central and Eastern Europe.

Finally, our paper joins the literature on the relationship between inflation stabilisation and central bank credibility. *Sargent* (*1981*) emphasises the commitment and credibility of policymakers in reducing high inflation, while later *Sargent* (*1982*) emphasises the establishment of an independent central bank in stopping hyperinflation. In his model of strong central bankers focusing only on inflation and weak central bankers focusing more on unemployment than inflation, *Ball* (*1995*) shows that only a strong central banker can reduce persistently high inflation. If there is no credible commitment from policymakers, attempts to bring down inflation will fail. *Goodfriend – King* (*2005*) examine the role and credibility of *Paul*

Volcker in the great US disinflation of the 1970s–1980s, while *Nelson* (*2005*), based on the 1970s inflation experiences, highlights strong policymakers as a precondition for credibility and stabilisation. According to the analysis of *Végh* (*1995*), in the case of a lack of credible policymaker commitment, the exchange rate as a nominal anchor is not sufficient and other fiscal anchors are needed to break down chronic inflation. Most recently, *Borio et al.* (*2023*) investigate the dual regime – low or high – nature of inflation. They show that the two regimes differ substantially not only in the average level of inflation, but also in its dynamics: in the high regime, inflation loses its "self-stabilising" character. They point out that early preventive action by the monetary authority is the only way to prevent a shift to a high regime and sticking there. Similar to credibility, *Jácome – Pienknagura* (*2022*) analyse the role of central bank independence and find that central bank independence was a necessary condition for the disinflationary processes in Latin America.

Our analysis contributes to the literature in several ways. On the one hand, we systematically examine past cases similar to the current inflation shock and show the differences in the main macro-variables between successful and unsuccessful disinflationary cases. On the other hand, we analyse the costs of disinflation on a larger database than the studies mentioned above, which includes the experience of the 21st century as well. Finally, the non-linear relationship between the evolution of GDP growth in disinflationary episodes and the relationship between central bank independence and cost-push shocks is demonstrated.

Section 2 of the study describes the data used and the analytical framework chosen. In *Section 3* the characteristics of successful and unsuccessful disinflation from one-off inflation shocks are described. In *Section 4*, we present stylised facts related to the stabilisation of moderately high inflation episodes and discuss the role of central bank independence.

2. Data and methodology

In our analysis, we basically consider the 20 per cent inflation level as the lower limit for moderately high inflation dynamics. *Dornbusch – Fischer* (*1993*) consider inflation dynamics between 15 and 30 per cent to be moderately high, while *Easterly* (*1996*) and *Bruno – Easterly* (*1998*) draw the line at 40 per cent for high inflation. As different levels are considered high in different countries in the light of the tolerance of society, *Végh* (*1995*) defines chronic inflation as being above 20–40 per cent for several years.

Our analysis is based on the World Bank's global inflation database, published for most countries in the world between 1970 and 2022[1] (*Ha et al. 2021*). In our study,

[1] https://www.worldbank.org/en/research/brief/inflation-database

we use the annual average inflation rate – this is consistent with the literature. The database contains annual inflation time series of various length for 201 countries. We note that it would be possible to look at the December annual index of a given year, as in the *Bruno – Easterly* (*1998*) study, but then we would have fewer observations due to the limited availability of monthly time series.

The performance of real economy is identified by the growth rate of real GDP from the World Bank's World Development Indicators database.[2] The fiscal variables, such as the government debt-to-GDP ratio and the fiscal balance, were extracted from the same World Bank database, as well as from *Ali Abbas et al.* (*2011*) and *Mauro et al.* (*2015*). The data series for short-term interest rates are based on the BIS database[3] and the IMF's International Financial Statistics database.[4] Data for unemployment and exchange rates against the US dollar are based on the Penn World Table,[5] while for more recent periods they are based on Bloomberg data (*Feenstra et al. 2015*). Global commodity price trends are captured by the unweighted average of three sub-indices (energy, non-energy and precious metals) from "The Pink Sheet" commodity price index of the World Bank.[6]

In our analysis in *Section 3*, we aim to identify periods of high inflation and to track the evolution of other macroeconomic variables besides inflation. Using data from the past 50 years, we focus on countries and periods where and when inflation started from a level below 10 per cent and rose relatively quickly to a high level of over 20 per cent. For these episodes, we present the distribution of the evolution of the main macro-variables (median and quartiles) in successful and unsuccessful disinflation cases. In *Section 4*, we examine disinflation episodes after inflation was above 20 per cent for at least two years and their impact on real GDP growth rates, also based on the quartiles of the distributions.

It is important to emphasise that in our paper we do not seek to identify causal relationships between inflation stabilisation and real growth, nor between the real cost of stabilisation and central bank independence. We do not delve deeper into the causes of inflation surges, which can be increases due to cost-push shocks in the energy markets, price liberalisation or even sudden depreciations of local currencies. Similarly, we do not investigate whether the episodes of disinflation were the result of deliberate economic policy actions or simply of favourable exogenous developments. For these reasons, the figures and stylised facts presented below can be interpreted as correlations, preferably, and in our analysis we aim to provide a narrative description of the joint evolution of these variables. Nevertheless, we

[2] https://databank.worldbank.org/source/world-development-indicators
[3] https://www.bis.org/statistics/cbpol.htm
[4] https://data.imf.org/ifs
[5] https://www.rug.nl/ggdc/productivity/pwt/?lang=en
[6] https://www.worldbank.org/en/research/commodity-markets

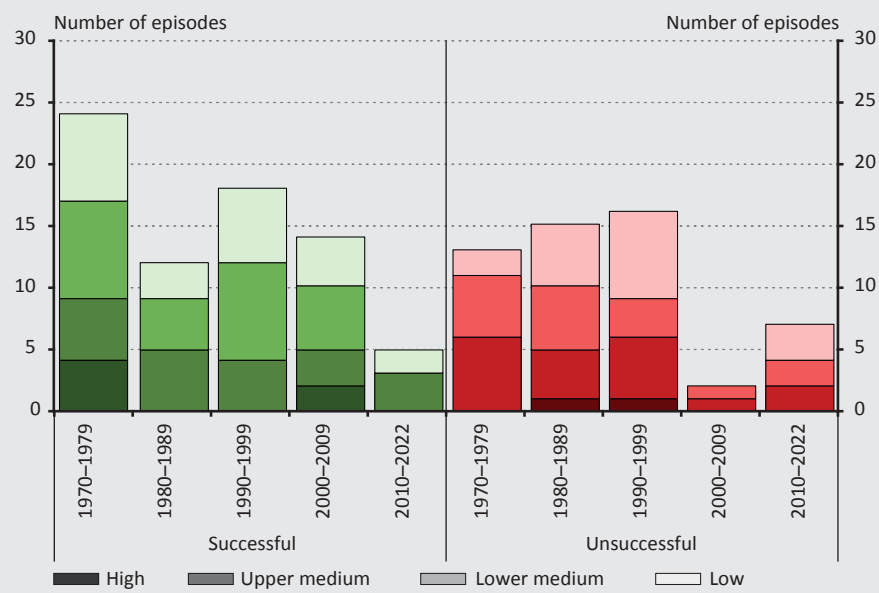
believe that the stylised facts we have found can be informative for economic policymaking as well.

3. Successful and unsuccessful disinflation after major inflation shocks

In the following, we look at episodes where average annual inflation rose above 20 per cent while it was below 20 per cent in the previous year and below 10 per cent in the year before. In some cases, a rapid correction followed, and inflation fell back to the single-digit range. In many cases, however, inflation stabilised at persistently high levels. Successful countries are defined as those where inflation fell below 10 per cent in the second year after a spike in inflation, while the unsuccessful episodes are defined as those where inflation remained above 20 per cent in the second year after a spike in inflation.

There were 73 successful episodes and 53 unsuccessful episodes from 1971 to 2022. There were 40 cases that did not fall into either of these groups (in these cases inflation ranged between 10 and 20 per cent), so they will be excluded from the rest of the analysis. Of the successful episodes, 40 per cent occurred in the early 1970s or in 2008, coinciding with global inflation peaks followed by a global disinflation phase (*Figure 2*). Of the unsuccessful cases, 28 per cent are concentrated in the early 1990s, while the distribution is even between 1970 and 1990.

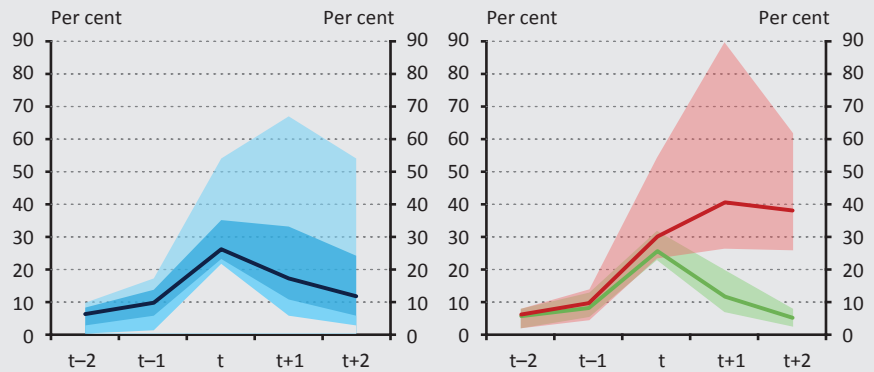
Figure 2
Time distribution of inflation episodes above 20 per cent by income level of countries in 2021 classified by the World Bank



Source: Based on World Bank data

Looking at the annual averages, of the episodes identified as a period of high inflation, inflation fell below 10 per cent in the year following the surge in one quarter of the episodes, while over a two-year horizon it was in the single-digit range in 44 per cent of the episodes (*Figure 3, left panel*). In the cases when inflation remained above 20 per cent, the dispersion is significant. In these unsuccessful cases, the surge in inflation was typically followed by a further rise a year later, and in half of the cases the rate stabilised above 40 per cent (*Figure 3, right panel*).

Figure 3
Inflation episodes above 20 per cent: all episodes (left panel), successful and unsuccessful disinflation episodes (right panel)

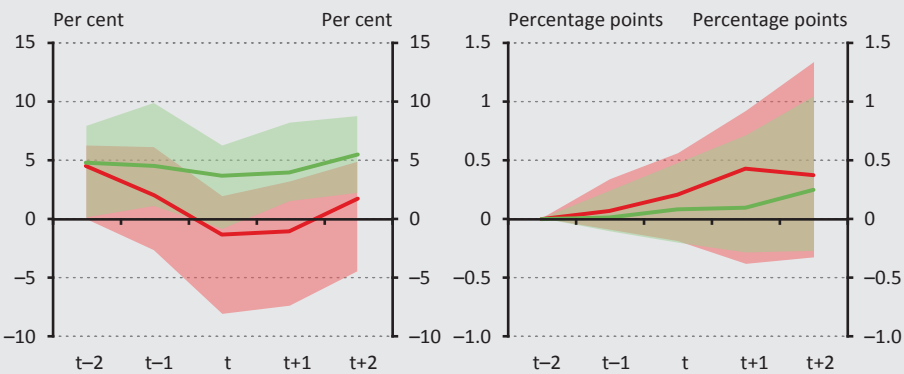


Note: The limits of the bands are the 10th, 25th, 75th and 90th percentiles in the left panel and the 25th and 75th percentiles in the right panel. The solid line is the 50th percentile (median). Green: successful cases; red: unsuccessful cases.

Source: Based on World Bank data

Looking at the performance of the real economy in the successful and unsuccessful episodes, there is a marked difference. In the successful cases, there is no significant change in the growth rate of real GDP either before or after the inflation surge. By contrast, in the high-inflation episodes, economies were already in a slowdown before the surge, and GDP shrank in the year of the surge and thereafter in most episodes (*Figure 4, left panel*). However, there is no significant difference in employment between the two groups, although the median value is slightly more favourable for the unsuccessful cases (*Figure 4, right panel*). This is in line with the results of *Bruno – Easterly* (*1998*), who found that the rebound in growth after disinflation is driven by an increase in total factor productivity.

Figure 4
Annual growth in real GDP (left panel) and employment compared to the second year before the surge in inflation (right panel) in successful and unsuccessful disinflation episodes



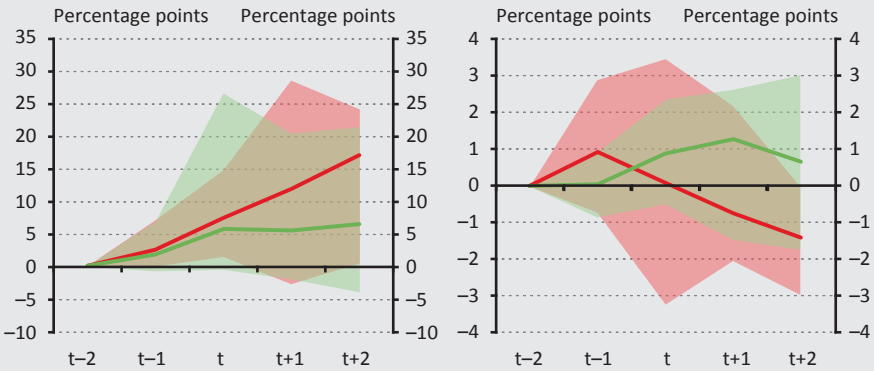
Note: The limits of the bands mark the 25th and 75th percentiles. The solid line is the 50th percentile (median). Green: successful cases; red: unsuccessful cases.

Source: Based on World Bank, Penn World Table and Bloomberg data

The government debt-to-GDP ratio rises similarly in both groups, typically by around 5–7 percentage points, in the period before the surge in inflation (*Figure 5, left panel*). In the years following high inflation, this rise stops in the successful cases, but continues in the unsuccessful cases, with the median increase exceeding 17 percentage points two years later. In the successful group, the fiscal balance typically improves already in the year of the surge in inflation to high levels, and this improvement is sustained (*Figure 5, right panel*). By contrast, in cases of unsuccessful disinflation, the fiscal balance deteriorates significantly from the onset of the surge in inflation, leading to a significant increase in the debt-to-GDP ratio – even relative to the group of countries that successfully disinflated. However, it is important to note, that the difference in the distributions of the two indicators is less significant than in the case of GDP growth and inflation.

Short-term interest rates, which essentially reflect the monetary policy stance, increased in both groups (*Figure 6*). In the successful cases of disinflation, interest rates rose more in the year before the high inflation level was reached and then fell slightly in the disinflation phase. For the unsuccessful countries, short rates continued to rise also in the two years after the surge in inflation. It should be noted, however, that appropriate interest rate data are only available for a limited number of the countries studied, and thus there is considerable uncertainty surrounding this result.

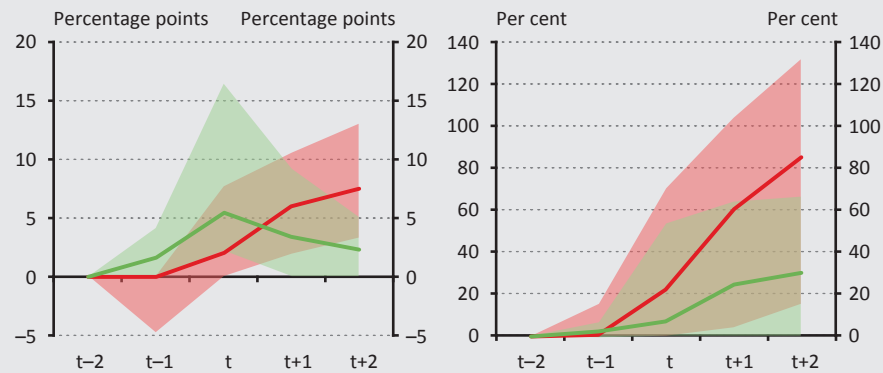
Figure 5
Percentage point change in government debt-to-GDP ratio (left panel) and fiscal balance (right panel) in successful and unsuccessful disinflation episodes compared to the second year before the surge in inflation



Note: The limits of the bands mark the 25th and 75th percentiles. The solid line is the 50th percentile (median). Green: successful cases; red: unsuccessful cases.

Source: Based on World Bank, Ali Abbas et al. (2011) and Mauro et al. (2015) data

Figure 6
Percentage point change in short-term interest rates (left panel) and percentual depreciation of the exchange rate against the dollar (right panel) relative to the second year before the surge in inflation in successful and unsuccessful disinflation episodes



Note: The limits of the bands mark the 25th and 75th percentiles. The solid line is the 50th percentile (median). Green: successful cases; red: unsuccessful cases.

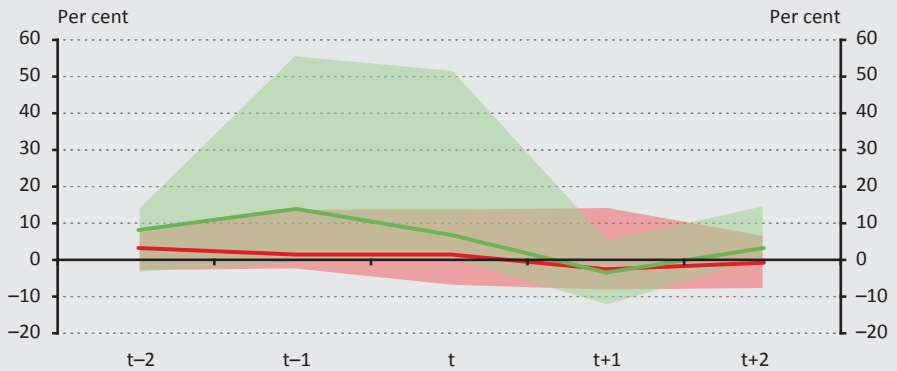
Source: Based on BIS, IMF IFS, Penn World Table and Bloomberg data

The exchange rate depreciated in practically all of the countries surveyed. The depreciation was much larger in the unsuccessful cases than in the successful ones, with the median value of the exchange rate against the US dollar falling by nearly 90 per cent in the former and by 30 per cent in the latter by the end of the period. This is consistent with the literature on exchange rate-based inflation stabilisation: the choice of the exchange rate as a credible nominal anchor leads to less depreciation of the domestic currency in successful cases.

As mentioned earlier, the case study approach we use is not directly suitable for identifying causal relationships. Although we found that earlier interest rate hikes and more disciplined fiscal policy tend to characterise successful disinflation cases, we cannot be sure that they are actually the cause. For example, the global inflationary period immediately preceding the financial crisis was overwhelmingly followed by successful episodes of disinflation (*Figure 2*), but during the global recession that accompanied the crisis, most countries did not need especially restrictive economic policy to bring inflation back down to low levels.

The importance of exogenous, global effects can be illustrated by comparing the evolution of commodity prices during successful and unsuccessful episodes of disinflation. The *right panel of Figure 1* illustrates that commodity price shocks played a dominant role in the development of the four global inflation waves. Indeed, the episodes of successful disinflations were characterised by initially high commodity inflation, especially in the year before the inflation peak, when the median was 14 per cent and the top quartile was 56 per cent (*Figure 7*). In the peak year, the rate of increase in commodity prices typically slows down and in the following year it starts to decline. It can be inferred that the improving trend in global commodity prices played a role in many of the successful disinflationary cases. Although there is an improvement in the year after the inflation peak in the unsuccessful cases as well, it is not nearly as large as in the successful cases. On the whole, while in most of the successful episodes cost-push shocks played an important role both in the surge and in the subsequent moderation of inflation, in cases where inflation was stuck at a high level, their role was typically secondary.

Figure 7
Annual growth rates of global commodity prices during successful and unsuccessful cases of disinflation



Note: The limits of the bands mark the 25th and 75th percentiles. The solid line is the 50th percentile (median). Green: successful cases; red: unsuccessful cases.

Source: Based on World Bank data

4. The cost of disinflation

In the previous section, we showed that inflation that rises from an initially low level often gets stuck in a high range. The initial surge was often caused by a (global) cost-push shock, such as the oil price shocks of the 1970s. The current wave of inflation is also partly driven by supply-side effects, such as disruptions in supply chains, as well as energy and food price shocks. The direct effect of such shocks is a change in relative prices, which, even if it causes inflation, should only be temporary. But how can high inflation persist after a one-off shock, or in other words, how can a sustained rise in *price levels* lead to a persistent rise in *inflation*?

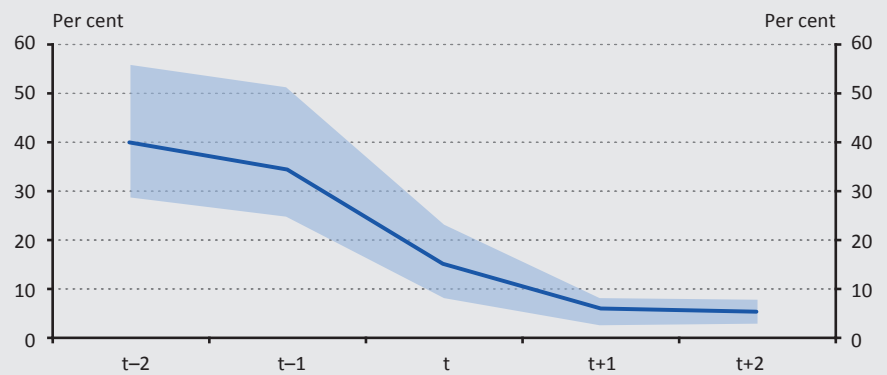
One possible explanation is that inflation expectations are adaptive, i.e. economic agents formulate their expectations for the future based on past inflation. In this case, it is irrelevant what causes inflation and whether this factor results in permanent or temporary inflationary pressures. The automatic rise in expectations may create a situation in which the central bank will have to consider whether to allow inflation to stagnate or to try to lower it. In the case of adaptive expectations, this may imply significant real economy costs.

Another possible explanation is wage indexation. If indexation is typical in the economy, i.e. prices and wages are set using past inflation rates, this has an effect similar to adaptive expectations. Although in this case expectations are not necessarily adaptive, the real economy cost of disinflation can be significant.

Ball (*1995*) shows the possibility that high inflation can persist without indexation under rational expectations. In his model, after an initial inflation shock, if the policymaker deems the potential real economy costs of disinflation too costly, it leads to inflation being locked in at a high level, and only a painful tightening can later restore price stability.

We now examine whether disinflation after periods of moderate inflation has a detectable effect on the path of GDP. In line with the stylised facts in *Section 3*, we look at the period 1970–2022. The year of disinflation (*t*) is defined so that the average annual inflation rate is above 20 per cent in *t*–2 and *t*–1 and below 10 per cent in *t*+1 and *t*+2.

Figure 8
Evolution of annual inflation in disinflation episodes from above 20 per cent to below 10 per cent



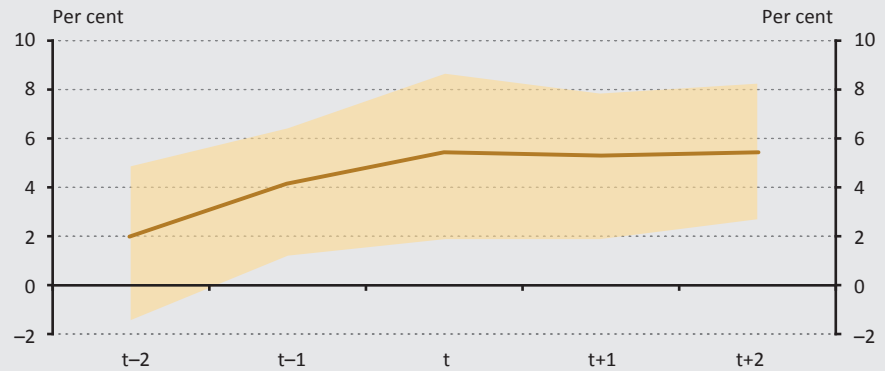
Note: The limits of the bands mark the 25th and 75th percentiles. The solid line is the 50th percentile (median).

Source: Based on World Bank data

Our sample contains 65 such cases, two thirds of which (44 cases) occurred in the two decades between 1990 and 2009. The median of the annual inflation rates is 40 per cent in the second year before disinflation, falling to 5 per cent in the second year after disinflation starts (*Figure 8*). The distributions suggest that the disinflation process typically starts earlier, and only a decline from above 20 per

cent to below 10 per cent takes place from year *t*–1 to year *t*+1. In the low inflation period (between *t*+1 and *t*+2), inflation no longer falls significantly.

Figure 9
Evolution of GDP growth in cases of disinflation from above 20 per cent to below 10 per cent



Note: The limits of the bands mark the 25th and 75th percentiles. The solid line is the 50th percentile (median).
Source: Based on World Bank data

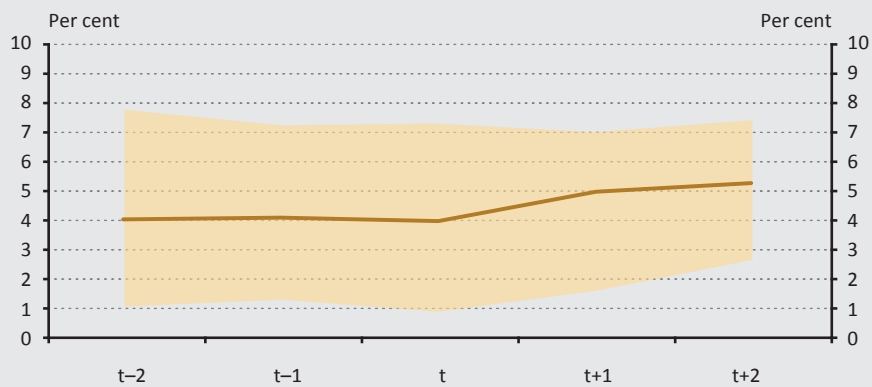
The annual growth rate of real GDP rises gradually from a lower level in the first two years (the median is close to 2 per cent in *t*–2) and stabilises at a higher level than previously after a successful case of disinflation (the median is 5.4 per cent in *t*+2; *Figure 9*). The temporary slowdown found by *Ball* (*1994*) is not present in our sample. Of the 51 episodes of disinflation for which real GDP growth data are available for all the five years under review, 35 have a higher average growth rate in the last two years than in the two years preceding the disinflation. Our result therefore seems to refute the main conclusion of *Ball* (*1994*) that there is a significant real economy cost in reducing inflation (permanently). There may be several reasons for this discrepancy. One is that *Ball* (*1994*) examines industrialised countries for the period 1960–1991. By contrast, we use data from 1970 to 2022, and for the widest possible range of countries. The identification of disinflation periods is also different: while we consider periods below 10 per cent for two years after two years of inflation above 20 per cent (allowing for a one-year transition period) as disinflation, *Ball* (*1994*) considers a decline of at least 2 percentage points from a peak in moving average trend inflation as disinflation.

The results of *Easterly* (*1996*) and *Bruno – Easterly* (*1998*) are consistent with ours. For example, *Bruno – Easterly* (*1998*) found that the GDP growth rate increases by an average of 3.3 percentage points compared to the years before the disinflation, which is very close to the result shown in *Figure 9*. An important methodological

difference, however, is that the data in these two studies run from the 1960s to 1994, and that disinflation is defined as year-on-year inflation in December being above 40 per cent for at least two years and then falling below 40 per cent for at least two years thereafter. Examining the experience of several years of disinflation in countries with moderate inflation, *Darvas* (*1999*) also concludes that in most cases there were no real economy costs. Despite the methodological differences, these analyses all suggest that the cost of disinflation in the double-digit range, which is less typical of the most advanced countries, is substantially lower than what *Ball* (*1994*) found.

In any case, we have also identified periods of disinflation using a set of criteria that may be more relevant for developed countries in the current inflationary environment. We looked for cases where inflation was above 10 per cent for at least two years and then fell below 5 per cent for at least two years after a transition year. We found 92 such cases, nearly two thirds of which occurred in the 1980s and 1990s.

Figure 10
Evolution of GDP growth in cases of disinflation from above 10 per cent to below 5 per cent



Note: The limits of the bands mark the 25th and 75th percentiles. The solid line is the 50th percentile (median).

Source: Based on World Bank data

The growth rate of real GDP did not typically slow during cases of disinflation from above 10 per cent to below 5 per cent, although there was also no significant improvement (*Figure 10*). In just over one half of the cases, growth was higher on average in the two years after the disinflation than in the two years before. Since the inflation levels considered here are closer to the cases of *Ball* (*1994*), our results

suggest that, contrary to the conclusions of *Tetlow* (*2022*), the cost of disinflation may have fallen significantly in recent decades.

According to *Ball* (*1995*), inflation may also become anchored at high levels because economic agents understand that the central bank, fearing real costs, is not doing all it can to suppress the inflation, and thus inflation expectations rise and disinflation becomes really costly for the central bank. This, however, is just a bad equilibrium outcome. If market perceptions are that the central bank gives little weight to real costs, they assign a higher probability to a firm disinflation and thus expect low inflation. In this good equilibrium, the cost of disinflation becomes low. But on what basis does the system arrive at a good or bad equilibrium?

Moving away from rational expectations and assuming adaptive expectations, however, the model of *Gibbs – Kulish* (*2017*) highlights the case of imperfect central bank credibility. The lower the credibility, the less responsive the economy is to the monetary authority's decision, and hence the higher the value of the sacrifice ratio.

In the following, we examine how the evolution of GDP growth during cases of disinflation depends on the credibility of the central bank and cost-push shocks. If the central bank's commitment to price stability is credible, the likelihood of a good equilibrium and a low sacrifice is higher.[7] If cost-push shocks are favourable, a small monetary tightening is sufficient for disinflation, and so the central bank is more likely to support disinflation, again increasing the probability of a low sacrifice and a good equilibrium.

The real economy cost is measured as the decline in the growth rate of real GDP after disinflation, i.e. the average of years $t+2$ and $t+1$ is subtracted from the average of years $t-1$ and $t-2$. In the following, we look again at the episodes of disinflation starting from levels above 20 per cent presented earlier. Central bank credibility is approximated by central bank independence, using *Romelli*'s (*2022*) index of central bank independence, which measures independence on a scale of 0 to 1 (1 = fully independent) by summing up a number of sub-indices. The evolution of cost-push shocks is captured by the commodity price inflation used earlier. The value of central bank independence in t is assigned to a given episode (*CBI*). In the case of commodity price inflation, the average of years $t-2$ and $t-1$ is subtracted from the average of years t and $t+1$, i.e. the change is measured in the first two years after the start of disinflation on average compared to the average of the two years before (*DCOM*). As before, we expect that the real cost is reduced by the *CBI* variable, but increased by *DCOM*.

[7] Again, it is important to stress that since we have not necessarily only looked at episodes where the economic policy performed deliberate disinflation, when we talk about real economy cost, it does not necessarily imply a causal relationship.

Table 1
Explanation for the loss of GDP growth

	(1)	(2)	(3)	(4)
CBI	–5.53 (5.44)	–11.27*** (3.90)	–11.09*** (3.99)	–9.30** (3.93)
DCOM	–	–	–0.015 (0.055)	0.283* (0.155)
CBI * DCOM	–	–	–	–0.532* (0.266)
Constant	–0.11 (3.35)	3.41 (2.30)	3.34 (2.35)	2.47 (2.26)
R^2	0.023	0.162	0.164	0.218
Number of observations	38	36	36	36

*Note: The dependent variable in each regression is the decline in the average annual GDP growth rate from the two years before the start of disinflation (t–2 and t–1) to the two years after (t+1 and t+2). Regression (1) used all observations for which GDP data and central bank independence index were available. In regressions (2) to (4), we have excluded from the sample the two extreme observations in terms of GDP loss. Explanatory variables: CBI: central bank independence index; DCOM: the change in average annual commodity price inflation between the two years preceding disinflation (t–2 and t–1) and the two years following it (t and t+1). In parentheses, White's heteroskedasticity-consistent standard errors are shown. ***, ** and * indicate significant estimates at 1, 5 and 10 per cent, respectively.*

Table 1 summarises the results of four estimates. The coefficients of each linear regression model were estimated by ordinary least squares, and their standard errors were estimated using White's heteroskedasticity-consistent estimator. The dependent variable in each case was the real cost. The explanatory variable in the first two cases is the independence index. In the first model, all observations were used for estimation, while in the second case we dropped two outlier observations, where the real cost was the highest (7.04 percentage points, Argentina, 1993) and the lowest (–23.65 percentage points, Azerbaijan, 1996). By dropping the extreme observations, the independence index that was insignificant in case (1) became significant at the one per cent level in estimation (2) with the sign we expected: higher independence is associated with lower real cost. Commodity inflation is not found to be significant in estimation (3). However, when the product of the two variables was included as a further explanatory variable in estimate (4), it became significant at 10 per cent with the expected sign. Furthermore, the interaction term is close to being significant at 5 per cent (P-value: 0.054).

The results of model (4) are worth evaluating in detail. The independence index remains significant (although now only at 5 per cent), and we continue to find that greater independence reduces the cost of disinflation. The dynamics of commodity prices also have the expected effect: their falling price dynamics reduces the real cost. One implication of the interaction term's coefficient is that for a central bank that is average in terms of independence in the regression sample (*CBI*=0.56),

the evolution of cost-push shocks does not affect the cost of disinflation, as the second (*DCOM*) and third members (*CBI∗DCOM*) essentially cancel each other out (0.283–0.56∗0.532=–0.015). However, in the case of a central bank that is less independent than the average, the impact of the third term will be smaller in absolute terms than that of the second, so that the fall in commodity inflation will affect the real cost as expected.

On the whole, the historical experiences of the real economy costs associated with disinflation suggest that output losses are far from typical, and that it is more common for real GDP growth rates to rise as inflation falls. Significant real costs occur in the cases when central bank independence is below average and global commodity price dynamics do not support disinflation.

At first glance, our results contradict the theoretical consensus emerging in recent years that expectations are not fully rational and that the Phillips curve has flattened (*Szentmihályi – Világi 2015*). Theoretically, our results could be explained if the evolution of cost-push shocks dominates our observations of disinflation, rather than the action of the monetary authority. This would be supported by the result shown in *Figure 7* that in the successful cases commodity prices evolve more favourably than in unsuccessful cases. The regression above, however, paints a more nuanced picture, as it suggests that central bank credibility/independence appears to substitute for the effect of commodity prices. This suggests that only in the case of less independent central banks can the evolution of the sacrifice ratio be a function of commodity prices. In the case of independent central banks, however, it is no longer true that the sacrifice ratio is lower where commodity prices develop more favourably.

5. Conclusions

In our study, we investigated the macroeconomic consequences of major inflation shocks and the course of disinflation using data from 201 countries between 1970 and 2022. Two questions were analysed: (1) Under what circumstances do inflation shocks lead to persistently high inflation? and (2) What are the real economy consequences of high inflation falling into the single-digit range?

Over the past half century or so, there were a number of successful and unsuccessful episodes of disinflation after major inflation shocks. Successful cases of disinflation have mostly been characterised by faster rises in short interest rates, more disciplined fiscal policy and more favourable commodity price dynamics. In these cases, economic growth did typically not slow, in contrast to episodes where inflation remained high. This latter result has also proved to be true in general, not only when inflation shocks were quickly reversed: disinflation after periods of

persistently high inflation was not associated with a slowdown in GDP growth in most cases.

Although the stylised facts we have collected are not directly suitable for identifying causal relationships, there are a number of lessons that can be drawn for economic policy. Successful responses to inflation shocks have been characterised by tighter monetary and fiscal policy and favourable developments in global cost factors. This suggests that there is a good chance of overcoming global inflation shocks such as the current one when commodity price rises are halted or reversed, but that this opportunity can be seized with a greater scope if tighter monetary conditions and disciplined fiscal policy are applied. Another important lesson is that disinflation does not necessarily imply a real economy cost, and this is true both for the reduction of inflation from the higher to the single-digit range and from the double-digit range to below 5 per cent. Moreover, in the former cases, accelerating economic growth is typical. The relationship we find between real cost and central bank independence suggests that a higher credibility of the disinflation commitment is more likely to lead to an acceleration of economic growth in the course of disinflation.

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An Empirical Analysis of the Predictive Power of European Yield Curves*

Marcell Péter Granát – Gábor Neszveda – Dorottya Szabó

For various reasons, the yield curve of government bonds serves as a reliable predictor of recessions in the US. This study provides an empirical analysis of whether there is such a relationship in European countries. The methodological framework employed in this study encompasses the utilisation of the Hodrick–Prescott filter in conjunction with a probit model. The modelling procedure in the literature is extended by optimally combining government bond maturity spreads and examining whether the results are also robust for European yield curves. The main finding of the paper is that in the US the spreads calculated from the yield of 7-year and 1-year government bonds are the best predictors, and they are similarly suitable for predicting economic crises in half of the European countries as well.

Journal of Economic Literature (JEL) codes: G17, O11, O47

Keywords: yield curve, recession, probit model

1. Introduction

For all economic actors, predictions about business cycles are crucial, and such projections have been offered for hundreds of years. Of the leading variables that can be used to forecast fluctuations in business cycles, the development of interest rates was already studied after the First World War in Hungary (*Máténé Bella et al. 2019*). Analysis of the recession-predicting capacity of the slope of the yield curve started in the late 1980s (for example, *Keen 1989*; *Stevens 1989*), and by the end of the 1990s this topic had generated numerous studies. These studies look at the dynamics of the difference between the yields on government bonds with different maturities over time, and at the relationship between this difference and real economic output. Empirically, downturns have been preceded by an inversion of the yield curve, when yields on short-term government bonds are higher than on

* The papers in this issue contain the views of the authors which are not necessarily the same as the official views of the Magyar Nemzeti Bank.

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The first version of the Hungarian manuscript was received on 15 June 2023.

DOI: https://doi.org/10.33893/FER.22.3.48

long-term ones, meaning that the yield spread is negative. This is because investors' risk perception about a country's economy affects the country's yield curve (*Matolcsy – Palotai 2016*). In such a scenario, investors' expectations reflect a potential recession for the period between the two maturities, along with a corresponding drop in inflation and an expansionary monetary response. There are two typical methods of analysis for predicting recessions based on this information: (1) forecasting the GDP growth rate in a quantitative manner with continuous models, and (2) predicting the probability of recessions with binary models. *Estrella et al.* (*2003*) find that the latter approach is better.

Estrella – Mishkin (*1996*) argue that yield spreads are useful indicators, partly because they are strongly influenced by monetary policy, and may therefore be able to sway the real economy. Moreover, they contain the expectations about inflation and interest rates, which the authors also consider to be crucial. The same authors published another paper on the predictive capacity of financial indicators, such as interest rates, share prices, monetary aggregates and the yield spread, using probit models (*Estrella – Mishkin 1998*). They showed that on a time horizon of 1–3 quarters, share prices and monetary aggregates are equally good out-of-sample predictors, but for forecasts longer than that the yield spread clearly dominates, typically alone, without the inclusion of any other variable.

By contrast, *Wright* (*2006*) concludes that yield spreads in themselves are not quite as good predictors of recession as when the model contains yields as separate variables. Interestingly though, the models supplemented with yields on the basis of the model did not predict a recession in 2006, while the yield spreads in themselves did. Wright believed the multivariate model, but it turned out that he was wrong. Prior to the 2008 crisis, another group of analysts from the Federal Reserve, *Haubrich et al.* (*2006*), also found that falling yield spreads are not likely to predict a recession.

After the Great Recession, several studies were published on this topic (*Chinn – Kucko 2015; Rudebusch – Williams 2009*), and in 2017 the American yield curve started to flatten once again. *Bauer – Mertens* (*2018a*) showed that the critical threshold of the yield spread is 0, and thus a positive value close to 0 is no cause for concern, but a negative yield curve spells trouble. The authors argued that since the period after the financial crisis was characterised by a low interest rate and yield environment, a peculiar phenomenon by historical standards, no definitive conclusions can be drawn from the dynamics of yield spreads.

In early 2019, various media outlets, including *Forbes*, *The Economist* and *Bloomberg*, wrote about the flattening of the American yield curve and argued that it was only a question of time before an inverted yield curve became reality and that this suggested an impending recession to economists. In August 2019, the difference between long-term and short-term US Treasury yields became negative, but instead of the projected financial crisis, the coronavirus pandemic ushered in a major downturn. Many analysts wondered whether this was simply a coincidence.

A similar dilemma was faced with respect to the forecasts observed at the time of the 11 September 2001 terrorist attacks in New York. *Chauvet – Potter* (*2005*) compared the forecasting capacity of the standard probit model with more sophisticated and extended probit models. The latter typically fared better in out-of-sample scenarios, but only the standard model predicted a recession for the end of 2001 on the basis of the information available until March 2001. The authors argue that based on this it would be wrong to conclude that the standard model performs better, since the information available to it did not include the events of 9/11, which had a marked effect on the downturn. Therefore, it can be said that predictive capacity of yield spreads should generally be tested on recessions that are primarily attributable to endogenous reasons rather than exogenous shocks. Accordingly, this analysis uses time series ending in 2019, thereby excluding the shocks caused by the coronavirus and the Russia–Ukraine war.

In connection with the war, one might contend that the pricing in the capital markets could have been used to predict a downturn. *Granát et al.* (*2023*) found that investor expectations only incorporated the threat of war 50 days before it started on 24 February 2022, and the literature on forecasting with the yield curve contains predictions for a much longer horizon (4 quarters), so the war period should also be excluded.

1.1. European yield curves

Examination of the yield curve's recession-predicting capacity was inspired by US Treasury bonds, but many studies devote special attention to the yield difference between European government bonds of different maturities. *Estrella – Mishkin* (*1997*) and *Chinn – Kucko* (*2015*) find that German and UK yield spreads are fairly good in predicting the probability of a recession, although the UK yield spread often predicts a high probability for an economic downturn in times without a recession. The French and Italian yield curves were also examined, but did not prove to be accurate indicators of recession. *Duarte et al.* (*2005*) used aggregate euro area data and probit models to successfully forecast the recessions in the European Economic and Monetary Union. *Hasse – Lajaunie* (*2022*) analysed the forecasting

capacity of the yield spread of 10-year and 3-month bonds in 13 OECD countries, including 8 from Europe, using a panel logit model. The yield spread proved to be significant even when various control variables, such as housing market yields, economic uncertainty or the central bank base rate, were included.

The present study analyses the case of the United States and looks at European countries[1] to see the recession-predicting capacity of yield spreads in the past 25 years.

2. Data and methodology

The daily and monthly data for government securities with different maturities were accessed from investing.com and the FRED database.[2] Some problems were caused by incomplete data and the fact that the length of the time series varied across countries. Since the yield spread used in the model was defined as the difference of two yields, the analysis could only utilise the observations where data was available for government securities of both maturities. The seasonally adjusted quarterly real GDP data were taken from Eurostat[3] and the FRED database. In the case of yield spreads, the quarterly values were defined as the geometric mean of daily observations.

Economists use different yield spreads in the literature. Some suggest maximising the difference between the maturities of the government bonds under review (*Ang et al. 2006*), others have a preference for the yield spreads of short-term and medium-term bonds (e.g. *Estrella et al. 2003*), while others examine the difference between the yields of the standard 10-year and 3-month bonds. The results of the latest paper by *Estrella* (*2022*) show that the 10-year/3-month yield spread has the best predictive capacity, and that the combined use of 10-year/2-year and 18-month/3-month spreads gives a more accurate prediction of recessions than when only one of these is included in the model. However, yield spreads usually follow very similar paths (*Bauer – Mertens 2018b*). The present paper looks at various potential combinations for the different countries.

[1] The countries under review: Belgium, Bulgaria, Czechia, France, Germany, Ireland, Italy, Poland, Portugal, Romania, Spain, Switzerland and the United Kingdom. Other European countries could not be included due to a lack of data.
[2] https://fred.stlouisfed.org/
[3] https://ec.europa.eu/eurostat/data/database

A probit model is used to predict the forecasting capacity. The models containing a binary dependent variable basically differ from OLS regression in that the dependent variable is binary, which implies that the estimated Y, the prediction, actually classifies the given observation into one of two groups. Such dependent variables are mostly modelled with linear probability models (LPM), logit models and probit models. Out of these, the LPM is the easiest to manage, but a major drawback is that the predicted probabilities can fall outside the range of [0,1], and the partial effects calculated in this modelling framework are sometimes logically impossible (*Wooldridge 2012*). The basic idea behind a logit and probit regression is that while keeping the linear combination, its result is transformed in such a way that the dependent variable interpreted in the (–∞, ∞) range is translated into a range of [0,1].

The probit model differs from logistic analysis in one central point. In contrast to the logit, the probit does not assume that the distribution of the probability *P* is logistic, instead a normal distribution is assumed. But this distribution function does not have a closed shape, so using a logit model is much simpler and more widespread. The probit model can be stated as equation (1):

$$E(Y \mid X) = P(Y = 1 \mid X) = \phi\left(\beta_0 + \beta_{spread}\right), \tag{1}$$

where $\phi(z) = P(Z < z), Z \sim N(0,1)$.

Recessions were defined with the Hodrick–Prescott filtering of real GDP data for European countries, while in the case of the US the NBER (2021) database[4] was used. The formal definition of the HP filter is shown in equation (2).

$$\min_{\tau}\left(\sum_{t=1}^{T}(y_t - \tau_t)^2 + \lambda\sum_{t=2}^{T-1}[(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2\right), \tag{2}$$

where the first term expresses how closely the time series is followed by the trend, while the second denotes how smoothly the latter reflects the former. The λ coefficient determines the trade-off between the two terms, which was chosen to be 1600 due to the quarterly data, in line with the literature. After the HP filtering, the cyclical components of real GDP were derived, which show the deviation from the trend. Based on empirical results, a recession is defined in the study as a period characterised by a cyclical component of real GDP that is lower than –1 per cent, because this was the value where the periods defined as recession by the NBER could be reproduced on US data. The same definition of recession was employed for European countries, which was justified as the European results were to be compared to US results. It must be noted though that the HP estimate does not

[4] https://www.nber.org/research/business-cycle-dating

always approximate actual European recessions, which should be taken into account when interpreting the results.

The study starts by examining US data to see whether the conclusions of *Estrella – Mishkin* (*1996*) can be extended for the 25 years that have elapsed since then. Unlike the authors mentioned above, who used 10-year and 3-month government bonds, the present models used the difference between the 10-year and 1-year government securities yields available to us, on two different horizons, with a 4-quarter lag. By reproducing the above study, the earlier period is from 1962 Q1 to 1995 Q1, while the second period is from 1995 Q2 to 2019 Q4. The predictive capacity in the two periods is used to draw conclusions about the present-day applicability of the findings from 1996.

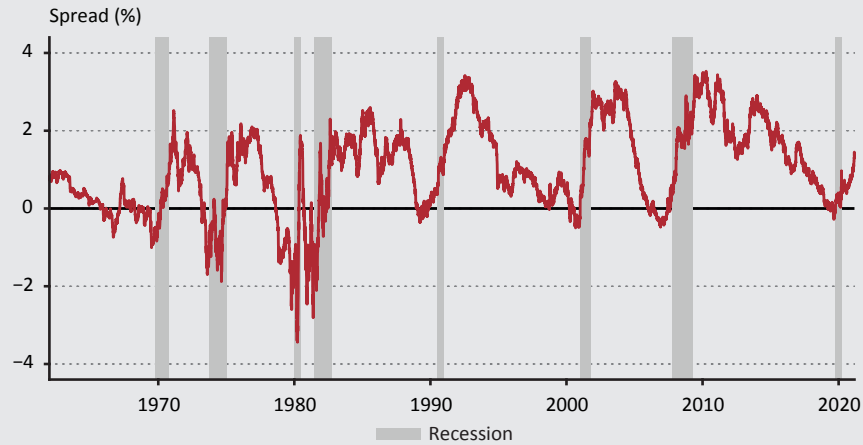
After this, it is examined whether the 10-year and 1-year maturities used are the best maturity combination from the perspective of predictive capacity. The scope of the analysis is then expanded to include various European countries, where the maturity combinations with the greatest predictive capacity are used.

3. Results

3.1. Results based on US data

In the case of the US, the difference between the 10-year and 1-year government securities yields was compared to the business cycle fluctuations defined by NBER. *Figure 1* shows the monthly and daily yield spreads, on a horizon starting in April 1953 and January 1962, respectively, and ending in March 2021 in both cases. It must be underlined that the study deducted shorter maturities from longer ones, although there are rare cases in the literature when the difference is defined in a “short-long” form. The procedure used here implies that the points in the figure that indicate an inversion of the yield curves are the ones where the yield spread enters negative territory.

Figure 1
Covariance between the 10-year and 1-year yield spread and recessions in the US



Source: Calculated from FRED data

Figure 1 clearly shows that yield curves were typically inverted 1–2 years prior to recessions, which can be explained by investors fearing an impending recession in these periods, and the figure indicates that these expectations usually proved to be correct. The figure also demonstrates that yield spreads sometimes start to increase even before the recession starts.

The probit model used was first run on US data, explaining the probability of recession with the yield spread defined as the difference between the 10-year and 1-year yields, with a 4-quarter lag. *Table 1* shows the probability of recession based on the model with different yield spreads before 1995, after 1995 and the period as a whole. As the yield spread declines, the probability of recession clearly increases over a 4-quarter horizon.

Table 1
Probability of recession with different yield spreads based on a probit model with a 4-quarter lag

Spread (percentage point)	Probability of recession (%)		
	Before 1995	After 1995	Total
1.21	0.08	6.66	5.32
0.76	0.97	11.11	9.81
0.46	3.74	15.06	14.06
0.22	9.03	18.82	18.25
0.02	16.62	22.37	22.29
–0.17	26.81	26.06	26.55
–0.50	49.64	33.15	34.82
–0.82	71.97	40.66	43.60
–1.13	87.58	48.28	52.42
–1.46	96.11	56.45	61.68
–1.85	99.35	65.74	71.78
–2.40	99.98	77.28	83.40
AUC (%)	**88.79**	**84.14**	**84.77**

Note: AUC is defined in the section 3.1.1.
Source: Calculated from FRED data

When comparing the results for the period before 1995 to the results of *Estrella – Mishkin* (*1996*), it was seen that the probabilities of a given yield spread were lower for spreads of over –0.5 per cent and higher for spreads of –0.5 per cent and below in our calculations. The comparison of these to the results of the period after 1995 shows that the present model predicts a recession with a lower probability with negative yield spreads than the model estimated based on the pre-1995 period. Based on *Bauer – Mertens* (*2018a*), namely that the development of the yield spreads is only a cause for concern if they enter negative territory, it was concluded that the predictive capacity of the yield spreads slightly diminished after 1995 relative to the period before that, although the yield spread was statistically significant in the model run for the period after 1995. The corresponding regression coefficients are summarised in *Table 3 of the Appendix*. The results for the whole period also attest that negative yield spreads are less likely to predict a recession in the model than based solely on the observations prior to 1995.

3.1.1. The model's classification capacity

When it comes to the classification task of binary models, the basic measures for assessing the goodness of the model's predictive capacity are sensitivity and specificity as well as the AUC (area under the curve), which can be defined as the size of the area under the ROC (receiver operating characteristics) curve. The model's sensitivity (equation (3)) is the ratio of the correctly classified 1 values (the occurrence of a recession in the present case) to all 1 values.

$$\text{Sensitivity} = \frac{TP}{TP + FN}, \tag{3}$$

where *TP* (true positive) means the number of classifications when the model predicted a recession that actually occurred, and *FN* (false negative) denotes the cases when the model was wrong not to predict a recession.

By contrast, specificity is the ratio of the correctly classified recession-free periods to all recession-free periods (equation (4)).

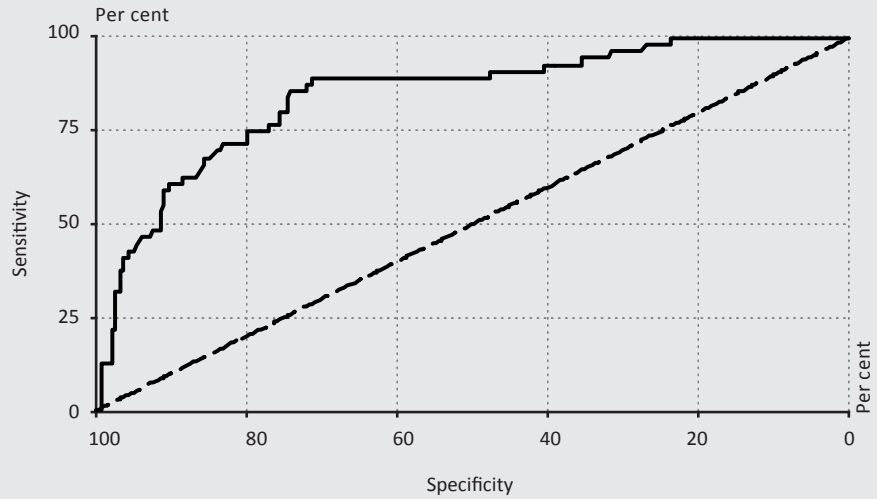
$$\text{Specificity} = \frac{TN}{TN + FP}, \tag{4}$$

where *TN* (true negative) means the classifications when the model correctly predicted that no recession would occur, and *FP* (false positive) denotes the cases when the model was wrong to predict a recession.

Classification models estimate one probability, whether a given observation has a value of 1 (recession) or not. Here, a threshold should be determined for deciding when to consider something 1 rather than 0. If a crisis is predicted even for very low probabilities, there will be less of a chance to miss recessions (high sensitivity), but of course false predictions will be all the more common (low specificity). In other words, sensitivity and specificity also depend on the threshold of choice.

The ROC curve can be drawn in a coordinate system where the *y* axis shows the different *sensitivity* values, and the *x* axis shows the different 1 – *specificity* values with thresholds of 0 and 1. The ROC curve that can be drawn in the model is shown in *Figure 2*.

Figure 2
ROC curve of the probit model for the whole period based on the 10-year and 1-year US yield spread



Note: The area under the curve (AUC) is 0.78. A ROC curve along the dashed 45-degree line would mean a model with random predictions.

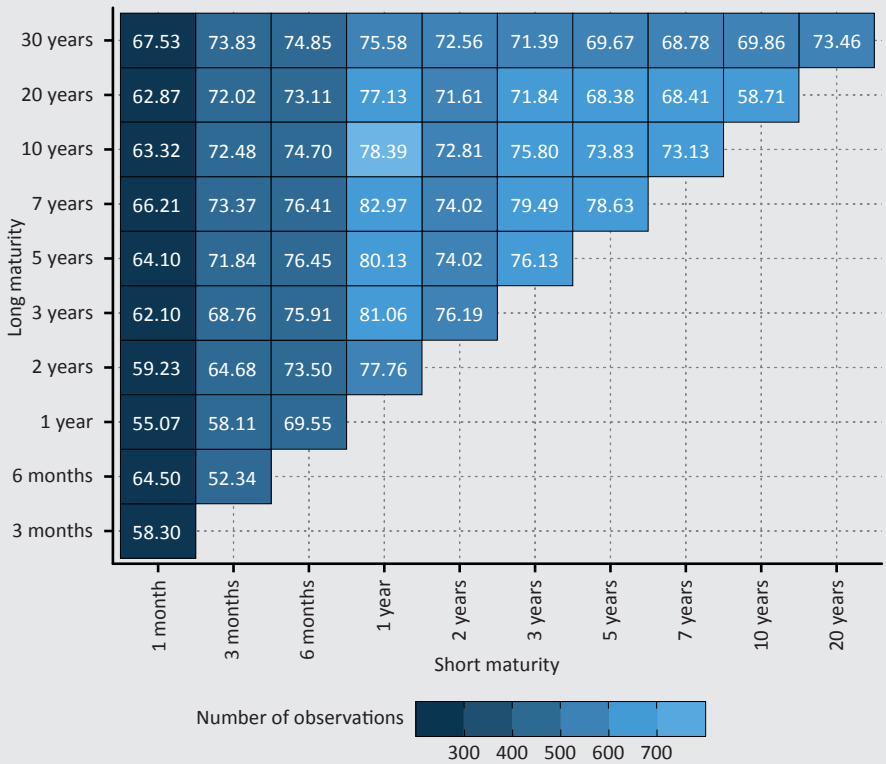
Source: Calculated from FRED data

Based on the area under the ROC curve, the AUC is 0.78. As the closer the AUC to 1 the better the classification capacity of a model (the greater the potential for high sensitivity with high specificity), it can be stated that the model where the yield spread was defined as the difference between the 10-year and 1-year government securities yields mostly predicts accurately.

3.1.2. Comparison of various maturity combinations

As noted before, there is no consensus in the literature about the maturity combination that best predicts recessions. The paper analyses the AUC values for the various combinations, and the results are summarised in *Figure 3*.

Figure 3
Analysis of the recession-predicting capacity of various yield spreads in the US



Note: The numbers in the figure show the AUC values corresponding to the individual maturity combinations (in per cent).

Source: Calculated from FRED data

The number of observations depends on the number of times the data for both maturity structures of the combination were available, and thus the number of observations exhibits a relatively large variability.

Figure 3 shows that the AUC takes its highest value in the case of 7-year and 1-year government securities, rather than in the original model. This is all the more interesting because this combination is not recommended by any study known to us, although 7-year bonds are more like medium-term paper, in which case the present results tally with the findings of *Estrella et al.* (*2003*). The average AUC values for the different maturities are summarised in *Table 4* of the *Appendix.* The often-used 10-year and 3-month combination is less appropriate according to the present results (although it still produces an AUC of 0.6–0.7), but the good performance of short maturities is in line with the claims that the predictive capacity

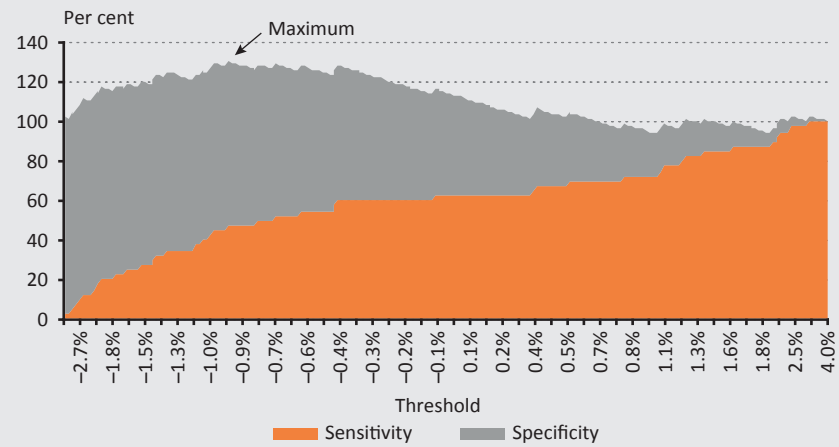
of yield curves mainly depends on the change in short-term yields. It can also be established that the 1-year maturity performs well when coupled with any of the longer maturities under review, and so this Treasury yield can be key in predicting recessions in the US.

3.1.3. Defining recession periods with the help of the cyclical components of GDP

In order to extend the model to European countries, the threshold of the cyclical component of GDP had to be established where a recession occurs, as no classification similar to that of NBER was available for these countries.

US data was analysed to see how the cyclical component of GDP derived with the Hodrick–Prescott filter can reproduce the recessions defined by NBER. This step in demonstrated in *Figure 4*.

Figure 4
Finding the optimal threshold for classifying recessions in the US



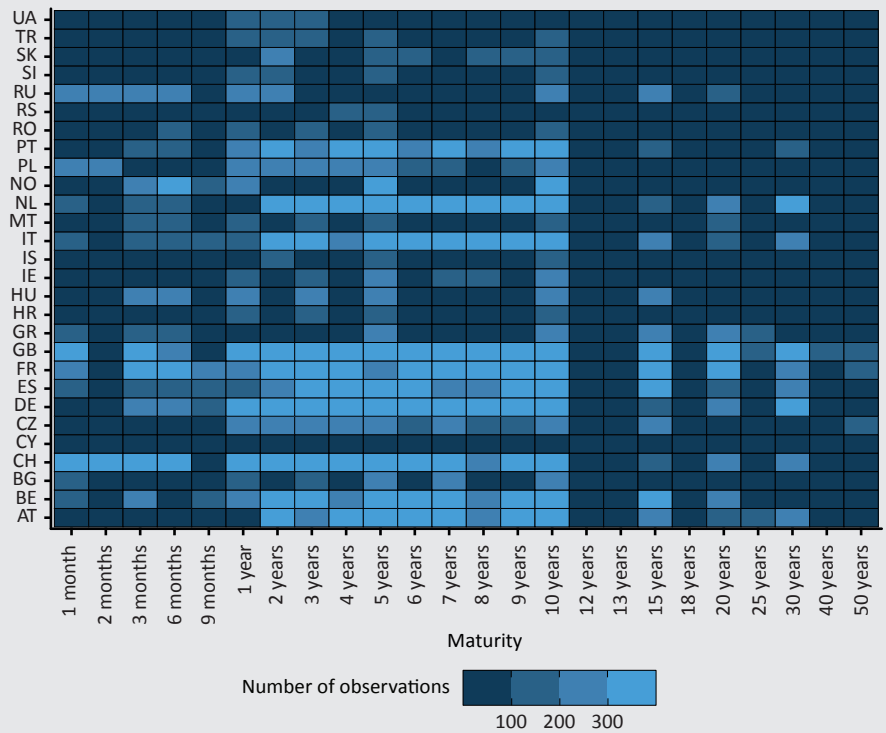
Note: Specificity and sensitivity are capped with a threshold of –1 per cent.
Source: Calculated from NBER and FRED data

The results show that the threshold can be determined as –1 per cent of the cyclical component of GDP. Accordingly, based on the data derived from the HP filtering of real GDP, only those periods can be classified as recessions in European countries when the cyclical component was –1 or lower. With this threshold, 47.5 per cent of the periods reported by NBER as recessions are classified correctly, along with 83.6 per cent of non-recession periods. Although determining the output gap like this is a common method, and only this can be used in European countries to determine recessions with a uniform methodology, it must be admitted that there is a major difference.

3.2. Extending the model to European countries

Based on the results derived from US data, the model was extended to European countries. The difference between the 7-year and 1-year yields was used in the same model as before, and recessions were defined based on the –1 per cent threshold of the cyclical component of GDP. Our initial database contained the yields of various government securities in Austria, Belgium, Bulgaria, Croatia, Cyprus, Czechia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Malta, Netherlands, Norway, Poland, Portugal, Romania, Russia, Serbia, Slovakia, Slovenia, Spain, Switzerland, Turkey, Ukraine and the United Kingdom. The number of observations per country and maturity are shown in *Figure 5*.

Figure 5
Number of observations per country



Source: Based on investing.com

It can be clearly seen that the lack of data causes problems in several countries, and thus the model was only extended to 13 countries: Belgium, Bulgaria, Czechia, France, Germany, Ireland, Italy, Poland, Portugal, Romania, Spain, Switzerland and the United Kingdom[5]. After the extension was narrowed to the countries listed here, the probit model was run on the data for these countries, where the yield spread used as an explanatory variable was chosen to be the difference between the 7-year and 1-year government securities yields, in line with the earlier results.

Table 2 gives a summary of the AUC values for the different countries, and it can be argued that most of the examined European yield curves have a good recession-predicting capacity. The model run for the Bulgarian and Spanish data performs even better than the US model in this regard.

Table 2
Results of the probit models run for European countries

	Coefficient	Standard error	P-value	AUC[a]/N[b]
Belgium				
Constant	–0.33	0.48	0.49	0.84
Spread	141.22	72.97	0.05	61
Bulgaria				
Constant	–5.54	1.76	0.00	0.95
Spread	–250.99	84.40	0.00	36
Czechia				
Constant	–0.27	0.30	0.37	0.49
Spread	5.75	24.75	0.82	73
France				
Constant	–1.14	0.37	0.00	0.45
Spread	14.03	31.22	0.65	81
Germany				
Constant	–1.20	0.29	0.00	0.63
Spread	–28.25	21.21	0.18	96
Ireland				
Constant	–1.03	0.35	0.00	0.72
Spread	–70.51	26.50	0.01	35
Italy				
Constant	–1.00	0.45	0.03	0.64
Spread	–31.76	23.12	0.17	52

[5] One condition was that at least 20 observations had to be available, with both the lagged values of the 1-year and 7-year yield spreads and the corresponding GDP data.

Table 2
Results of the probit models run for European countries

	Coefficient	Standard error	P-value	AUC[a]/N[b]
Poland				
Constant	1.17	0.75	0.12	0.84
Spread	191.87	72.61	0.01	29
Portugal				
Constant	–1.74	0.41	0.00	0.79
Spread	–41.76	13.43	0.00	53
Romania				
Constant	–1.06	0.72	0.14	0.49
Spread	–14.53	37.95	0.70	24
Spain				
Constant	–4.50	1.14	0.00	0.93
Spread	–239.77	62.51	0.00	35
Switzerland				
Constant	–2.00	0.36	0.00	0.81
Spread	–111.52	28.44	0.00	94
United Kingdom				
Constant	–1.43	0.24	0.00	0.67
Spread	–33.71	19.77	0.09	97

Note: [a] AUC: area under the curve (Constant rows). [b] N: number of observations (Spread rows).
Source: Calculated from investing.com data

Table 2 also shows the regression results of the probit models run for various European countries. The results attest that the yield spread only proved to be significant at 5 per cent in Bulgaria, Ireland, Portugal, Spain and Switzerland. In the United Kingdom, the spread's predictive capacity can be considered significant at a significance level of 10 per cent. Moreover, for Bulgaria and Spain the AUC shows that the yield spread of 7-year and 1-year bonds is a more accurate predictor than in the US (where the AUC was 82.79). The estimated coefficient of the yield spread was contrary to expectations in Belgium, Czechia, France and Poland, while in the other countries a drop in the spread (an upward shift of an inverted curve) predicts the closing of the output gap. Based on our results, there is a negative relationship between the yield spread and the probability of recession in nearly 70 per cent of the countries examined. However, this relationship is significant in only 38 (or 46) per cent of the countries. In nearly one third of the European countries, we obtained results that differed from the expectations, and the relationship was significantly positive in one sixth of the countries.

4. Conclusion

The study used a probit model to first examine whether the predictive capacity of the yield spread, defined as the difference between the 10-year and 1-year government securities yields, changed on a 4-quarter horizon in the past 25 years compared to the period before 1995. It was found that the probability of a recession decreased in the case of inverted yield curves, albeit only slightly, but the statistical significance of the spreads was preserved in the model run for the later period.

After this, US data was used to find the maturity combination best predicting recessions. According to the results, the difference between the 7-year and 1-year yields is the best predictor.

Before the model was extended, US data was used to find the –1 per cent threshold for the cyclical component of GDP, under which an economy can be said to be in recession (output gap signalling a recession). These results were used to run the model on European countries where sufficient data was available. According to the findings, out of the 13 countries examined, the yield spread has a significant and negative relationship to the future output gap in only 6 cases. Furthermore, based on the AUC, yield spreads in Bulgaria and Spain are more effective in predicting recessions than in the US.

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Appendix

Table 3
Estimated coefficients of the probit models run for the US

	Coefficient	Standard error	P-value
Probit, before 1995			
Constant	–0.93	0.19	0.00%
Spread	–1.85	0.41	0.00%
Probit, after 1995			
Constant	–0.75	0.12	0.00%
Spread	–0.62	0.10	0.00%
Probit, Total observations			
Constant	–0.75	0.09	0.00%
Spread	–0.72	0.10	0.00%
LPM, Total observations			
Constant	0.25	0.02	0.00%
Spread	–0.12	0.01	0.00%

Source: Calculated from FRED data

Table 4
Average AUC results for the US calculated on the basis of various yield spread combinations, using a probit model

Maturity[a]	Average AUC	Maturity[b]	Average AUC
1 month	0.62	3 month	0.58
3 months	0.67	6 months	0.58
6 months	0.74	1 year	0.61
1 year	0.79*	2 years	0.69
2 years	0.74	3 years	0.73
3 years	0.75	5 years	0.74
5 years	0.73	7 years	0.76*
7 years	0.70	10 years	0.73
10 years	0.64	20 years	0.69
20 years	0.73	30 years	0.72

*Note: [a] Used as short-term in the model. [b] Used as long-term in the model. * Highest value.*
Source: Calculated from FRED data

Factors Shaping Euro and Forint Cash Holding Ratios – The Rise of Cash Demand for Savings Purposes from the Turn of the Millennium*

Anikó Bódi-Schubert – Ildikó Ritzlné Kazimir

This study reviews the factors shaping forint and euro cash demand for savings purposes by examining the cash holding ratio. Forint and euro cash holding ratios are both rising, which points to an increase in cash savings. According to the results, in the long run, the cash demand for savings purposes is determined by traditional variables such as wealth and yields, along with uncertainty, the price of financial services and the institutional environment. In the short run, the change in uncertainty and the evolution of short interest rates dominate. Crises and the sudden shifts in the institutional environment lead to a shock, with large growth in the cash holding ratio for both currencies.

Journal of Economic Literature (JEL) codes: E12, E41, E58, E71

Keywords: cash demand, error correction model, uncertainty, cash holding ratio

1. Introduction

Cash plays a complex role in the economy: people purchase goods and services with it as a means of payment, which is referred to as the transactional demand for money. Economic actors hold some of their savings in cash, which is called the wealth-holding or precautionary motive (*Odorán – Sisak 2008*). This study focuses on the cash demand for savings purposes in the case of the forint and the common European currency, the euro. With the rise of digitalisation and electronic payments, a fall in cash demand has often been predicted in the past decades, but cash holdings have continued to grow in most countries of the world. This seemingly counterintuitive process has resulted in numerous studies, some of which are based on the micro-level analysis of consumer behaviour or take a macroeconomic approach to the subject (*Bagnall et al. 2016; Fujiki 2020; Rösl – Seitz 2022*). This trend remained intact, despite the large rise in electronic payments triggered by the lockdowns during the Covid-19 pandemic (*MNB 2022*). In Hungary, the value

* The papers in this issue contain the views of the authors which are not necessarily the same as the official views of the Magyar Nemzeti Bank.

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The first version of the Hungarian manuscript was received on 6 June 2023.
DOI: https://doi.org/10.33893/FER.22.3.67

of cash transactions conducted through online cash registers dropped by 13.6 per cent between 2019 and 2020, while the volume of currency in circulation increased by 9.9 per cent. Therefore, consumption-based and income-based transactional demand for money[1] (*Fisher 1912*) does not explain the recent major expansion in cash demand.

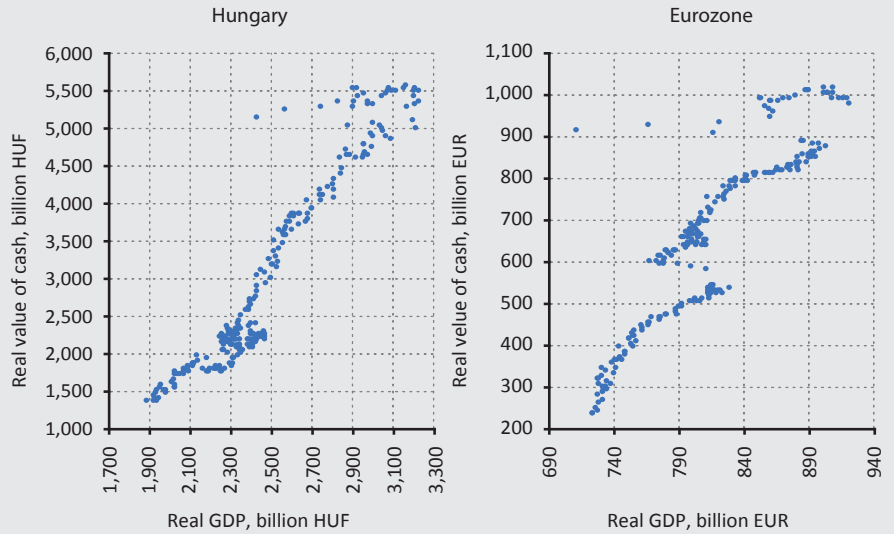
This study explores the motives for the cash demand for savings purposes, which is probably becoming increasingly important, although it cannot be observed directly. This issue is all the more significant because in order to formulated the appropriate policy measures for saving incentives or to influence the amount of cash in circulation, the factors shaping the cash demand for savings purposes should be established clearly.

Due to the highly sensitive nature of this topic, surveys do not yield reliable results with respect to the frequency and amount of cash savings. There are various methods for making an implicit determination of cash demand for savings purposes, such as examining the wear and tear of banknotes and the velocity of the denominations in circulation, or the comparison of electronic transactions and household consumption (*Végső 2020*). The method employed here is based on the approach used by *Dreger and Wolters* (*2009*). They argue that in an economy with stable payment preferences, there is only transactional demand for money, and one unit of income elasticity of cash demand, in other words the velocity of money, and its inverse, the cash holding ratio, are constant. But if the cash holding ratio is not constant, it implicitly expresses non-transactional demand for cash.

Figure 1 illustrates the importance of cash demand in savings.

[1] It should be noted that Fisher does not simply mean cash but money in general, where the nominal demand for goods depends only on the amount of money in the economy.

Figure 1
Development of the volume of cash and the real value of GDP in Hungary and the euro area, 2001–2022 and 2002–2022



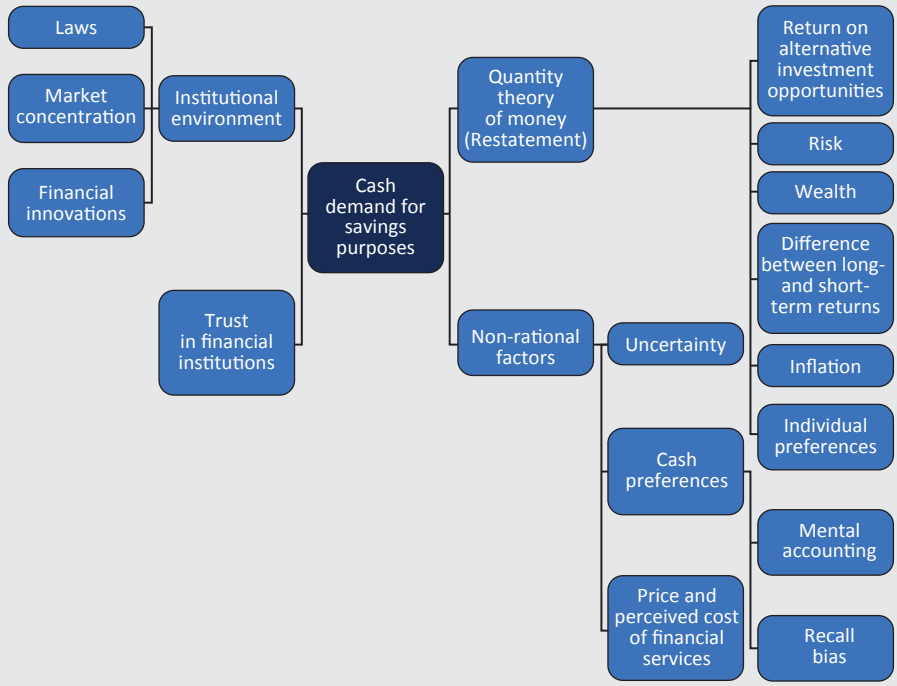
Note: Monthly data, base year: 2010.

Source: Based on data from the Magyar Nemzeti Bank (central bank of Hungary, MNB), the European Central Bank (ECB) and the Hungarian Central Statistical Office (HCSO)

Figure 1 shows that the relationship between the real volume of cash and real income (real GDP) is far from stable, and that there are structural breaks in it, which underlines the importance of, and changes in, the cash demand for savings purposes. The structural breaks can be observed in Hungary between 2003 and 2004, in connection with the 2008 crisis and the recovery, along with the period after March 2020, whereas the euro area exhibits structural breaks due to the economic crisis of 2008–2009 and the 2020 Covid-19 crisis.

The evolution of the breaks and the different steepness of the sections in *Figure 1* are attributable to the factors affecting the cash demand for savings purposes, which are summarised in *Figure 2*, illustrating the conceptual model of the present study.

Figure 2
Factors affecting the cash demand for savings purposes



Cash holding preferences refer to the non-rational behaviour explaining savings held in cash, using a traditional economic approach. Households' financial decisions are often characterised by inconsistent and non-rational attitudes. These include mental accounting, where people set apart an amount of money for designated purposes. This is usually done in cash, because consumers find it easier to review and control their decisions in a material form, and overspending becomes more likely when opting for electronic payment methods (*Raghubir – Srivastava 2008*). The assessment of the different mental "accounts" also varies; it depends on the objective and the source as well (*Thaler 1985*). Another typical feature of non-rational consumer behaviour is when economic actors stick with unreasonable habits to justify an earlier decision. According to the recall bias, unusual, extraordinary events are perceived to be more frequent than they actually are. That is why earlier negative experiences and news related to the financial sector continue to have an effect for decades (*Hámori 2003*).

The evolution of the transaction costs of financial services can also lead to non-rational behaviour, if losses are felt more than the potential gains realised on an investment. In such a scenario, rising prices reduce the demand for other investment opportunities, due to loss aversion. An increase in the relative price of financial services may encourage households with relatively low savings to keep their accumulated assets in cash instead and thus avoid transaction costs. *Hicks* (*1935*) uses the cost of financial services in a broad sense, including both the actual and the alternative cost.

The above non-rational attitudes were also confirmed by a representative survey of the MNB conducted in 2022 among the Hungarian adult population. According to the results, 68 per cent of the population believed that many people held their savings in cash because they had had negative experiences with banks, and 60 per cent of respondents thought that cash was a good way of collecting money for a designated purpose. Furthermore, 65 per cent agreed that those with low savings did not benefit from keeping their money in a bank. *Belházyné Illés et al.* (*2018*) also underline that even among micro, small and medium-sized enterprises, using cash is a deep-seated attitude in certain situations.

In connection with cash holding preferences, it is also worth mentioning that Hungarian households' indebtedness increased significantly between 2004 and 2008. The 2008 FX loan crisis placed a huge burden on households, as even in late 2007 they spent 13 per cent of their disposable income on repayments and 40 per cent of debtors had low income in 2010. As a result of the negative experiences, households' loan demand fell after the crisis and so did their confidence in banks. This led to a greater use of cash among low-income earners, who financed their various livelihood crises from cash after the Great Recession (*Gosztonyi 2017*). This was confirmed in the survey results by *Horn and Kiss* (*2019*), who found that income, occupation and place of residence all have significant explanatory power for having a bank account and a bank card and thus also indirectly cash use. *Deák et al.* (*2021*) and *Végső et al.* (*2018*) showed that age, educational attainment and income are also key when it comes to choosing between methods of payment, and they also affect individuals' banking and bank card holding.

Uncertainty, first emphasised by *Keynes* (*1965*), is crucial in monetary theory. In an economic sense, uncertainty and risk are not synonymous, because in the latter case the probability of the outcomes is known. If economic processes were only influenced by risk, the future would be predetermined in the sense that all possible outcomes and the corresponding probabilities were known. But when it comes to uncertainty, the future is a set of unprecedented outcomes, because the potential outcomes and their probabilities are all unknown, and past trends do not give an indication of the future.

In uncertainty, decision-makers either avoid decision situations due to the lack of knowledge, or, giving in to their "animal spirit", they dive into an activity without second thoughts. The Keynesian uncertainty theory explains the type of behaviour when in the event of economic and social crises people want to acquire cash even at the expense of great losses, and the velocity of money declines (*Szepesi 2013*). In the absence of information, when making their decisions, people rely on the behaviour of the majority or the average, which leads to a conventional or common view of a situation (*Bélyácz 2013*). The spillover effect of a negative experience on other decision-makers is highlighted, among others, by *Kiss et al.* (*2018*) in connection with bank runs. In an uncertain situation with a lack of information, the urge to act is triggered by fear, anxiety and stress. The impulsiveness of action is also influenced by social media. This was seen during the waves of panic buying at the onset of the Covid-19 pandemic (*Omar et al. 2021*). The hoarding drive of households was a response to a sudden and unprecedented situation. But it did not involve just consumer goods alone, as cash demand also rose considerably. In connection with cash holding preferences, *Hicks* (*1935*) points out the time required to adjust to the new circumstances, which is partly due to the lack of information, and it should also be taken into consideration.

Rösl and Seitz (*2021*) also analysed the effect of uncertainty on cash demand, examining the evolution of the cash in circulation during Y2K, the Great Recession and the Covid-19 crisis. They found that the uncertainty caused by the crises they reviewed exerted a special shock on the demand for large denomination banknotes, and in such critical periods cash functions as a sort of public insurance service. This is because possessing and quickly accessing cash during the turbulent periods caused by a crisis helps mitigate the panic among the public, thereby facilitating stabilisation.

According to the new quantity theory of money, cash demand depends on wealth, personal preferences, the expected inflation rate and the yields of various alternative assets. Wealth includes assets in a broad sense, for example human capital, so there is low fungibility between the different types of wealth. Cash demand increases with wealth if the yield on other assets or the expected inflation drops. In the new quantity theory of money, the adjustment process of the wealth portfolio is the transmission mechanism between the amount of money and the price level (*Friedman 1986*). However, shifts in the prices of alternative assets may have a different effect on cash demand, because when asset prices rise significantly, household demand for cash increases because their wealth also expands. But higher asset prices could also dampen money demand (*Dreger – Wolters 2009*).

Finally, the role of institutions should also be highlighted as a factor influencing cash demand. In a broad sense, the institutional infrastructure includes the legal environment and the development of economic activities and financial services. The development of services is often related to technological progress, which may boost the profitability of financial services. Financial market innovations lead to a proliferation in cash alternatives and thus also an increased velocity of money. The evolution of institutions affects the equilibrium of financial markets and the effectiveness of economic policy, especially the achievement of inflation targets (*Minsky 1957*). *Miller* (*1991*) points out the effect exerted by financial innovations and deregulation processes on cash demand. *Bordo et al.* (*1997*) showed how the changes in financial institutions and also the structural changes in the economy affect the velocity of money. The effect of institutional changes on the velocity of money was also emphasised by *Kim* (*2014*). *Wasiaturrahma et al.* (*2019*) examined the volume of cash as a function of electronic means of payment (credit card, debit card) and the frequency of electronic payments, finding that the rise in the number of credit cards held by households has a negative effect on cash holdings, while an increase in the number of debit cards exerts a positive effect. *Laidler* (*1999*) demonstrated that institutional changes lead to an instability of the demand for money in the narrow sense.

The institutional environment is interpreted in a broader sense in this study. In particular, the correlations in society and the economy cannot be determined independently of space and time (*Csaba 2021*). In connection with the cash demand for savings purposes, three main factors in the development of the institutional system are highlighted. First, there is the way that financial markets are shaped directly by regulators. Recent policy measures have focused on expanding the use of electronic solutions. In Hungary these include the introduction of the instant payment system or the fact that from 1 January 2021 retailers using an OCR (online cash register) are required to offer at least one electronic payment solution. Another group of interventions, such as the introduction of the financial transaction levy and industry-specific taxes, along with free-of-charge withdrawal twice a month, regulate the market and optimise budget revenues. And the third, final group is the proliferation of financial innovations due to the relationship between institutions and technology. Such financial innovations include the rise of chip cards enabling tap-and-go payment and the appearance of FinTech firm services.

Another important factor related to institutions is seen in the evolution of the market structure. In the past decade, concentration in the market share of financial institutions has increased in Hungary, driven by acquisitions as well as the bankruptcies among regional credit institutions in 2014, when the operating licence of six institutions were withdrawn by the central bank due to insolvency.

Takarékbank became a legal successor to the regional credit institutions and FHB, which contributed to the growing concentration, along with the merger between MKB and Budapest Bank in March 2022.

The factors influencing cash demand also include activities in the non-observed economy (*Belházyné Illés – Leszkó 2017*). *Sisak* (*2011*) confirmed that the cash demand in the non-observed economy has a major impact on total cash demand, although this could not be quantified with his model.

The non-observed economy comprises numerous activities, a detailed and complete accounting of which, broken down by activity, is required in the national accounts, in accordance with ESA2010 (European System of National Accounts 2010). The appropriateness of the calculations is regularly verified by Eurostat on behalf of the European Court of Auditors. This means that Hungarian and euro area GDP data include the value added of non-observed activities. In Hungary, the non-observed economy accounted for 14.9 per cent of GDP in 2005, more than half, 57.7 per cent, of which, was due to tax evasion, and only 6.5 per cent of which was generated from illegal activities, for example drug trafficking and prostitution (*Murai – Ritzlné Kazimir 2011*).

The Hungarian government has introduced several measures since 2012 to combat tax evasion. To name but a few, the domestic recapitulative statement was introduced, just like the reverse charge of VAT, the obligatory use of online cash registers and the EKÁER system. The effectiveness of the measures is attested by the evolution of the VAT gap as measured on behalf of the European Commission and the estimation of VAT evasion using tax audit data, according to which VAT evasion peaked in 2011 at around 30 per cent relative to the total expected revenue, before dropping to 6.6 per cent by 2019 (*Ritzlné Kazimir – Máténé Bella 2020*; *EC 2021*). Thus, the decline in tax evasion could not have generated the massive rise in cash demand.

The present study ignored the cash demand-generating effect of the non-observed economy, mainly because the target variable was the cash holding ratio, and its calculation was not based on income from labour statistics but on GDP, precisely in order to take into account all primary income in the national economy, including income from the non-observed economy, when adjusting for the effect of the transactional demand for money.

The study examines the evolution of the cash demand for savings purposes and the factors affecting it in Hungary and the euro area. The paper follows the methodology of *Dreger and Wolters* (*2009*) and wishes to focus its examination and therefore looks at the cash demand for savings purposes and its main factors by calculating

the cash holding ratio and filtering out the transactional demand for money from cash demand and expanding the theoretical framework of the analysis.

2. Data

In collecting the data, a monthly database was compiled for Hungary and the euro area between 2000 and September 2022. However, some data were missing for this period, and the introduction of euro in the form of cash in January 2002 also limited the horizon of the analysis. The sources included data published on the websites of Eurostat, ECB, HCSO, MNB, and one time series was downloaded from the search data from Google Trends.

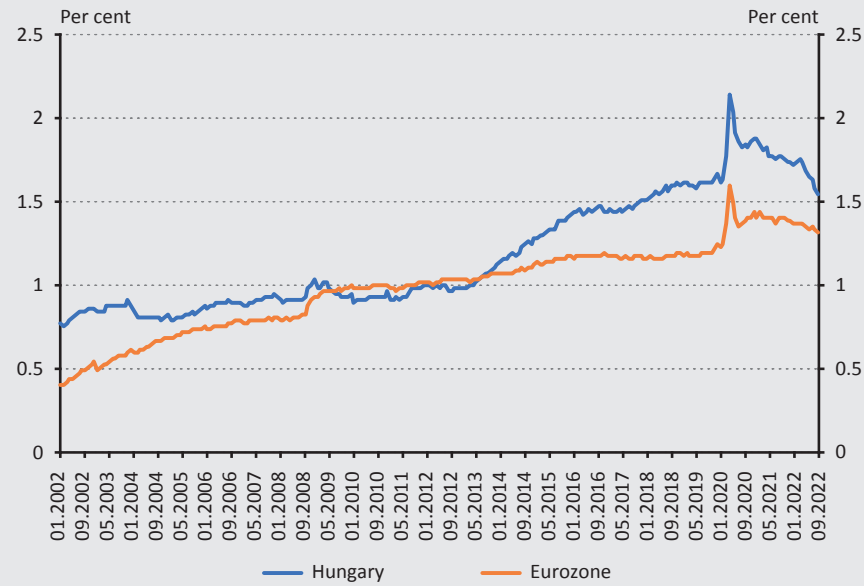
When selecting the indicators, the cash holding ratio was calculated from the seasonally and calendar-adjusted amount of cash in circulation[2] and – in the case of the Hungarian data – from seasonally adjusted time series of cash other than at monetary financial institutions[3] and in the course of this the proxy of real income was considered to be the chain-linked GDP (reference year 2010).[4] This was chosen because it contains entrepreneurial and capital income as well as the income generated in the non-observed economy. However, GDP is only available with a quarterly frequency, so it was broken down into a monthly time series with the Chow–Lin method, and the indicator series was the volume index of seasonally adjusted monthly industrial production compared to the average of 2015[5] (*Sax – Steiner 2013*).

When determining the nominal income time series, the consumer price index[6] was used instead of the GDP deflator, because the consumer value of real income was to be established. The GDP deflator is not suitable for this purpose, as the implicit price index of GDP is derived on the production side through a double deflation of the price index of goods and current expenditure, and on the output side as the aggregate result of the price indices of various final consumption items. For example, foreign trade price indices considerably influence the GDP deflator. Using the consumer price index instead of the GDP deflator is quite common; see, for example, *Sorensen – Yosha* (*2007*). The consumer price index was the basis for

[2] *Currency in circulation reported by MFIs, central government and POGIs in the euro area (stocks)*: https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=117.BSI.M.U2.Y.V.L10.X.1.U2.2300.Z01.E&periodSortOrder=ASC
[3] *Balance sheets of monetary financial institutions and monetary aggregates*: https://statisztika.mnb.hu/statistical-topics/balance-sheets-of-financial-institutions/monetary-and-other-balance-sheet-statistics/press-release---other-monetary-financial-institutions
[4] *GDP and main components (output, expenditure and income)*: https://ec.europa.eu/eurostat/databrowser/view/NAMQ_10_GDP__custom_7214506/default/table?lang=en
[5] *Industry – monthly data – index (2015 = 100) (NACE Rev. 2)*: https://ec.europa.eu/eurostat/databrowser/view/EI_ISIN_M__custom_4370627/default/table
[6] *HICP – monthly data (annual rate of change)*: https://ec.europa.eu/eurostat/databrowser/view/PRC_HICP_MANR__custom_4368815/default/table

calculating consumer price indices relative to the previous year's average ($HICP_t$), which was then used to calculate the nominal income time series with chain-linking (*Anwar – Szőkéné 2008*). The cash holding ratio was derived as the volume of cash relative to nominal income. The cash holding ratio in Hungary and the euro area is presented in *Figure 3*.

Figure 3
Development of the cash holding ratio in Hungary and the euro area



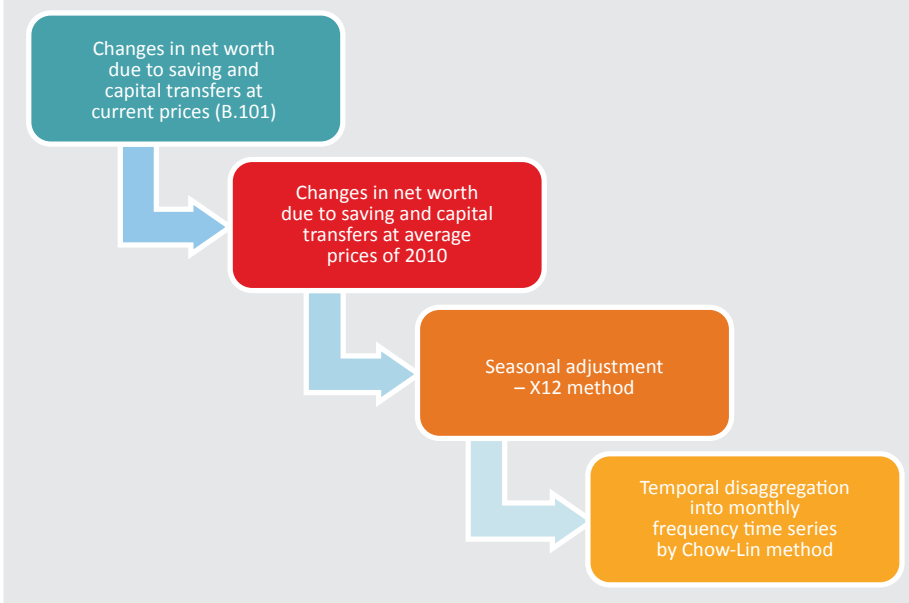
Source: Calculated based on MNB, ECB and Eurostat data

The Hungarian cash holding ratio was always higher than the euro area value, with the exception of the years of the 2008 economic crisis. The start of the crisis lifted both cash holding ratios under review in October 2008, and the onset of the first wave of the Covid-19 pandemic triggered a panic, with an unprecedented spike in both Hungary and the euro area.

The change in wealth was approximated with an indicator called the "changes in net worth due to saving and capital transfers" published for households and non-profit institutions serving households within the national accounts. However, this is only available at current prices and with a quarterly frequency.[7]

First, the current price time series was transformed into a 2010 average price by chain-linking. Choosing the appropriate price index posed dilemmas because the real change in wealth should ideally be calculated from the weighted price index of wealth items. Unfortunately, no such price index is available, and thus the consumer price index was chosen. After this, seasonal adjustment was performed with the X12 procedure. Finally, the quarterly time series was broken down into a monthly one. No monthly indicator time series is available for temporal disaggregation of the change in real wealth, and so the broken-down real GDP time series was used during the Chow–Lin MaxLog method. The calculation is shown in *Figure 4*.

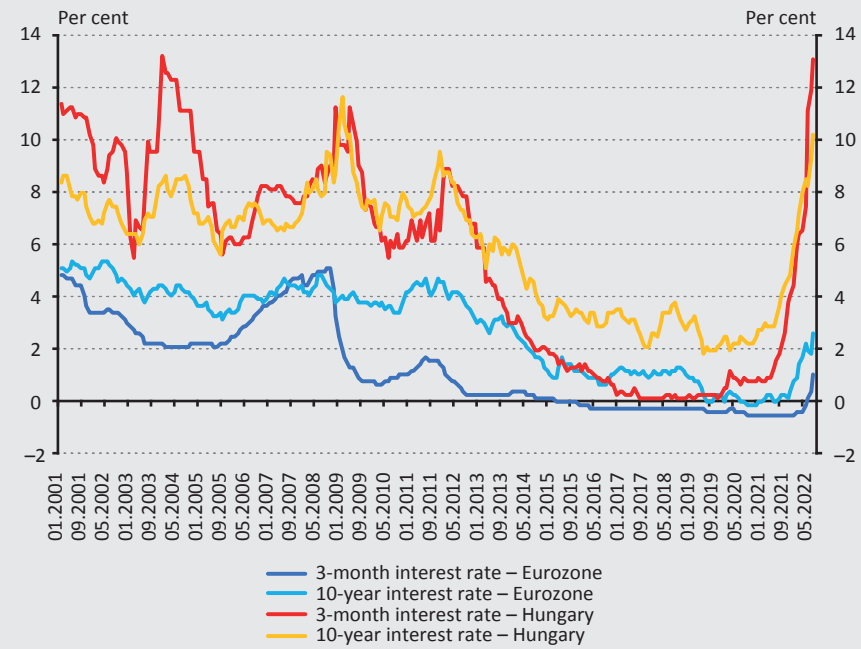
Figure 4
Steps of calculating the monthly time series of net wealth



[7] *Non-financial transactions – quarterly data*: https://ec.europa.eu/eurostat/databrowser/view/NASQ_10_NF_TR__custom_5605323/default/table
The quarterly non-financial sector accounts of national economy: https://statinfo.ksh.hu/Statinfo/themeSelector.jsp?&lang=en

With respect to yields, 3-month and 10-year benchmark rates were used for the Hungarian economy,[8] and the 3-month EURIBOR and 10-year interbank rate was used for the euro area.[9] The rates are presented in *Figure 5*.[10]

Figure 5
Development of 3-month and 10-year interest rates



Source: Based on MNB and ECB data

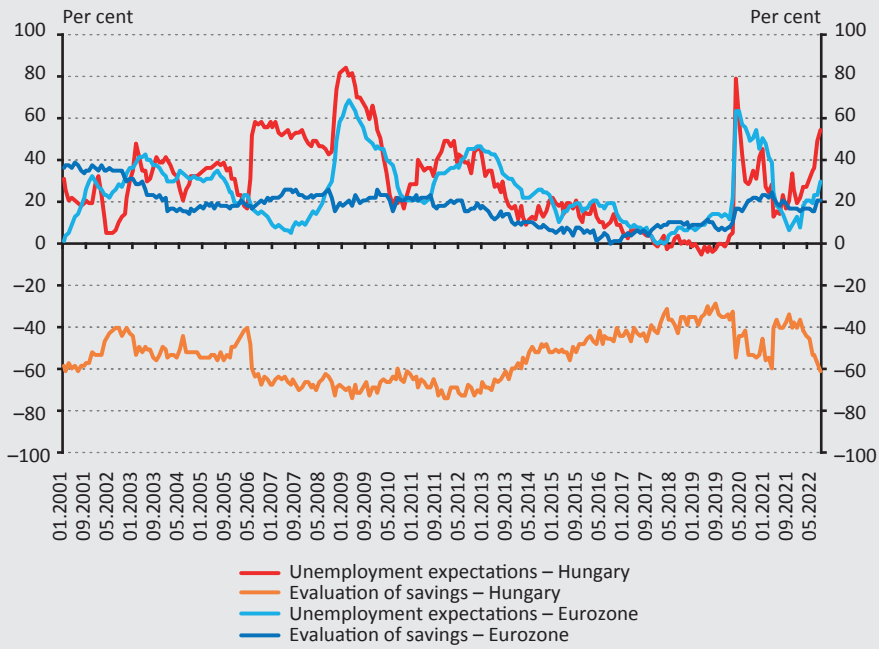
[8] *Benchmark yields on government debt securities*: https://statisztika.mnb.hu/timeseries/data-6559

[9] *Long-term interest rate for convergence purposes – 10-year maturity, denominated in euro – Euro area 19 (fixed composition) as of 1 January 2015*: https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=229.IRS.M.I8.L.L40.CI.0000.EUR.N.Z&periodSortOrder=ASC
Euribor 3-month – Historical close, average of observations through period: https://sdw.ecb.europa.eu/quickview.do?SERIES_KEY=143.FM.M.U2.EUR.RT.MM.EURIBOR3MD_.HSTA&periodSortOrder=ASC

[10] In connection with Hungarian interest rates, the peak at the end of 2003 deserves special mention, which was influenced by the FX liberalisation process that ended in 2001. This was the time when the forint became fully freely convertible, which, compounded by the deficit produced by the fiscal expansion in 2002, caused major problems. The government urged the devaluation of the forint, citing the deteriorating competitiveness of exporters. In the end, the Monetary Council approved the shift in the forint's exchange rate band on 4 June 2003. This decision surprised market participants, and it was followed by the depreciation of the forint, rising inflation and thus an increasing interest rate. The ensuing financial crisis called for fiscal consolidation. Among other measures, the scope of the subsidised housing loan programme was reduced at the end of the year. Together with the high interest rates, this measure made foreign currency loans attractive to households, which was one of the main reasons behind the falling income after the 2008 crisis. The next peak in interest rates was related to the Great Recession, followed by the second interest rate peak during the W-shaped recovery. Finally, Hungary experienced another change in the interest rate path after the start of the Covid-19 crisis, and the rise in interest rates that began then had come close to the 2003 peak by 2022 Q3.

Subjective uncertainty and the risk of investments was involved in the analysis on the basis of the Keynesian theory. These factors were measured with indices chosen from a range of items in the Economic Sentiment Indicator (ESI).[11] Uncertainty is reflected in the unemployment expectations for the subsequent 12 months,[12] while risk is mirrored by the perception of the current saving options.[13] *Figure 6* contains these indicators.

Figure 6
Expectations of unemployment and assessment of savings, ESI indices



Source: Edited on the basis of Eurostat data

There is much more variation in the perception of the saving situation in Hungary than in the euro area. Until 2014, savings were usually seen more favourably around elections. From 2013, related to the rise in household wealth, savings were steadily assessed in a more positive light. Slumps came during the Covid-19 crisis and during the war that started in February 2022, as well as the ensuing energy crisis. The

[11] The ESI is based on monthly business and household surveys conducted by the European Commission. The Hungarian data are surveyed by GKI Gazdaságkutató Zrt. The consumption survey is available at: https://ec.europa.eu/info/sites/default/files/questionnaires_hu_cons_hu.pdf, and data are available here: https://economy-finance.ec.europa.eu/economic-forecast-and-surveys/business-and-consumer-surveys/download-business-and-consumer-survey-data/time-series_en

[12] Question 7 in the questionnaire asks: How do you expect unemployment to change over the next 12 months? (1. fall sharply, 2. fall slightly, 3. remain the same, 4. increase slightly, 5. increase sharply)

[13] Question 10 in the questionnaire asks: In the current economic situation, do you think that: (1. the situation is very unfavourable for saving, 2. fairly unfavourable for saving, 3. favourable for saving, 4. very favourable for saving)

perception of savings was more balanced in the euro area. The attitude towards saving opportunities was only dampened slightly after the 2008 crisis.

The index measuring the unemployment outlook, which reflects uncertainty, also varies more widely in the Hungarian data. In the first section of the time series, uncertainty fluctuates significantly in the election years until 2010. Other than this, the 2008 crisis and the downturn in 2011–2012 caused larger swings. After that, uncertainty steadily declined until the beginning of the Covid-19 crisis in 2020, when it almost reached the 2008 levels in March, before remaining permanently high. In the euro area, the uncertainty caused by the unemployment outlook did not cause such variation in the period under review, but the 2008 crisis, the 2012 downturn and the Covid-19 lockdowns raised uncertainty considerably.

The real effective exchange rate is equal to the purchasing power of the nominal effective exchange rate – i.e. the weighted nominal exchange rate of trading partners – relative usually to the average of a fixed year, and shows the opportunity cost of holding cash in the domestic currency. It is calculated by using the consumer price index or other price indices, for example the producer price index. In the euro area, the real effective exchange rate is an indicator of the euro demand for non-residents, while in the case of the forint it shows the domestic reserve demand of foreign currencies (*Fischer et al. 2004*). The incorporation of this indicator was necessitated by foreign demand and the FX demand replacing domestic currency holdings.[14]

Inflation cannot be included in the model, because the consumer price index has already been used to calculate the cash holding ratio. However, the standard deviation of the consumer price index is a good indicator of the fluctuations in inflation (*Fischer et al. 2004*). The indicator, in other words the variability of price levels, points to the instability of the inflationary environment, and as expected a rise in standard deviation reduces the cash holding ratio. Fischer et al. used the standard deviation of inflation data from the previous four years in their model.

The consumer price index of financial services was also included in the analysis.[15] The price of financial services determines the demand for fungible financial products (*Arango-Arango et al. 2018; Alvarez – Lippi 2017*), and its evolution serves as a non-rational motive for cash holding.[16] In Hungary, consumer prices of financial services

[14] *Forint nominal effective and real effective exchange rate indices*: https://statisztika.mnb.hu/timeseries/data-6526

[15] *HICP – monthly data (annual rate of change) – Financial services*: https://ec.europa.eu/eurostat/databrowser/view/PRC_HICP_MANR__custom_4368963/default/table

[16] According to the COICOP (Classification of Individual Consumption by Purpose) nomenclature for the goods and services purchased by households, the price index of financial services includes the following services: "Account servicing, bank cards, credit cards, loans, savings fees, money transfer, wire transfer fees and other savings bank fees, the management fee of private pension funds", along with "financial investment advice and tax advisory fee, and the transaction costs of brokers and real estate agencies, etc." (*HCSO 2019: p. 84*). This means that the price index also includes the cost of savings, lending and payments.

rose by 250 per cent between 1 January 2001 and September 2022, with average annual growth of 5.4 per cent between 2001 and 2021. In the same period, the average annual growth of consumer prices was 3.7 per cent. The rise in the price of financial services was strongly influenced by the introduction of the financial transaction levy on 1 January 2013, which was raised from 0.1 per cent to 0.3 per cent on 1 August 2013. As a result, the price of financial services increased by 36 per cent in one year. The price increase was realised not only in January and August, because some banks passed on the financial transaction levy in their fees in the months following the introduction and the hike. Furthermore, other financial items, such as account servicing and bank card fees also rose over the course of the year (*HCSO 2014*).

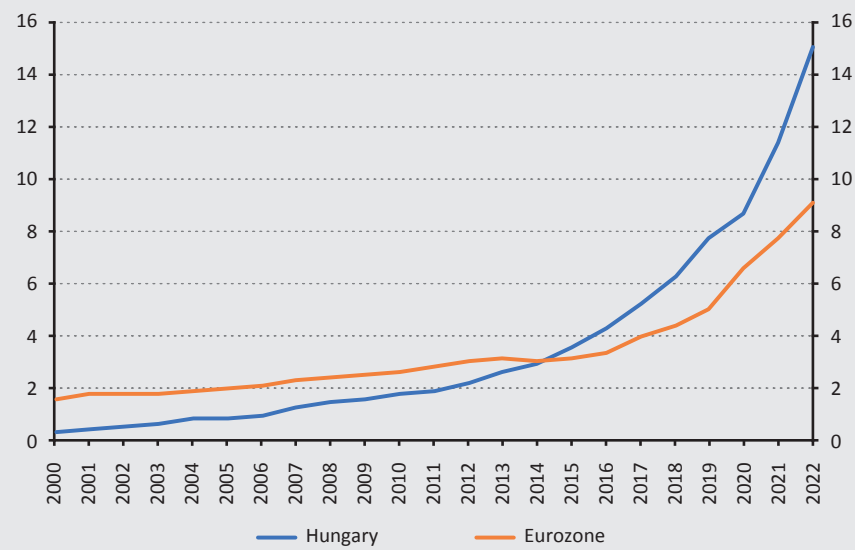
At the same time, the financial services price index in the euro area was 99 per cent of the January 2001 levels in September 2022. However, this does not mean that it remained flat throughout this period: it declined slightly until the onset of the financial crisis, then stagnated until early 2012, and fell by around 10 per cent in 2012. This may have been related to the supervisory and regulatory steps necessitated by the contraction in the balance sheet total in the EU's banking system, and to the Greek bailout package and the ECB's liquidity measures (*MNB 2012*). The price of financial services in the euro area remained more or less unchanged until 2018 and then started to rise somewhat from 2018.

A detailed analysis of institutional changes is beyond the scope of this paper, due to the complexity of how the three dimensions mentioned in the previous chapter, namely policy, regulation and market structure, evolved, and to the extent of the study's time horizon. However, since the paper focuses on the cash holding ratio, it is argued that the institutional changes are implicitly reflected in the changes of the payments infrastructure. It should be emphasised that the change in the infrastructure is influenced by the change in payment habits, which in this interpretation can also be regarded as a proxy for the transactional demand for money. The examination also involves the euro area, and accordingly variables describing the payments infrastructure were sought that were available for both areas. The collected dataset contains the following variables: number of terminals and transactions conducted through terminals (ATM and POS), over-the-counter cash withdrawals in bank branches, the number of POS transactions conducted with cards issued domestically, the number of domestically issued bank cards, and the number of wire transfers and bank branches.

The evolution of the institutional environment in Hungary and the euro area exhibits several similarities. The number of ATMs had already previously reached its maximum level in both cases, in 2017 in Hungary and in 2014 in the euro area. Since then, it has been on the decline: at the end of 2021 it stood at almost double the end-2000 figure in Hungary and it was 40 per cent higher than the end-2000 figure

in the euro area. The number of POS terminals rose in the period under review. By the end of 2021, it had increased by 740 per cent and 400 per cent compared to end-2000 in Hungary and the euro area, respectively. The turning points came earlier in Hungary in the number of transactions. As regards over-the-counter cash withdrawals, most transactions were conducted in 2002, before diminishing steadily after that. As the number of over-the-counter cash withdrawals contracted, ATMs were on the rise until 2011, but after that the number of transactions consistently decreased. At the same time, the number of POS transactions increased dynamically, up until the end of the period. This occurred later in the euro area, where over-the-counter cash withdrawals peaked in 2009, and ATM cash withdrawals did so in 2015. The dynamic institutional development in Hungary is also demonstrated by the fact that the share of wire transfers within all transactions was steadily declining from the start of the period, while in the euro area this indicator reached its highest point in 2009.

Figure 7
POS card purchases per ATM cash withdrawal



Note: Number of ATM cash withdrawals with cards issued by resident PSPs – at terminals provided by resident PSPs – from euro area (changing composition): https://data.ecb.europa.eu/data/datasets/PSS/PSS.A.U2.F100.I10.I111.NT.X0.20.Z0Z.Z
Number of POS transactions with cards issued by resident PSPs - at terminals provided by resident PSPs – from euro area (changing composition): https://data.ecb.europa.eu/data/datasets/PSS/PSS.A.U2.F000.I10.I200.NT.X0.20.Z0Z.Z
Number of ATM cash withdrawals with cards issued by resident PSPs – at terminals provided by resident PSPs – from Hungary: https://data.ecb.europa.eu/data/datasets/PSS/PSS.A.HU.F100.I10.I111.NT.X0.20.Z0Z.Z
Number of POS transactions with cards issued by resident PSPs – at terminals provided by resident PSPs – from Hungary: https://data.ecb.europa.eu/data/datasets/PSS/PSS.A.HU.F000.I10.I200.NT.X0.20.Z0Z.Z

Source: Calculation based on ECB data

Figure 7 shows the number of POS transactions per ATM withdrawal. These two time series provide a good overview of the developments in Hungary and the euro area. In the Hungarian payment system, the ratio of POS transactions to ATM withdrawals was lower than in the euro area in the early 2000s, but the payments infrastructure has undergone a dynamic transformation since then. Since 2015, the number of POS transactions per ATM transaction has been consistently higher than in the euro area. This was influenced by the development of the infrastructure, affected by policy and regulatory measures, as well as by the market structure of financial institutions and payment habits.

It is quite difficult to capture institutional change with a single time series, and it can be derived as a latent variable produced as the aggregate impact of the above processes. The number of POS card purchases per ATM withdrawal is available with an annual frequency, which was broken down into monthly frequency with the Chow–Lin method, for which no indicator series was used.

Nevertheless, the overall transformation of the institutional environment is not fully captured by the above indicator. Therefore, an index of the searches for "Magyar Közlöny" (Hungarian Official Journal) was downloaded from Google Trends. The frequent transformation of the legal environment affecting several areas increases uncertainty and thus promotes the growth in cash holding. The primary source for tracking the changes in Hungarian laws is the Hungarian Official Journal. The frequency of the change in the legal environment and the importance of the new or amended laws can be approximated with Google Trends data for the corresponding search term. Of course, this index series does not directly measure the change in the complexity of the legal environment, it merely acts as a proxy. The Google Trends data series was cumulated, because this indicator is thought to offer a good approximation of the evolution of the legal environment's complexity. The benefits of using Google Trends data in econometric models was already pointed out by *Choi – Varian* (*2012*).

3. Methodology

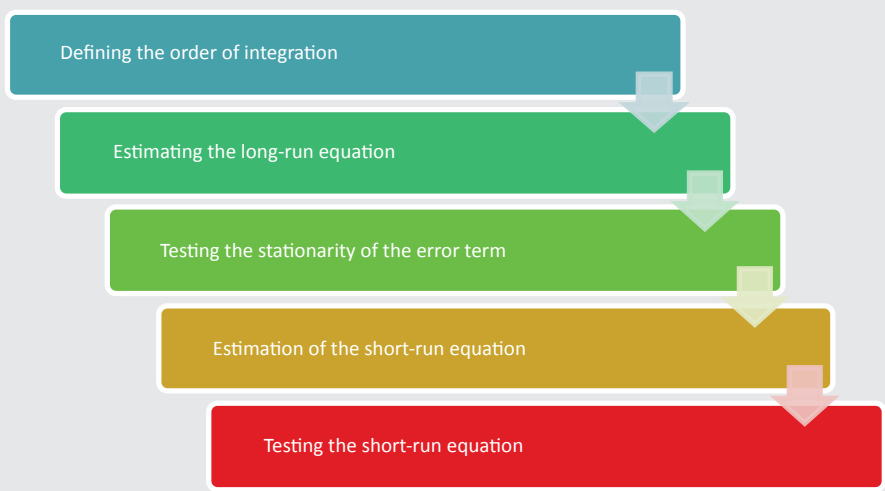
In the modelling, it was assumed that the long-run development of the cash holding ratio and the variables determining the cash demand for savings purposes is kept close to each other by an equilibrium mechanism. In the present case, it is the long-run equilibrium of the cash demand for savings purposes in the sense that the right side of the long-run correlations (see Equation (*1*) and (*2*)) can be considered the relative cash demand for savings purposes. The temporary adjustment of the deviations from the equilibrium occurs in the subsequent periods. These processes can be modelled with the error correction model, for which two equations need to be estimated. The first assumes the existence of time series that move close to

each other on an equilibrium path in the long run. The variables are then around the actual equilibrium path, and some market mechanism pushes the time series back towards the equilibrium path after the temporary deviations. An equation fitted on such processes models the long-run equilibrium, and the estimation error refers to the deviation from the equilibrium. This can also be seen as the speed of short-term adjustment, and it is used as an explanatory variable in the short-run equation written for the differences in the original variable. If the equilibrium concept is relevant, there are no major deviations from the equilibrium (*Engle – Granger 1987*).

In the long-run equation, the time series are not stationary, and the order of their integration is the same. A time series is considered stationary if the covariance between y_t and y_{t-s} only depends on s, and it is independent from t, and the correlation between the time series and its lagged version is independent from the beginning of the time series. This also means that the variance of error terms is constant, $\mathrm{Var}(u_t) = \mathrm{Var}(u_{t-s})$, if $s > 0$, the given time series has no trend, seasonality, and its autocorrelation structure remains constant over time. Stationary time series are considered to be integrated of order 0 and are denoted as I(0). If a time series can be made stationary through differentiation, it is called a series integrated of order one [I(1)]. The error correction model ensures the connection between the two horizons (*Miller 1991*).

The steps of fitting the model are presented in *Figure 8*.

Figure 8
Steps of fitting the error correction model



Source: Based on Engle – Granger (1987)

When quantifying the institutional changes, the general-to-specific method by *Hendry* (*1995*) was employed.

The following long-run equations were estimated for the Hungarian and euro area cash holding ratios:

$$\log(k_{EU,t}) = \gamma_{EU} + \beta_{EU,1}\log(nw_{EU,t}) + \beta_{EU,2}sr_{EU,t} + \beta_{EU,3}lr_{EU,t} + \beta_{EU,4}esiu_{EU,t} + \beta_{EU,5}\log(reer_{EU,t}) + \beta_{EU,6}inst_{EU,t} + \beta_{EU,7}D1 + \beta_{EU,8}D2 + ect_{EU,t} \quad (1)$$

$$k_{HU,t} = \gamma_{HU} + \beta_{HU,1}\log(nw_{HU,t}) + \beta_{HU,2}sr_{HU,t} + \beta_{HU,3}lr_{HU,t} + \beta_{HU,4}rir_{HU,t} + \beta_{HU,5}esiu_{HU,t} + \beta_{HU,6}\,reer_{HU,t} + \beta_{HU,7}inst_{HU,t} + \beta_{HU,8}\log(cpisd_{HU,t}) + \beta_{HU,9}cpik_{HU,t} + \beta_{HU,10}MK_{HU,t} + \beta_{HU,11}D2 + ect_{HU,t} \quad (2)$$

where *k* is the cash holding ratio, *nw* is the change in net wealth, *sr* is the 3-month interest rate, *lr* is the 10-year rate, *esiu* is unemployment, and *cpik* is the consumer price index of financial services. In the equations, *reer* denotes the real effective exchange rate, *inst* is the number of POS transactions per ATM transaction, *MK* refers to the cumulative Google Trends results for the search term "Magyar Közlöny" (Hungarian Official Journal), *cpisd* is the standard deviation of inflation in the 18 months preceding the relevant period, and *rir* shows the ratio of short- and long-term interest rates. Finally, *D1* is the dummy for the crisis between October 2008 and December 2011, while *D2* denotes the levelshift outlier due to the Covid-19 pandemic that began in April 2020. $ect_{EU,t}$ and $ect_{HU,t}$ are error terms in the long-run equation, representing the deviation from the equilibrium path, the lagged value of which is incorporated into short-run equations (3) and (4).

Short term correlations are presented in equations (*3*) and (*4*).

$$dlog(k_{EU,t}) = c_{EU} + \alpha_{EU,1}dlog(k_{EU,t-3}) + \alpha_{EU,2}dlog(nw_{EU,t}) + \alpha_{EU,3}d(sr_{EU,t-1}) + \alpha_{EU,4}d(esiu_{EU,t-1}) + \alpha_{EU,5}D3 + \alpha_{EU,6}D4 + \alpha_{EU,7}D5 + \alpha_{EU,8}D7 + \alpha_{EU,9}D8 + \alpha_{EU,10}D9 + \alpha_{EU,11}D10 + \alpha_{EU,12}D11 + \alpha_{EU,13}ect_{EU,t-1} \quad (3)$$

$$d(k_{HU,t}) = c_{HU} + \alpha_{HU,1}d(k_{HU,t-1}) + \alpha_{HU,2}d(sr_{HU,t-3}) + \alpha_{HU,3}d(esiu_{HU,t}) + \alpha_{HU,4}d(MK_{HU,t}) + \alpha_{HU,5}D6 + \alpha_{HU,6}D7 + \alpha_{HU,7}D8 + \alpha_{HU,8}D10 + \alpha_{HU,9}D11 + \alpha_{HU,10}D12 + \alpha_{HU,11}D13 + \alpha_{HU,12}D14 + \alpha_{HU,13}ect_{HU,t-1} \quad (4)$$

where the meaning of the variables is the same as in the long-run equation, and *α* shows the estimated values of the parameters. *Di*, *i* = 3,…,14 denote the additive outliers in the short-run model.

4. Results

Due to the availability of data, the error correction model was fitted on the period between January 2004 and September 2022 for the cash holding ratios of both currencies. The first step in the error correction methodology chosen here is the testing of the stationarity of the incorporated variables, using the ADF (augmented

Dickey–Fuller) test. The tests were performed with a constant and trendless specification, determining the order of integration of the variables included in the analysis. The null hypothesis of the ADF test is that the variable follows a unit root process. The test results are presented in *Table 3 of the Annex*, which shows that the variables involved in the analysis follow an I(1) process, with the exception of the Google Trends "Magyar Közlöny" search index, at a 1 per cent significance level.

The long-run equations were fitted on the original variables, before calculating their error terms and testing the stationarity of the error term. The parameters of the variables, the statistics describing the fit of the equations and the error term's ADF test results are shown in *Table 1*.

The parameters of the long-run equation largely were in line with our hypothesis. The rise in wealth reduces the cash holding ratio in the long run, and the long-term interest rate and the euro short-term rate have the same effect. Although judging from the parameters the relationship between the short-term interest rate and the forint cash holding ratio seems to be unidirectional, there is a negative correlation between the two variables. The positive parameter is due to the fact that on account of the multicollinearity arising from the ratio between the short- and long-term interest rates this parameter cannot be interpreted in itself.

In case of short- and long-term interest rate ratio variable was applied instead of difference, because the difference between short- and long-term rates foreshadows how short-term rates will evolve in the future. The models describing money demand usually use the difference between the interest rates as an explanatory variable, but here their ratio was chosen because we assume that the relationship between the difference and the cash holding ratio is not linear. The interest ratio variable has no expected sign. The correlation to cash holding is usually negative, because higher long-term interest rates suggest higher short-term rates in the future. But its sign can also be determined by the relative return on the series of future short-term interest rates as well as by inflation expectations (*Friedman 1977*). In Hungary, the variable is negatively correlated with the cash holding ratio.

Higher unemployment expectations point towards greater uncertainty and result in a larger cash holding ratio in the euro area. In Hungary, the long-run negative correlation is attributable to the relationship between the unemployment outlook and falling income. The ESI index signalling risks and measuring savings opportunities was not significant in any of the long-run models. As a result of real depreciation, the opportunity cost of forint and euro cash holding increases, which leads to lower cash holdings.

Table 1
Parameters of the long-run equations

Variable name	Hungary			Euro area		
	Variable	Parameter	t-statistics	Variable	Parameter	t-statistics
Cash holding ratio – dependent variable	k			log(k)		
Constant	γ	2.080	16.989***	γ	1.891	5.136***
Change in net wealth	log(nw)	–5.200	–4.461***	log(nw)	–26.765	–26.858***
3-month interest rate	sr	0.076	11.471***	sr	–0.007	–3.5***
10-year interest rate	lr	–0.087	–16.657***	lr	–0.039	–6.85***
Ratio of 3-month to 10-year interest rates	rir	0.002	6.682***			
ESI – unemployment expectations	esiu	–0.546	–14.119***	esiu	0.002	10.333***
Real effective rate	reer	–56.462	–7.393***	log(reer)	–0.343	–4.271***
Number of POS transactions per ATM transaction	inst	0.619	4.805***	inst	0.909	5.934***
Consumer price index standard deviation	log(cpisd)	–0.043	–4.046***			
Financial services price index	cpik	0.001	3.608***			
Google trend – Magyar Közlöny	MK	4.210E–05	1.825*			
Dummy (2008M10–2011M12)				D1	0.082	9.117***
Dummy (2020M4–)	D2	0.213	9.095***	D2	0.113	6.844***
Adjusted R^2	0.978			0.969		
Durbin–Watson-statistics	0.444			0.624		
Number of observations	223			223		
Error ADF test value	–6.317***			–7.21***		

*Note: ***, **, *: significant at 1, 5 and 10 per cent*

The institutional change parameter is positive for both currencies. In the past decades the transactional use of electronic money has become increasingly popular and commonly accepted as the institutional environment changes, and the transaction function of cash is gradually declining as the infrastructure matures. Paradoxically, this results in the rise of the cash holding ratio.

In the case of forint cash holding, the 18-month standard deviation was found to be significant, as a higher standard deviation reduces the cash holding ratio. With respect to the euro area, no horizon was found for which the standard deviation of inflation data had significant explanatory power for long-run cash holding.

Higher financial service prices entail a higher cash holding ratio, which confirms the assumption that with higher financial service prices investing savings is perceived as less logical, which is a non-rational motive for cash holding. No such correlation was found for the euro, which is assumed to be partly attributable to the heterogeneity of the euro area's banking system.

In the case of cash holding in Hungary, the cumulative time series of the search results for "Magyar Közlöny" is an indicator for the overall evolution of the legal environment, and the parameter has a positive sign.

Euro cash holding was significantly increased by the crisis between October 2008 and December 2011, so a levelshift outlier was incorporated into the long-run model for this period. The measures introduced on account of the Covid-19 pandemic in 2020 transformed the market environment to the extent that a levelshift outlier had to be incorporated into the model for this purpose as well.

The stationarity of the error term was tested for both equations, and it was found that both error terms were stationary in the case without a constant, which allows this data to be incorporated into the short-run model. The short-run equations are summarised in *Table 2*.

The short-run model was fitted on the difference of the cash holding ratio for Hungarian data, while in the case of the euro area cash holding ratio the log value was differentiated. The cointegration approach is appropriate for this analysis, because the error term of the long-run equation was stationary, and in the short-run equation the one-period lagged value was significant and negative, which means that short-term developments are converging towards the long-run equilibrium.

In fitting the short-run equations, the general approach was used, and the variables of the long-run equation and the appropriateness of its lagged time series were examined, taking into account the parameters of the fit of the model. This yielded equations of a much simpler structure than in the case of long-run time series, although several additive outliers cropped up in the short-run processes, especially towards the end of the time series.

Table 2
Parameters of the short-run equations

Variable name	Hungary			Euro area		
	Variable	Parameter	t-statistics	Variable	Parameter	t-statistics
Cash holding ratio – dependent variable	d(k)			dlog(k)		
Constant	c	0.011	5.483***	c	0.004	6.602***
Cash holding ratio	$d(k_{t-1})$	–0.142	–3.755***	$dlog(k_{t-3})$	0.098	2.328***
Changes in net wealth				dlog(nw)	8.195	7.648***
3-month interest rate	$d(sr_{t-3})$	–0.011	–4.485***	$d(sr_{t-1})$	–0.003	–3.377***
ESI – unemployment expectations	d(esiu)	0.001	4.453***	$d(esiu_{t-1})$	0.001	2.842***
Google trend – Magyar Közlöny	d(MK)	–0.001	–4.761***			
Dummy (2006M1)				D3	–0.018	–2.35***
Dummy (2008M1)				D4	–0.025	–3.265***
Dummy (2008M10)				D5	0.054	6.919***
Dummy (2010M1)	D6	–0.048	–3.066***			
Dummy (2020M3)	D7	0.164	9.946***	D7	0.069	8.044***
Dummy (2020M4)	D8	0.353	14.211***	D8	0.110	10.795***
Dummy (2020M5)				D9	–0.061	–5.034***
Dummy (2020M6)	D10	–0.096	–5.425***	D10	–0.053	–5.85***
Dummy (2020M7)	D11	–0.060	–3.58***	D11	–0.037	–3.532***
Dummy (2020M8)	D12	–0.054	–3.441***			
Dummy (2020M11)	D13	0.069	3.874***			
Dummy (2022M8)	D14	–0.071	–4.462***			
Error correction factor	ect_{t-1}	–0.067	–2.549**	ect_{t-1}	–0.036	–2.108*
Adjusted R^2	0.789			0.797		
Durbin–Watson-statistics	1.989			1.738		

*Note: ***, **, *: significant at 1, 5 and 10 per cent*

In the short term, the change in the Hungarian cash holding ratio is explained by the change in the cash holding ratio from the previous period. Thus, growth in the preceding month reduces the growth in cash holding in the current month. The rise in the short-term interest rate preceding the reference month by three months reduces the cash holding ratio of the reference month, and the negative parameter value is line with expectations. As unemployment expectations increase, the cash holding ratio grows, and the rise in the Google searches for "Magyar Közlöny" slightly decreases the latter in the short run.

The short-run cash holding ratio of the euro area is determined by the parameter's value three months prior to the reference period. It is influenced by the speed of change in wealth: an accelerating rise in wealth raises the euro cash holding ratio. An increase in the short-term interest rate in the preceding month reduces the cash holding ratio of the reference period, confirming the theory. Finally, rising unemployment expectations from one period earlier raise cash holding in the reference period.

In both equations, the rise in the short-term interest rate reduces the cash holding ratio, while uncertainty decreases it.

As regards the outliers, the outlier from January 2006 was probably caused by the continued euro area enlargement and publication of the ECB's guideline on regulating the cash supply.[17] The outliers from 2008 were due to the unfolding economic crisis for both currencies. The outlier from 2010 was partly due to the middle "peak" in the W-shaped recovery from 2008, as the 6.6 per cent GDP contraction in 2009 was followed by 1.1 per cent growth in 2010. On the other hand, the measures introduced in 2010, such as the nationalisation of private pension assets, the transformation of the tax regime, the cutting of red tape, and the introduction of special taxes in banking, telecommunication and the energy sector, resulted in a marked change in the regulatory environment.

The other group of outliers is explained by the Covid-19 lockdowns in 2020, the related measures, the easing of the lockdown and the subsequent waves. In March 2020, strict control measures had to be implemented in almost every European country, including Hungary. At the same time, laws were drafted to protect the threatened industries and those employed there and mitigate the impact of the downturn, and they came into effect during the same month or in April. As a result, the cash holding ratio increased substantially in March and April. The accumulated cash holdings decreased between May and August, when the lockdowns were partially eased.

In Hungary, the second wave that hit in November entailed another rise in the cash holding ratio. Finally, the last outlier came in August 2022, triggered by the partial

[17] https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006O0009

phase-out of the cut in utility prices due to the energy crisis, which impacted not only households but also manufacturing sectors.

The fit statistics of short-run equations are presented in *Table 4 of the Annex*.

The autocorrelation arising from the error term of the short-run equations was analysed with an LM test. No autocorrelation can be demonstrated in the present models with a lag of two periods. The heteroscedasticity of the models was measured with the Breusch–Pagan–Godfrey test. According to the results, the error term does not exhibit conditional heteroscedasticity in either model. According to the Jarque-Bera test, the normal distribution of the error term is acceptable in both models. Finally, Ramsey's RESET test was also performed on both models. The results show that the structure of the model fitted on the euro area suggests a missing variable, although the test statistics do not indicate a missing variable in the Hungarian model.

5. Conclusions – Summary

This study sought to offer a complex approach to the cash demand for savings purposes. While the impact of traditional financial market correlations, such as the rational motives for cash holding, were found to be significant, the results show that several seemingly non-rational motives were verified for the cash demand for savings purposes, in both the euro area and Hungary. Among the latter factors, uncertainty plays a key role in the cash holding ratio. It exerts an impact in both the short and the long run, raising the cash holding ratio when it increases, but failing to have the same reducing effect when it declines. The conclusions are therefore consistent with the results by *Rösl and Seitz* (*2021*), who also confirmed that economic and social crises increase cash demand.

Since these factors, such as uncertainty, the rapid shifts in the institutional environment amidst the turbulent economic and social changes as well as the non-rational perception of the return on investments by economic actors, are expected to remain dominant, in the medium term the cash demand for savings purposes is not projected to decline substantially in Hungary or in the euro area.

It must also be emphasised that the Hungarian data confirm that rising financial service prices entail a higher cash holding ratio in the long run, probably because households believe that it is less rational to invest savings when financial service prices are higher. No such correlation was found for the euro, but it is worth noting that the consumer price of financial services increased by 250 per cent in Hungary, while it fell by 1 per cent in the euro area in the period under review.

The results show that the cash holding ratio can be used to demonstrate the impact of non-rational behaviour at the macro level regarding cash demand, and

the implications cannot be ignored when making economic policy decisions and developing incentives. As a result, in the context of the shocks in recent years and the subsequent adjustment processes, the impact mechanism of the variables in the traditional theories has become difficult to decipher.

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Annex

Table 3
Results of unit root tests

Variable name	Hungary		Euro area	
	Test specification	t-value	Test specification	t-value
Cash holding ratio	N, 1	–12.371***	N, 1	–12.590***
Changes in net wealth	N, 1	–3.381***	N, 1	–11.961***
3-month interest rate	N, 1	–4.754***	N, 1	–6.208***
10-year interest rate	N, 1	–7.251***	N, 1	–8.274***
Ratio of 3-month to 10-year interest rate rates	N, 1	–18.762***		
ESI – unemployment expectations	N, 1	–16.522***	N, 1	–11.666***
Real effective rate	N, 1	–13.087***	N, 1	–12.783***
Number of POS transactions per ATM transaction	N, 2	–16.155***	N, 2	–16.155***
Consumer price index standard deviation	N, 1	–3.599***		
Financial services price index	N, 1	–3.095***		
Google trend – Magyar Közlöny	N, 1	–2.105**		

*Note: ***, **: significant at 1, 5 per cent*

Table 4
Test statistics for short-run models

Test	Hungary		Euro area	
	Test statistics	P-value	Test statistics	P-value
LM-test	0.075	0.928	1.774	0.1723
Breusch–Pagan–Godfrey	0.665	0.796	1.003	0.449
Jarque–Bera	4.588	0.101	0.599	0.741
Ramsey RESET test	0.921	0.358	3.28	0.001

Horizontal and Vertical Value Creation in Bankrobotics and the AI-Washing Phenomenon*

Alexandra Prisznyák

Artificial intelligence, machine learning, intelligent robots and related innovative technologies are emerging as driving forces that are reprogramming the traditional remnants of the banking sector. The purpose of this groundbreaking study is to localise the concept of bankrobotics, clarify the conceptualisation of bankrobotics technologies and analyse their applications in banking. Their value creation is interpreted along vertical and horizontal dimensions. On the basis of in-depth interviews, the approach and implementation of their organisational adoption are discussed, along with the factors inhibiting value creation. The author proposes the classification of partner chain-based AI systems, the introduction of incident databases and the establishment of disclosure obligations regarding investments in bankrobotics, to avoid the spread of the AI-washing phenomenon in the banking sector.

Journal of Economic Literature (JEL) codes: G21, O33

Keywords: artificial intelligence, bankrobotics, value creation, banking AI incident database, AI-washing

1. Introduction

The innovative technologies of the digital era are impacting the economics of many industries, while promoting productivity, profitability and efficiency as well as the customisation of services and the customer experience and the management of risks and security through the rationalisation of operations (*Aghion et al. 2017; Wirtz et al. 2018; Kaya 2019; EP 2020; EC 2018, 2019; EBF 2019; Cheng – Jiang 2020*). The Covid-19 pandemic was the main driver behind companies' digital transformation in recent years (*Harkácsi – Szegfű 2021*). The activities of FinTech firms that filled a gap in improving the quality of market services facilitated the financial inclusion of groups excluded from the services of mainstream financial institutions (incumbent traditional banks, insurers) and the enhancement of the consumer experience (*ESA 2022; Alt et al. 2018*). In the FinTech industry, payment

* The papers in this issue contain the views of the authors which are not necessarily the same as the official views of the Magyar Nemzeti Bank.

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The first version of the Hungarian manuscript was received on 21 March 2023.

DOI: https://doi.org/10.33893/FER.22.3.97

service solutions, blockchain technology and robo-advisory services have become crucial (*Bagó 2023*). In connection with the rise of FinTech and BigTech companies, neobanks and challenger banks, the Bank for International Settlements (BIS) has pointed out the potential risks of traditional banks being crowded out from the market as well as of the fragmentation and marginalisation of banking activities (*BIS 2018*). The utilisation of FinTech technologies has brought about an era of personalisation and immediate omnichannel customer service, triggering a change in banks' business models (beyond banking) (*El-Gohary et al. 2021*). In response to the changed consumer needs of the digital era (hyperpersonalisation, consumer experience), incumbent banks operating in the shadow of their FinTech and BigTech competitors had no choice but to increase their digital capabilities, coupled with reorganisation (*Szikora – Nagy 2020; EP 2020, 2021, 2022; EBA 2020; Prisznyák 2023*). Along with their own digital transformation, banks also play a key role in financing the digital transition of the economies, and in how that shapes global society. Banks' engagement in sustainability and social awareness-raising regarding artificial intelligence (AI) and the related innovative technologies has also increased considerably in the recent period (*Tomašev et al. 2020*). The active use of digital technologies (sustainable robo-advisory services, green crowdfunding) provides a major boost to the social development of green finance (*Horváth 2022*).

The hype surrounding AI generates strong investor and consumer pressure on organisations to use AI. This paper seeks to introduce the concept and research avenue of bankrobotics and present the use of bankrobotics technologies in banks' front/middle/back office areas. Value creation for stakeholders is examined in the vertical and horizontal value creation model of bankrobotics. The implementation of value creation in the market is assessed through in-depth interviews. Based on the reported experiences, the different forms of implementing investment in bankrobotics and the various managerial approaches are analysed, along with the management's level of familiarity with AI and the related innovative technologies, as well as the main factors inhibiting value creation. I also draw attention to AI-washing, which hampers value creation, and propose a classification of partner chain-based AI risks and the establishment of a publicly available AI incident database.

2. Research questions and hypotheses

To answer the research questions summarised in *Table 1*, the literature is analysed, along with the in-depth interviews with banking and IT experts who took part in the introduction of the innovative technologies.

Table 1
Research questions and hypotheses

Research question	Hypothesis
Q1: What is AI?	**H1:** Corporate asset.
Q2: What are the typical forms of investments and developments in bankrobotics?	**H2** In-house, partnering, acquisition and hybrid forms can all be observed.
Q3: What are the approaches to investment?	**H3:** Top-down approach.
Q4: What about the technological know-how of bank managers?	**H4:** Corporate leaders are not always able to distinguish technologies (AI, ML, robot).
Q5: What organisational and other factors support/hinder the value creation of investments in bankrobotics?	**H5:** Legal constraints, data, labour demand, organisational culture.

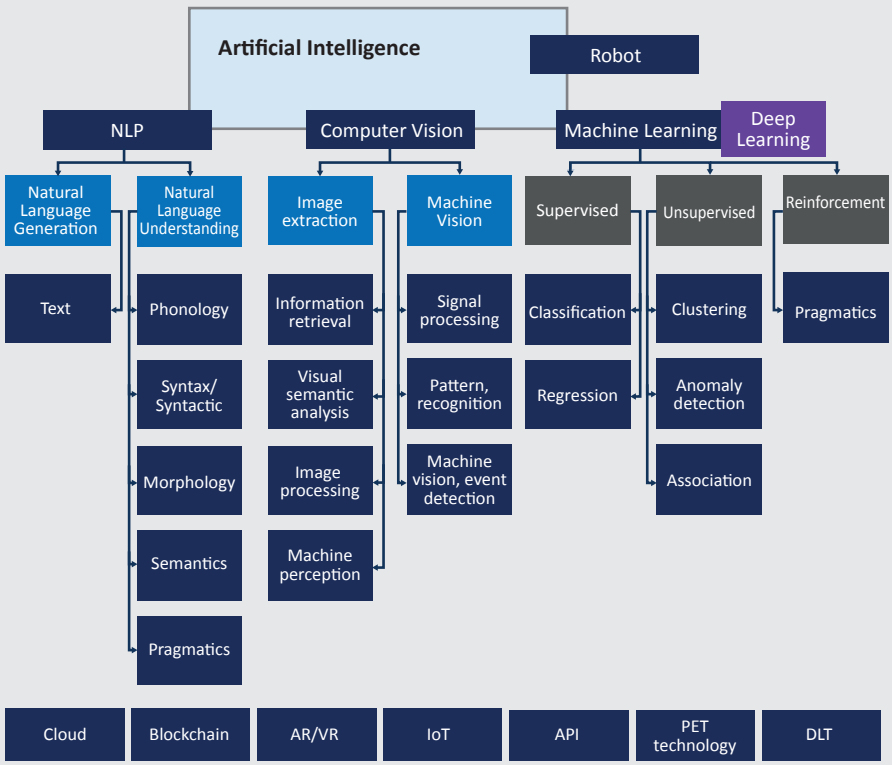
3. The concept of bankrobotics and the AI-washing phenomenon

In response to the challenges of the digital era, many leading large banks have devised a technology/AI strategy aligned with the organisational strategy and launched AI and robot projects. Investment in innovative technologies improves banks' response capacity (*Pintér – Herczeg 2023*). In an effort to distinguish itself and backtest its cost-optimisation strategy, the China Construction Bank Corporation opened the world's first human-free, fully-automated branch in 2018 (*Zhang 2018*). The rationalisation of branches and assessing the level of social acceptance are important aspects for the organisations undergoing digital transformation and looking to ensure their future competitive advantage (*Payne et al. 2021*). This phenomenon can also be seen at euro area banks (*Discanno 2023*). However, the operational performance of the companies that adopt digital technologies does not automatically increase when such technologies are implemented (*Szalavetz 2022*).

The technologies of the digital era pose a challenge to banks when they need to navigate the triangle of efficiency, risk management and client needs, compounded by more and more stringent regulatory requirements (*EBF 2019*). Although there is no generally effective method for stimulating FinTech innovation by regulators, the practical application of an innovation hub and a regulatory sandbox seem to be conducive (*Fáykiss et al. 2018*). Artificial intelligence, different algorithms-based machine learning (ML) and deep learning, intelligent robots, computer vision, natural language processing (NLP), cloud technologies, application programming interfaces (APIs), distributed ledger technology (DLT), virtual reality (VR), IoT (the Internet of Things), quantum supercomputers and privacy enhancing technologies (PET) all vary widely in the banking sector, which is based on strong customer confidence and a regulatory framework (*Figure 1*). The complementary application of these technologies is among the strongest reset drivers in the traditional operation of the financial system and the banking sector (*Alt – Puschmann 2016*).

In response to the increasing use of these technologies in the banking sector and the importance of the sector-specific regulatory environment, I hereby propose to establish the concept of bankrobotics and a sector-specific research avenue.

Figure 1
Innovative technologies applied in banking



Note: AR: Augmented Reality

From the perspective of technology, the concept of bankrobotics refers to the application of innovative FinTech technologies in the banking sector to rationalise and improve banking processes and services. By contrast, FinTech is a broader category that should be interpreted in the wider financial sector as it also covers areas (and market players) other than the banking sector. In other words, bankrobotics can be defined as a key component of FinTech, but the two concepts are not synonyms, due to their different goals and the different frameworks of regulatory challenges.

In the banking sector, the use of AI and ML technologies is often referred to as banking robotics, bankrobotics or robo-banking. *One might wonder why "robotics" and "robo-banking" are used for AI and machine learning technologies that are software systems rather than physical robots.*

Due to the convergence of technologies, the line between robots and AI concepts has become blurred (*Török – Ződi 2021*). To put it another way, the two otherwise different technologies are sometimes falsely identified as synonyms. The universal use of the term "robot" in the banking sector is attributable to various factors. Using the term "robot" for slave-like work has its roots in the literature (Čapek, Asimov), referring to robots who work as servants in a human-centric world, or to physical robots aimed at replacing human workflows. The innovative technologies used in the banking sector are increasingly seen in several front/middle/back office workflows, facilitating process automation, 24/7 customer service and the replacement of monotonous, repetitive processes (robot-like activities). Consequently, in the banking sector, the term 'robot' is used for the automation of processes by a robot (software). Beyond entertaining fantasies, today's society can experience the integration of robots in real life. The banking sector has several humanoid (service) robots, although they are yet to be introduce in Hungarian branches. They use a combination of the above technologies to promote the social acceptance of robots (*Figure 2*). In their case, the software-based AI is coupled with a hardware. To reflect the blend of software and physical form, the most commonly used term is simply "robot". I argue that the AI hype can also lead to an incorrect use of the terms, as the consumer and investor pressure in the market has considerably increased the use of "robot" and "AI" among organisations (when referring to products/services/processes in marketing texts).

Figure 2
Intelligent robots in banks' customer areas

	2010	2014	2015	2016	2016	2016	2017	2018	2019	2019
Robotics company	YDreams	Softbank Robotics	Aldebaran Robotics	Softegy Innovations	Nautilus Hyosung	IDMind	Paaila Technology	Sberbank robot lab	Nam A Bank	Promobot
Bank deploy the robot	Santander Group	HSBC, Mizuho Bank, Rabobank, Capital Bank of Jordan, Emirates NBD, Leumi Group, DSK Bank	Mitsubishi UFJ bank	City Union Bank	Sberbank	Banco Bradesco	Paaila Technology	Sberbank robot lab	Nam A Bank	National Bank of Oman, Sberbank
Hungarian robot landscape	X	X	X	X	X	X	X	X	X	X

Note: Figure by the author.

The Federal Trade Commission (FTC) encourages companies to avoid overselling technological capabilities and making hollow promises when advertising AI-based products. (*FTC 2021, 2023*). *State et al.* (*2023*) emphasise the rise of AI-washing, where the term AI is often used for basic ML algorithms. For the same concept, *Seele and Schultz* (*2022*) use "machinewashing", emphasising organisations' deliberately deceptive or misleading behaviour (communication). "AI-washing" refers to corporate practices/behaviour where an organisation seeks to position itself positively (reputation) by emphasising AI-based operation and solutions and their advantages to key stakeholder groups (investors, customers, media, others), without actually engaging in any meaningful activity in that area. In connection with the threat posed by this, the European Union's *Ethics Guidelines for Trustworthy Artificial Intelligence* (*EC 2019*) contains policies that discuss the responsibility of service providers. In this context, requirements are stipulated for the accurate description of products and reliable and transparent communication (*EC 2019, EC 2020*). I argue here that in the long run AI-washing could undermine investor confidence, as AI-based value creation does not happen if organisations' AI capabilities are not improved over the long term.

4. Introduction and application of bankrobotics technologies

When assessing the investment objectives of innovative FinTech technologies, *Kou et al.* (*2021*) find that the most important aspects are related to competitiveness, operational efficiency, cost-optimisation and other non-financial factors (customer satisfaction). *Shaikh et al.* (*2017*) highlight the rise in sales volume, while *Eyal* (*2017*) focuses on the option to increase market value, and *Leung and Chung* (*2020*) emphasise potential cost cuts and increased efficiency.

Based on the assessment of the available AI capabilities and their objectives, banks decide on the form of investment in bankrobotics (the technology applied) and the form of implementation. The discipline of innovation management has long discussed the value creation that can be achieved through the external knowledge-enhancing opportunities offered by internal corporate R&D activities and innovation capabilities (*Lunn 2016*). Investments in bankrobotics can be realised in various forms: (1) in-house, (2) acquisition, (3) partnering, and (4) hybrid (*Tanda – Schena 2019; Schena et al. 2018*). Relying on external knowledge (partnering, acquisition), banks can increase the range of solutions and knowledge regarding the technology applied. Banks usually offer differentiating services in-house to safeguard data assets and bank security, while non-differentiating activities are typically supported

by supplier and partner developments (*McKinsey 2020*). In the case of in-house developments, free, open-source solutions offer a cost-effective way to enhance an organisation's digital capabilities (*HGMA-PWC 2019*).

The use of artificial intelligence, robots and the related innovative technologies in banks' front/middle/back office areas creates value in a complex manner, typically linked to various points in the workflow (*Prisznyák 2022a*). During the conceptual analysis of bankrobotics technologies, one might ask *what can these technologies be used for and how do they facilitate the value creation of the different banking processes?*

Artificial intelligence refers to systems that display intelligent behaviour by analysing their environment and taking actions, with some degree of autonomy, to achieve specific goals (*EC 2018*). It is difficult to give a legal definition of AI due to the absence of a uniform AI concept. The European Commission has made great strides towards regulating a trustworthy artificial intelligence (*EC 2019, 2020, 2021*). Pursuant to the prevailing legislation, it is considered a corporate asset among intangible assets (software), but it has additional qualities that raise issues of whether the technology can be classified as a legal person. However, the weak point of these proposals is the ability of applying moral and ethical considerations (*Stefán 2020*). As regards the legal person status of AI, its development and autonomy can be the key to the solution in the future (*Klein 2021*). AI includes the algorithm-based ML models often used in the banking sector, which allow projections to be made and preprogrammed tasks to be run (*EBA 2020; EP 2020*). There is no single ideal algorithm, as the choice of algorithm is aligned with the objectives of the business area during ML model building (*Prisznyák 2022b*).

In front office sales and marketing, ML plays a key role in CRM strategies, customer classification, transaction management, the preparation of action plans and proposals, churn rate projections, fraud prevention, chatbots and client communication, and biometric identification and verification (*Aggarwal et al. 2014*). Robo-advisors and virtual assistants support portfolio and wealth management by forecasting trends and returns, and by portfolio optimisation and asset allocation (*Rouf et al. 2021; Marchinares – Alonso 2020; Bartram et al. 2020; Strader et al. 2020; Beketov et al. 2018*). In the middle office area, it supports lending processes and thus the preparation of credit scoring systems' decisions (scoring, others) and client profiles. In a related paper, *Nica et al.* (*2021*) analysed the assessment opportunities for client profiles used in mortgage management. In back office areas such as Compliance, KYC, KYI and AML, ML offers crucial help in customer registration, AML/CFT issues and the analysis of suspicious transactions using video/e-KYC and AML solutions (*Prisznyák 2022b; Johari et al. 2020; Jullum et al.*

2020). Other major areas for use include customer service, where machine learning models assist in customer sentiment analysis and the development of customer management strategies based on the incoming complaints. In HR, ML models can effectively support recruitment, selection, the review of CVs and the performance assessment of employees (*Vasantham 2021*). They are also crucial in bank security (the prevention of cyberattacks).

The whole organisation is also impacted by the use and value creation of NLP and computer vision technologies (*Chaubey et al. 2022*). NLP supports the communication between customers and the bank and in-house communication (analysis of written and spoken texts), sentiment and behaviour analysis as well as the digitalisation and analysis of documents (*Aparaj et al. 2013; Elcholiqi – Musdholifah 2020*). Character recognition can help assist in lending, AML/CFT and the analysis, translation and summary of data, news and documents (legal documents, annual financial statements) from external sources. Character recognition and the related document analysis can also considerably support the work of customer service through the recognition of loan applications, account statements and reports (*Khurana et al. 2023; Patel – Trivedi 2020*). Therefore, it effectively supports customer identification and the forecasting of customers' financial difficulties (*Hajek et al. 2014*).

ML and NLP technologies are often assisted by computer vision using a sensor (camera), not only with robots. Computer vision also promotes bank security through the cameras installed in branches (detection and prevention of suspicious transactions, ATM manipulation). The visual recognition of data helps it assist customer identification, processes requiring verification and the monitoring of the movement of documents within the bank (*Chaubey et al. 2022*).

Other solutions that support operation include cloud technologies (storage of large amounts of data), IoT (collection and analysis of data from devices, such as smart devices and cameras), VR (the use of a virtual environment to enhance the customer experience), APIs (integration of an application with other service providers and systems, establishment of data links), PET (protection of the personal customer data, encryption and anonymisation of data) as well as DLT and blockchain technology (secure data management and monitoring) (*Campbell et al. 2021*).

5. An interpretative model of vertical and horizontal value creation in bankrobotics

The potential impact and value creation of bankrobotics technologies is presented along vertical and horizontal dimensions (*Figure 3, Table 2*). *We will see the value created by bankrobotics technologies, for whom it is created and at what levels.* From the perspective of vertical value creation, the following levels should be analysed separately: (1) nano (operation level); (2) micro (organisational level), (3) mezzo (bank sector), (4) macro (national economy), and (5) global. At the individual levels, the examination of the vertical value creation dimensions is further refined by completing the analysis from the perspective of the following players as well: (1) investors, (2) customers/clients, (3) institution (bank), and (4) employees. The limitation of the model is that it does not discuss other stakeholder groups. Different stakeholder groups have different forms of value created for them by investments in bankrobotics (the technologies applied), which is presented in *Table 2*.

Figure 3
A model of horizontal and vertical value creation in bankrobotics

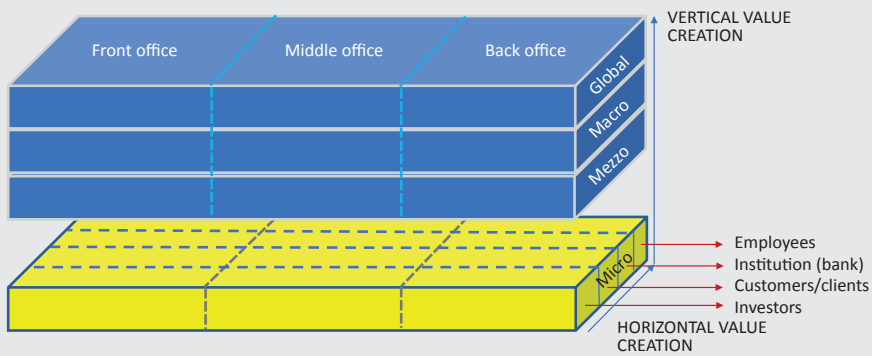


Table 2
Horizontal and vertical value creation in bankrobotics

	Investors	Customers/clients	Institution (bank)	Employees
Nano	• identification of investment opportunities based on a personalised risk management strategy, decision support • enhancement of investor confidence • reducing transaction costs	• improvement of the customer experience and the service • increasing personalisation • objective evaluation • financial inclusion • availability of new products and services	• cooperation between specialised areas (business/IT/legal), responsibilities, risk management • operation optimisation (reduced resource needs, improved quality), KPIs • more digital services • omnichannel and communication • data collection and analysis	• allocation of labour to tasks with higher value added • replacement of monotonous tasks • integration of AI/robot into a team
Micro	• portfolio management and wealth management optimised by an innovative technology • identification of trends, analysis of market sentiment	• omnichannel communication supported by AI (chatbot, AI advisor, 24/7) • protection of personal data	• AI strategy, responsible areas • development of digital organisational capabilities (in-house/partnering/acquisition), conducive organisational culture • integration of AI/robots into the organisational culture • supporting business model transformation • change management (change of mindset) • (cyber)security	• awareness-raising, training • development of new responsibilities • redefining tasks and responsibilities • attraction of AI talent
Mezzo	• impact of reduced transaction costs on trading (facilitating market liquidity)	• overall reduction of banks' costs • branch rationalisation trend • competitive enhancement of the consumer experience	• transformation of the range of digital products/services • rise of neobanks • development of an AI ecosystem in the banking sector • ethical AI policies for the banking sector • creation of data and knowledge pools	• increased demand for AI experts in the banking sector • transformation of banking (necessary skills, knowledge, competencies)
Macro	• impact of bankrobotics regulation on investments • algorithmic trading can increase the efficiency and speed of financial markets	• facilitation of the financial inclusion of underbanked players in the macroeconomy • awareness-raising about AI in society, supporting education (FinTech, sustainable banking)	• more efficient, lower-cost and faster financial transactions in the economy as a whole (supporting productivity growth) • financing and improvement of digital organisational capabilities (supporting cybersecurity) • reduction of economic disparities (financial inclusion) • management of market distortions (AI risk) • reduction of regulatory costs • promoting the transparency and stability of the financial system (money laundering, suspicious transactions), increased confidence	• polarisation of the labour market, frictional unemployment • enhancement of employees' digital competencies
Global	• transforming investment climate in the national economy • impact of investor confidence and market sentiment on AI hype cycles • general democratisation of trading (robotic support not requiring expertise)	• transformation of digital consumer habits • social challenges of human–robot interactions (robot rights, legal personality) • social diffusion and inhibitors (incidents) of AI and the related innovations • enhancement of certain human skills • impact on social inequalities • consequences of the unethical use of AI	• supporting sustainable banking and ESG objectives • the impact of technology on cross-border services and global trade • financial integration of developing countries (temporary slump in the learning phase) • clarification of responsibility and insurance issues • international collaboration (AI ecosystem) • development of data and security regulation for international banking	• rise of (physical) robots • transformation of labour demand • increased income inequalities within society • social conflict (?)

6. Own research results: The practical implementation of investments in bankrobotics

6.1. Data collection: in-depth interviews

In line with the research questions presented, structured in-depth interviews were conducted between December 2022 and May 2023 related to the practical implementation of investments in bankrobotics. The interviewees were banking, business and software development professionals who participated in projects related to AI, ML and robot developments (*Table 3*). The duration of the interviews was capped at 120 minutes, but they usually lasted 90–120 minutes. The results are published anonymously. The in-depth interviews are limited by the experiences of the interviewees (specialisation in IT, banking sector), which may reduce the potential of generalising the survey.

Table 3
Summary of the experiences about the investments in AI and robots: in-depth interviews and bankrobotics WS

#	Profession	Experience (years)	Interview (minutes)	Industry, sector
1.	Head of AI Division	9	120	Banking sector, information technology
2.	R & D Director	15	120	Information technology
3.	Software developer	6	90	Information technology
4.	Machine learning engineer	7	90	FinTech, healthtech
5.	Project manager	25	120	Information technology
6.	IT manager	25	80	Banking sector
7.	Automation manager	12	90	Banking sector
8.	Machine learning engineer	17	120	Banking sector, pharmaceutical industry
9.	IT Programmer	23	120	Banking sector, pharmaceutical industry
10.	Software Development Engineer	7	120	Information technology
11.	Research & Development, AI developer	6	120	Information technology
12.	IT project leader	6	120	Banking sector, pharmaceutical industry
13.	IT specialist	20	90	Banking sector
14.	Project controller	6	84	Banking sector
Total interviews (hours)			24.7	

Note: Bankrobotics WS is a series of workshops organised by the Institute for Training and Consulting in Banking Ltd.

6.2. Research results

The summary of the interviews related to Q1, Q2, Q4 and the responses can be found in *Annex 1*.

6.2.1. Corporate asset feature of AI (*Q1*)

With one person declining to comment, all interviewees agreed that with its present capabilities, artificial intelligence is a corporate asset, and it should not be treated as a legal personality. However, 40 per cent of respondents can imagine robot rights and the question of legal personality being discussed to reach a social consensus, as AI develops in the future.

6.2.2. The implementation of investments in bankrobotics (*Q2*)

Based on the experiences from the in-depth interviews, the development of AI systems in the banking sector usually starts in-house, in relation to customer-specific processes and those related to the ordinary course of business, supplemented by the inclusion of advisors and partner firms. In the case of R&D processes and processing system and specialised workflows, the inclusion of an external developer and/or cooperation with (FinTech) tech companies becomes more important. In other words, cooperation is strongly influenced by the nature of the project and the fulfilment of in-house, specialised preconditions (in-house IT/AI skills) at the bank. In-house development of front/middle office decision support systems has the advantage that the banks' intellectual property, data assets and customer data are protected, bank security and cybersecurity are facilitated, and code base ownership and the management of capacity planning issues are ensured. The development of AI-driven processing systems (typically a back office activity) is often supported by contracted suppliers. The advantages of developments completed by external providers include bridging the gaps in technology and capacities (flexible capacity planning – time, employees), but partnerships also involve counterparty risk. External knowledge can be acquired in various forms. Acquisition (start-ups) and venture capital investments can both facilitate the integration of technology and expertise unavailable to the bank. Acquisition can also mitigate the security risks related to bank data through ownership. It can be seen that the in-house development of an organisation's AI skills and knowledge is supported by AI solutions from suppliers and acquired firms as well as experience from expertise and projects. The form of implementation is influenced by the business objective (differentiation), the business area and bank security issues.

7.2.3. The approach to investment (*Q3*)

According to the in-depth interviews, investments in robotics are dominated by a top-down approach, mainly driven by pressure from investors and market competition. In extreme cases, a bottom-up approach can come into focus, especially at firms that place an emphasis in their organisational culture on motivating employees, or when the organisation does not have an AI strategy and the management does not have knowledge about AI. However, there are also hybrid solutions, when – in a bottom-up manner – business development proposals shape a corporate AI strategy that has not fully matured.

7.2.4. Management's knowledge about AI and the related innovative technologies (*Q4*)

AI hype and a lack of knowledge about AI on the part of managers can cause problems in cooperation with suppliers, due to unrealistic expectations about technology and value creation. Issues arising from the management's lack of technological knowledge can already be detected in the negotiation phase of projects. Key points in project planning include: the objective of the planned investment in bankrobotics (technology) and the value creation of the business area (improved efficiency, saved resources, other), the planning of the necessary preconditions (assets, AI experts) and capacities, data security issues as well as the establishment of risk and success factors (KPIs). When partners are involved, one common problem is the bank management's unrealistic expectations about the technology and the development time (time needed for testing), which leads to underestimated resources in planning. Ideally, the communication between the bank's management and the supplier is supported by an IT expert at the bank. These experts play a crucial role in formulating realistic expectations about bankrobotics projects on behalf of the bank's management. In the absence of this key player, unrealistic expectations can cause problems in the cooperation between the bank and the supplier.

6.2.5. Factors inhibiting/supporting implementation and value creation (*Q5*)

The factors inhibiting implementation and value creation are classified into 7 main categories and 29 subcategories based on the experiences shared in the in-depth interviews. *Table 4* shows the supporting factors, the absence of which can hamper the value creation of investments in bankrobotics.

Table 4
Classification of factors supporting the value creation of investments implemented in bankrobotics

Main category [subcategory]	Subcategory	Subcategory elements
Organisation [9]	AI strategy	Development of an AI strategy in line with the AI strategy of the parent company
	Establishment of a dedicated organisational unit and organisational forums	Establishment of the responsible organisational unit, positions, responsibilities and accountability
	Organisational culture conducive to AI	Environment supporting innovation; integration of the "robot" into the organisation (team member)
	Awareness-raising about AI	Awareness-raising and training of employees
	Size and global presence of the organisation	Alignment to the cultural, regional and local AI regulation environment
	Cost/profit pull factors	Establishment and continuous review of value-creating and cost factors
	Protection of the bank's data assets and supporting cybersecurity	Observance of data security rules and policies; establishment and support of operating and security requirements, system protection (access rights, cybersecurity at banks), ensuring compliance
	Organisational capacity-building	Necessary instruments (hardware, software); knowledge transfer, AI knowledge base
	Social responsibility and external knowledge transfer	Collaboration with universities, start-ups; supporting awareness-raising among customers and society
Executives, management [2]	Change management	Governing organic transformation, change of mindset, commitment (embodied in action as well); supportive organisational communication
	Technological skills	Basic AI knowledge, technological skills (avoiding unrealistic expectations caused by AI hype)
Operational employees [2]	Managing employee fears and resistance	Managing employee resistance (fear of job loss, rising workload in IT) through organisational change management
	AI experts, employee skills, education	Attraction of AI experts; talent management

Table 4
Classification of factors supporting the value creation of investments implemented in bankrobotics

Main category [subcategory]	Subcategory	Subcategory elements
Other stakeholder groups [4]	Investors, market	Communication of accurate technological capabilities (AI-washing), communication about the investment in bankrobotics vis-à-vis consumers and investors
	Competition and market trend analysis	Competition and technological trend analysis
	Customers	Customer needs and requirements (assessment, discussion); measuring technological penetration and satisfaction; customer education: responsible product use and judgement
	Partner, supplier	Choosing a supplier with specialised AI expertise, knowledge transfer; managing counterparty risk
Data and data governance [3]	Acquisition and storage of the necessary data	Provision of the necessary amount and quality of data (managing data quality issues, proper data cleansing), storage (server/cloud)
	Data loading, data feed, system connections	Availability of in-house and external data silos, API integration; harmonisation of subsidiary and partner systems
	Data security	Protecting customer data, anonymity, rethinking technology workflow
Technology [4]	Project management: Management/business/ development/legal team cooperation	Using a short chain of communication and creating a communication link between the bank and the supplier: having an IT/AI expert at the bank is crucial for realistic scheduling, clarifying expectations and the reliable estimation of the necessary resources; accurate business need specifications (related KPIs)
	AI risk management system	Operation of a risk management system
	Model building – algorithm selection	Appropriate data labels: representativity; choosing the appropriate algorithm and model calibration; ensuring model requirements (transparency, non-discrimination, explainability)
	Operation, monitoring and human oversight	Workflow support of the system: human oversight; controlling system performance (accuracy, negative feedback loops), reparameterisation when necessary, defining intervention scenarios (system shutdown)
Legal considerations [5]	Compliance	Compliance with legal regulations (AI laws, DORA, GDPR, others), risk classification; implementation of ethical guidelines
	Information to customers and contracts	Customer information in line with legal requirements – integration into customer contracts
	Application limits	Slow adaptation in the international and domestic regulatory environment
	Regulatory sand box	Providing an opportunity for the business area to test the model (supporting the bank's IT/AI experts)
	Data reporting obligations, documentation	Observance of model and operating requirements (technical documentation, record-keeping requirements)

Based on the experiences detailed above, I summarised the results of my research results in *Table 5*.

Table 5
Summary of research results

Research question	Hypothesis accepted/ rejected	Research results
Q1	**H1: accepted**	AI should be treated as a corporate asset.
Q2	**H2: accepted**	In-house, partnering, acquisition and hybrid forms can all be observed.
Q3	**H3: accepted**	Top-down approach dominates. The bottom-up approach is characteristic of organisations that do not have an AI strategy and where the management has limited knowledge about AI. As a hybrid solution, the top-down approach can be transformed based on the specification of the bottom-up business area/IT/supplier.
Q4	**H4: partially accepted**	AI hype and the lack of knowledge about AI on the part of managers can cause problems in the cooperation with suppliers, due to unrealistic expectations about technology and value creation.
Q5	**H5: accepted and adding additional factors**	The factors inhibiting the implementation and value creation of investments in bankrobotics were classified into main and subcategories, as presented in *Table 4.*

7. Conclusions and proposals

Investments in bankrobotics typically create value for an organisation as a whole, not just for a specific business unit, thanks to the related activities. The difficulties involved in measuring value creation highlight the risks of the implemented technologies and the need to classify them as well as the operation of the related risk management frameworks. In risk classification, organisation-specific *partner chains should be defined.* Partner chains are neighbouring areas working in close cooperation that can impact each other's activities indirectly but significantly, due to their shared business processes as well as the systems and the data used. The risk classification of the AI systems used in these partner chains should be established based on the interaction between the areas and the application of the technology in the individual areas.

In relation to publicising investments in bankrobotics, banks and regulatory authorities need to work together to develop the requirements while considering the following:

- The extent and impact of the investment in bankrobotics: investments that can have a major impact on banking operation and customers need to be treated as a priority (e.g. ML-based IRB models) and disclosed.

- Security and data protection: investments need to comply with stringent security and data protection requirements, as well as the European Union guidelines and laws on ethical AI. In the course of disclosure, these aspects should be given priority so that customers receive sufficient information on the use of the system, its security and capabilities and the protection of their data.

To supplement the current practices (FinTech and Digitalisation Report), the author proposes the introduction of a publicly available database of AI incidents during the operation of investments in bankrobotics, which should be coordinated by the supervisory authority while considering the following minimum requirements: incident ID, incident title (short summary); detailed description of the incident; date of the report/detection of the error; date of the intervention/correction; banking areas affected; (potentially) affected customers; the company developing the AI system or the name of the bank (in the case of an in-house development); operating bank. This proposal rests on the following main considerations:

- *Trust and responsibility:* The AI law published by the European Union determines the rules of responsibility for damages caused related to the development, operation and dissemination of AI systems, where in certain cases high-risk AI systems can be subject to more stringent rules, and even a certification can be required to prove the appropriateness of the system. In this context, the proposed database would be transparent and help establish and maintain mutual trust between market participants and stakeholders, thereby facilitating transparency and accountability, and the development and operation of ethical AI systems, in line with the European Union's guidelines on ethical AI.

- *Development of the banking sector:* The disclosure of incidents stimulates innovation and the necessary developments, promoting the development of organisational capabilities and banks' accountability culture.

- *User/customer protection and customer experience:* In addition to the group of customers affected (households, companies, other customers), the basic details of the incident would be known to customers, which would improve the protection of the users involved in the incident. Successful, transparent management of incidents can help restore confidence and allows customers to make conscious decisions while interacting with AI systems.

Verifying AI labels (avoiding AI-washing): AI systems need to be supervised by the competent authorities. The supervisory authority needs to have policies in place for labelling AI systems, and the exact definition of AI systems and the risk classification used should be clearly established. These policies can determine labelling requirements and supervisory procedures.

Compliance inspections: the supervisory authority needs to conduct regular inspections at banks to verify the labelling and use of AI systems, and to supervise and investigate the reported AI incidents.

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Annex

Annex 1
Research questions and answers – interviews on questions Q1, Q3 and Q4, summary of answers

#	Q1	Q3	Q4
1.	no comment	top-down	the business area has limited knowledge, the modelling department usually does not know it
2.	corporate asset	top-down	the project leaders usually have a realistic requirement (higher expectations can also be seen)
3.	corporate asset	top-down	sometimes – typically affects the order process
4.	corporate asset	top-down	FinTech managers are usually well-versed in a wide range of technologies
5.	corporate asset	bottom-up	superficial knowledge of AI
6.	corporate asset	hybrid	superficial, misconceptions
7.	corporate asset	top-down	a competency hub is operated within the organisation, and AI training is a part of that
8.	corporate asset	bottom-up	the management has broad knowledge
9.	corporate asset	bottom-up	lack of prior knowledge
10.	corporate asset	top-down	prior shortcomings and high expectations
11.	corporate asset	top-down	superficial, prior shortcomings and high expectations
12.	corporate asset	top-down	gaps in knowledge, only second-hand knowledge
13.	corporate asset	top-down	shortcomings and high expectations
14.	corporate asset	top-hybrid	the project leaders usually have a realistic requirement, but they have less information about implementation and the technology

Estimating the Energy Demand of the Residential Real Estate Stock in Hungary Based on Energy Performance Certificate Data*

Mónika Bene – Antal Ertl – Áron Horváth – Gergely Mónus – Judit Székely

In our study, estimates are made for the distribution of the Hungarian residential real estate stock in 2020 by energy characteristics. In our calculations, which are novel in Hungary, a new database has been compiled by combining the energy certificates issued since 2016, the 2016 Microcensus and the housing construction statistics of the HCSO. Energy performance certificate data are assigned to the dwellings included in the Microcensus and to the 68,000 new dwellings built in the period since then. A statistical relationship is established between the characteristics and the energy demand of dwellings, which is then extrapolated to the stock as a whole. This is processed to present the estimated calculated energy consumption per square metre of the Hungarian residential real estate stock and the characteristics of the estimate by area and real estate type. Our results can support sustainable mortgage lending in the financial system.

Journal of Economic Literature (JEL) codes: G21, O13, Q40, R30

Keywords: flat, energy, EPC, EU Taxonomy

1. Introduction

The Hungarian residential real estate stock will need to be almost completely renewed in terms of energy efficiency in the next decade or decades. Only a modern real estate stock with minimal energy demand can lead to achieving the country's 2030 "Fit for 55" climate targets and the 2050 goal of European climate neutrality,

* The papers in this issue contain the views of the authors which are not necessarily the same as the official views of the Magyar Nemzeti Bank.

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We wish to thank Gábor Révész (ELTINGA) for his professional support. We are also grateful to Donát Kim and the staff of the Sustainable Finance Analysis Division at the Magyar Nemzeti Bank (central bank of Hungary). The research was performed on their commission and supported by them under research contract 35838-1/2023. The results cannot be considered as an official estimate of the MNB.

The first version of the Hungarian manuscript was received on 7 June 2023.

DOI: https://doi.org/10.33893/FER.22.3.123

as set out also in Hungary's Long-Term Renovation Strategy (*ITM 2020*). To achieve this goal, it is essential to assess the current state of the stock, as well as to plan and calculate the costs and to set up an effective incentive system. However, even in the interests of achieving such an important goal, an energy audit cannot be carried out quickly on more than four million real estate units, and the conditions can only be characterised by estimations. In our study, we contribute to these estimations by creating a new database and by its statistical processing.

The renewal of the dwelling stock, as one of the largest energy consumers in the economy, is essential for an environmentally sustainable future. In this study, our calculations contribute to narrowly-defined, direct objectives. The focus of the projection at this time is on the EU Taxonomy target, as a priority for the financial sector, which establishes rules for sustainable finance that can only be derived from the stock as a whole. The primary objective of the study is to estimate the limit of the top 15 per cent of the Hungarian residential real estate stock in terms of energy consumption per square metre as at 31 December 2020. This requires an assessment of the energy quality of the entire dwelling stock.

According to Point "7.7 Acquisition and ownership of buildings" of Annex I of the European Commission Delegated Regulation (EU) No 2021/2139, from the perspective of the EU taxonomy, the following buildings are considered to contribute substantially to climate change mitigation: buildings constructed before 31 December 2020 which have at least a Class *A* energy certification. Alternatively, the building is in the top 15 per cent of the national or regional building stock expressed as an operational Primary Energy Demand (PED) and verified by appropriate evidence, which at least compares the performance of the asset to the national or regional stock built before 31 December 2020 and at least distinguishes between residential and non-residential buildings. In the case of buildings completed after 31 December 2020, the building complies with the criteria set out in Point 7.1 of the above Annex, relevant at the time of purchase. On the basis of the above, for the regulation, it is necessary to estimate the limit of the top 15 per cent from an energy point of view. Based on the projection to the total stock, this is of course also given. Although the Taxonomy does not specify a distinction by building type, both professional considerations and past practice justify the setting of limits by building type. Based on the results of this study, in the case of residential buildings, even the separation of detached houses and condominiums can be justified, as the results are significantly different in terms of energy demand.

The value estimated in our study, i.e. the lower limit of the best 15 per cent of residential real estate in Hungary in terms of energy efficiency, provides important considerations for the financial sector. The main reason for this is that the green finance attitude is gaining ground among regulators, central banks and profit-oriented actors as well (*Sági 2020*). From a real estate financing perspective, one of the key drivers is the issuance and trading of what are called green bonds. While

green bonds may not only be linked to the real estate market (*Bokor 2022*), the mortgage lending market is a natural way to enforce a green finance attitude, both because of its inherently securitised nature and the high energy intensity of the underlying assets (residential real estate). While there is no universally agreed rule on what is considered "green" for residential mortgage lending, there is consensus that, in line with the EU regulation quoted above, a real estate unit must be in the top 15 per cent in the country in question regarding energy efficiency (*Ritter 2021*). Since a simultaneous and thorough expert assessment of all domestic real estate is essentially impossible, we believe it is necessary to develop a procedure that can provide an estimate of the distribution of energy demand of residential real estate in Hungary. Beyond supporting regulatory and prudential aspects, our calculation can also contribute to the development of financial products.

The limit of the top 15 per cent of the Hungarian dwelling stock in terms of energy is estimated as follows. As a first step, we process the database of energy performance certificates produced in Hungary between 2016 and 2020, which contain the primary energy demand of the built unit at building or dwelling level, calculated by an expert, and certain technical parameters of the built structure. Additional data is linked to these using the 2016 Microcensus of the Hungarian Central Statistical Office (HCSO). In the second step, statistical relationships between the energy demand of the residential real estate units and their characteristics as defined in the first step are estimated using two different methodologies. In the third step, since the database of energy performance certificates is not representative for the whole country in several aspects, such as age and location, the estimated correlation is extrapolated for the total dwelling stock of the country using the weights of the Microcensus.

To our knowledge, this study is among the first to perform this calculation for Hungary. The methodology of our work is cutting-edge, even in international comparison. Although the study of the relationship between the energy demand of buildings and their characteristics is a popular research topic, offering the possibility to use a wide variety of statistical methodologies, a large part of the studies focuses on the variation of energy use over time (e.g. within a day or a year).[1] There are far fewer works on topics that are more relevant for us and that look at the dwelling stock in a cross-sectional manner, using technical or other characteristics (e.g. age) to focus on a certain indicator of the distribution of the total stock (e.g. average, median or top 15 per cent). In our experience, a major and serious limitation in this area is the nature and quality of available data: in most cases, either the detailed energy demand of buildings or the distribution of the national building stock is not available to researchers.

There are several approaches to handling this problem in literature. Some studies ignore the problem: *Antonín* (*2019*) examines the dwelling stock in the

[1] For comprehensive summaries of these, see e.g. *Sun et al.* (*2020*) or *Al-Shargabi et al.* (*2022*).

Czech Republic, and although he uses detailed energy demand data from energy certificates, he does not adjust them for the potentially different distribution of the dwelling stock across the country, and basically he gives the lower limit of the top 15 per cent of available energy certificates. A similar approach is used for Italy by *Nidasio et al.* (*2022*). Others face a partial lack of data in relation to the energy demand of residential real estate. In this case, the authors make some kind of simplifying assumption most of the time. For example, the estimate of the Irish Central Statistical Office (*ICSO 2019*) uses the letter code of existing certificates instead of the energy demand which is not available to them and extrapolates it by location, building type and year of construction for the whole country, in order to determine the best 15 per cent in terms of energy. Of course, in this case, the 85th percentile (the lower limit of the best 15 per cent) is not a numerical annual energy demand, but the letter code of the category in which the (calculated) 85th percentile of residential real estate falls in terms of energy demand. This greatly simplifies the calculations in some cases: in some countries, the recent introduction of stringent energy efficiency standards for new-build real estate means that a good starting point is to take a count of the real estate units built since the restrictions were introduced, determine their share of the total real estate stock and compare this ratio to the 15 per cent. Studies we are aware of use this approach with minor or local modifications in Norway (*Multiconsult 2021*), Denmark (*Jyske Realkredit 2022*) and the Netherlands (*CFP 2022*).[2]

Where these data or regulatory changes are not available, researchers have to use other types of information to approximate energy demand. In France, *Florio and Teissier* (*2015*), instead of using a distribution of the letter codes of energy certificates, assigned so-called type buildings from a European catalogue of thousands of types of buildings to a large sample of French residential buildings with many technical characteristics, and then combined these data to estimate the annual energy demand and energy efficiency class for each residential unit in the sample. The common European type building system (the result of the so-called EPISCOPE/TABULA project) is also used by *Csoknyai* (*2023*), who defined the energy efficiency of the Hungarian building stock using a bottom-up method. In an earlier work, *Csoknyai et al.* (*2016*) made similar calculations for several countries in the Central and Eastern European region.

Of course, studies that perform calculations very similar to the present paper on the dwelling stock in Hungary should be mentioned separately. In this regard, we highlight two works. On the basis of detailed data from Hungarian energy certificates, *Ritter* (*2022*) – after concluding that the lower limit of the best 15 per cent for energy efficiency in Hungary falls into the *CC* category – estimates the exact value from the distribution of energy demand in 2016–2019. Presumably due to

[2] It is worth noting that these studies, probably due to the relative simplicity of their methodology, have typically not been published as academic papers, but as public material for public policy or market actors (banks and investors).

the limitations of data on the dwelling stock and the scope of the study, the author does not address the fact that the composition of energy certificates and the total dwelling stock may differ (e.g. the certified stock is newer and therefore on average more energy efficient than the entire stock in the country).

The approach of *Kovács et al.* (*2021*) is different. In the framework of an earlier, large research programme, they defined twenty-three so-called type buildings representing Hungarian residential real estate, and based on these, they selected a statistically representative sample of two thousand buildings from the Hungarian stock, which they assessed in more detail from an energy point of view. This allowed for an empirical determination of the energy demands of type buildings, from which a weighted lower limit of the best 15 per cent per type can be derived.

The closest methodological approach to our study in the literature is that of *Hettinga et al.* (*2023*). In this study, the authors produce a predictive algorithm that can estimate the letter code of the certificate for all residential real estate in the Dutch real estate register, based on data from energy certificates in the Netherlands. According to the authors, this algorithm predicts the energy efficiency class much more accurately than by assigning the energy consumption of the TABULA model buildings developed for the Netherlands to the data in the land register and determining the energy efficiency levels on that basis. In the present study, we also use a large number of energy certificates, from which a statistical relationship between the characteristics of the residential real estate and energy efficiency is estimated. There are two main differences in our methodology. On the one hand, we do not have a register of the Hungarian real estate stock as in the Dutch case, and thus we must use the Microcensus for the national extrapolation. On the other hand, in this study we focus not so much on the energy efficiency class of the best 15 per cent of the residential real estate stock, but on its actual (calculated) energy demand. We see three advantages of this decision. First of all, this is a more accurate measure of the underlying physical processes to be modelled (the amount of energy consumed by the country's residential housing stock) than the category indicated by the energy efficiency class, since the latter can easily be changed by regulation from time to time. Secondly, this methodology, even with the inherent uncertainty of statistical estimation, can give a more accurate estimate of the 85th percentile than the letter-coded energy efficiency class. In the literature we processed it is typical that the best 15 per cent falls somewhere in the upper part of the rather broad *C* category, but since we have no more information beyond this, we are forced to stop here or to interpolate in some simple way between the category boundaries. Thirdly, to achieve a *BB* or better category, it is necessary to meet criteria other than the primary energy indicator – i.e. renewable energy production. Thus, estimates for letter codes would require the use of more uncertain categorical estimates rather than ordinal ones. The much more detailed database of energy certificates that we use allows us to work more accurately, which is pioneering in the international literature.

2. Research methodology

The energy characteristics of the Hungarian dwelling stock are the subject of a research programme that has been ongoing for several years. In addition to the intensive background work on data collection and data processing, a study on the correlation between the energy performance and price of detached houses (*Ertl et al. 2021*) has also been published, which was joined by a central bank survey with a calculation among new dwellings (*Hajnal et al. 2022*) and a publication on the summary data of certificates (*HCSO 2023*). Our research to estimate the condition of the residential real estate stock consists of three parts. Firstly, the data from the 2016 Microcensus of the residential real estate stock and the new dwellings survey were merged with the energy performance certificates. The result is a database representing the residential real estate stock at the end of 2020 with 68,000 dwellings. Secondly, a statistical correlation was estimated between data for the energy consumption per square metre of the energy certificate and the dwelling characteristics surveyed in the Microcensus. This estimation was performed separately for houses and flats. Finally, using this relation, an energy demand was assigned to each real estate unit that was part of the Microcensus stock but could not be linked to an energy certificate. This results in an estimated energy consumption per square metre for each residential real estate unit in Hungary for 31 December 2020. The results of this approach are presented below.

The real estate units can be ranked according to their energy consumption per square metre, so that the limit value for the best 15 per cent can be determined. Ranking is also possible by type and geographical location. Our methodology can also be updated annually to integrate newly built real estate units.

The estimate itself offers many interesting things which show the relationship between energy consumption per square metre and housing characteristics. The construction period and certain masonry and building engineering characteristics are assigned partial coefficients in the OLS -prediction, which show the overall change on the energy consumption per square metre.

Since the main goal of our work is to estimate the characteristics of the stock, this is in fact a prediction task. We therefore considered it appropriate to also use a prediction method that does not explicitly represent partial effects. The correlation between the energy consumption per square metre and the dwelling characteristics was also performed using the random forest method.

Accordingly, we first present our baseline database and the merged database, and then the statistical estimations performed on the merged database. Our results are presented in the following section, where projections for the whole stock are presented.

2.1. Databases used

2.1.1. Database of energy performance certificates

Based on the European Union guidelines, the energy certification of buildings in Hungary is regulated by Decree 7/2006 (24. V.) TNM on *the determination of the energy characteristics of buildings* and Government Decree 176/2008 (30. VI.). The former determines the calculation method itself, and the latter describes the certification process and the certificate. In the present project, the data of the completed certificates were received by the HCSO for statistical processing from the Lechner Knowledge Center, which manages them. Our research focuses on certificates issued between 2016 and 2020. The calculation methodology changed in 2016, and thus the data before 2016 cannot be compared with the data after 2016. Since, from the aspect of the EU Taxonomy, our aim was to observe the situation at the end of 2020, we used the data after 2016. For the same reason, although post-2020 certificate data is also available, only certificates issued up to 2020 were considered. However, our methodology can also be applied by extending the time horizon.

Table 1 shows the number of energy certificates processed. The table on the certificates issued shows that many certificates worse than *FF* are also issued. At the same time, every year there are more and more real estate units that are at least modern and have been awarded *AA–BB* certification.

Table 1
Number of energy certificates issued for residential buildings for certifications completed between 2016 and 2020, by letter of classification

		2016	2017	2018	2019	2020
AA++	Minimal energy demand	521	398	348	354	453
AA+	Outstandingly energy efficient	0	702	840	445	594
AA	Better than zero energy requirements	0	0	0	342	639
BB	In compliance with zero energy requirements	372	1,505	2,040	3,293	4,869
CC	Modern	16,299	27,062	28,879	30,875	37,639
DD	Close to modern	11,840	18,203	17,950	16,447	15,156
EE	Better than average	12,616	19,631	19,313	17,333	15,123
FF	Average	12,346	18,255	18,761	16,842	14,371
GG	Close to average	11,260	17,218	17,917	16,261	13,645
HH	Poor	14,517	21,143	22,172	21,149	17,362
II	Bad	11,191	15,892	16,931	15,805	13,251
JJ	Extremely bad	5,749	8,149	8,579	7,909	6,550
	Total	**96,711**	**148,158**	**153,730**	**147,055**	**139,652**

Source: Calculated on the basis of the database of the Lechner Knowledge Center, processed by the HCSO

Looking at the purpose of certifications, most of the energy analyses are linked to the sale of real estate (*Table 2*), which is understandable given the legal obligations of the seller. It can be seen, however, that in these years the proportion of new dwellings within certified real estate (certificates prepared for occupancy authorisation) rose to over 10 per cent. Overall, the second most frequent reason for certification is tendering. The category of certification for own use may reflect more than one of the above purposes, which have not been identified by the client for the energy professional. Where several certificates were prepared for the same real estate unit, the one closest to the year of the survey was taken into account (for dwellings surveyed in the Microcensus, the one closest to 2016, for new dwellings the one closest to the year of construction).

Table 2
Number of energy certificates issued for residential buildings for certifications completed between 2016 and 2020, by purpose of certification

Reason of certification	2016	2017	2018	2019	2020
Sale of real estate	83,201	119,047	120,906	106,401	88,645
Tender	3,958	10,720	13,611	17,134	19,740
Occupancy authorization	4,295	8,632	8,946	11,982	18,531
Renting of real estate	1,962	2,579	2,449	2,654	1,542
Obligation imposed	197	86	54	38	87
Public building, state-owned	8	29	6	19	16
Own use	3,090	7,065	7,758	8,827	11,091
Total	**96,711**	**148,158**	**153,730**	**147,055**	**139,652**

Source: Calculated on the basis of the database of the Lechner Knowledge Center, processed by the HCSO

The geographical distribution of available certificates is important for the territorial representativeness of the database. This is shown – by region – in *Table 3*. It can be seen that the database covers a wide area of the country: in our research, we were able to draw on tens of thousands of data points from all regions.

The proportion of certifications carried out in relation to the stock by region and type of settlement is shown in *Table 4*. The highest rate is found in the cities of Pest County, where the share of certificates is 19 per cent of the total, while the lowest rate is found in the municipalities of the Southern Great Plain.

Table 3
Number of energy certificates issued for residential buildings for certifications completed between 2016 and 2020, by region

Region	2016	2017	2018	2019	2020
Budapest	27,635	39,868	38,114	33,593	27,829
Pest county	11,873	19,622	20,641	20,159	18,619
Central Transdanubia	10,685	15,438	15,873	15,607	15,798
Western Transdanubia	9,475	14,361	14,921	14,896	15,491
Southern Transdanubia	8,371	11,628	12,592	12,470	12,451
Northern Hungary	7,928	13,580	14,892	14,974	14,636
Northern Great Plain	9,853	17,603	19,187	18,516	18,431
Southern Great Plain	10,891	16,058	17,510	16,840	16,397
Total	**96,685**	**148,158**	**153,730**	**147,055**	**139,652**

Source: Calculated on the basis of the database of the Lechner Knowledge Center, processed by the HCSO

Table 4
Share of energy performance certificates issued for residential buildings (2016–2020) as a proportion of the dwelling stock in 2020, by region and type of settlement

Region	County seat	Town	Rural municipality	Total
	(%)			
Budapest	18			18
Pest county		19	17	18
Central Transdanubia	17	16	15	16
Western Transdanubia	17	15	15	15
Southern Transdanubia	16	15	11	14
Northern Hungary	15	13	11	13
Northern Great Plain	18	12	10	13
Southern Great Plain	18	12	9	13
Total	**17**	**15**	**13**	**15**

Source: Calculated on the basis of the database of the Lechner Knowledge Center, processed by the HCSO

2.1.2. The Microcensus Dwelling Questionnaire

After the energy performance certificate database presented above, we briefly present the contents of the "Microcensus 2016" database for the dwelling stock, which are described in more detail elsewhere (*HCSO 2017; HCSO 2018*). In 2016, the seventh Microcensus was carried out, with some 440,000 addresses listed in 2,148 municipalities across the country. The selection of addresses was based on stratified sampling and participation was mandatory. This sample – taken between the two censuses – is therefore representative of the residential real estate stock in Hungary. The Microcensus Dwelling Questionnaire is also presented in *Annex 1* of our study. The following data is available from this source:

- exact address of the flat/house,
- area of the flat/house,
- period of construction of the flat/house, roughly by decade,
- masonry type of the flat/house,
- type of heating of the flat/house
- nature of renovation works completed on the flat/house after 2005,
- number of dwellings represented by the flat/house in the Hungarian dwelling stock.

The data was linked to the energy certificates based on the precise address and/or topographical lot number of the real estate.

Technical data of the real estate can play an important role in its energy performance. Some of them directly: type of masonry, type of heating, insulation, replacement of windows and doors. Some of these are indirectly related to the energy demand, such as the period of construction in relation to the materials and construction technology used at that time. We therefore hypothesised a detectable correlation between these characteristics and the calculated energy demand, which we tested statistically. Naturally, we are aware that many other criteria can have a significant impact on the energy performance of dwellings, but in this research we had to rely on the information available in the Microcensus.

2.1.3. New Dwelling Questionnaire

New residential real estate units built between 2016 and 2020 were included in the database on the basis of the OSAP 1078 dwelling construction survey. With the exception of renovation characteristics, which are not relevant for new dwellings, the same data are available as in the Microcensus. When extrapolated to the national stock, these dwellings represent themselves, i.e. they are assigned a weight of 1. This database contained data on 83,000 residential real estate units. The data was linked to the energy certificates based on the precise address and/or topographical lot number of the real estate.

2.1.4. Merged, weighted database

For our analysis, we used the 2016 Microcensus dwelling stock as a basis and linked the energy certificates issued between 2017 and 2020 to these records. The linking variable was the address identifier available from the address register of the HCSO, which was assigned to the energy certificate using the general address cleaning service. In this process, it was possible to match on a sub-registry level address identifier for almost 70 per cent of the nearly 480,000 certificates of which 22,300 dwellings could be identified in the Microcensus database.

In the next step, we looked for energy certificates for dwellings occupied between 2016 and 2020 available from the OSAP 1078 data collection. Since the exact sub-

registry level address of these dwellings is not known, only that of the building, the set of certificates for 2016–2020 was narrowed down to those issued for the entire building. This is also deemed justified because it is common practice to prepare an energy performance certificate for the entire building for the occupancy permit. The linking variables were the topographical lot number of the building and the year of occupancy, and the certificates were only taken into account if the whole building was classified in a single energy class and the certificate was issued in the year of occupancy or the year before. In this way, certificates could be linked to 56.5 per cent of the dwellings occupied between 2016 and 2020. In total, 22,300 energy performance certificates were associated with the 386,000 dwellings in the Microcensus, while 46,700 were associated with the 83,000 new dwellings. The question may arise why the data linkage was not complete for new dwellings, since the issuance of a certificate is mandatory at the time of occupation. The main reason is that the exact address details were often not yet known when the occupancy permit for each real estate unit was issued, which is when the statistical census is taken, so the information needed to make the link was not always available.

The energy distribution according to the resulting aggregated database is shown in *Table 5*. In total, we obtained access to 69,000 individual records where the calculated energy demand of the real estate and the characteristics of the dwellings are available. This stock, based on the weights of the Microcensus, represents 300,000 residential real estate units of the national stock.

Table 5
Number and distribution by energy category of data with dwelling characteristics linked to energy performance certificates

	Number of dwellings in the merged database	Share (%)	Number of dwellings represented in the merged database	Share (%)
AA++	640	0.9	658	0.2
AA+	1,703	2.5	1,886	0.6
AA	682	1.0	793	0.3
BB	5,744	8.3	6,839	2.3
CC	34,087	49.5	63,424	21.0
DD	5,300	7.7	30,547	10.1
EE	3,409	4.9	33,575	11.1
FF	3,344	4.9	33,578	11.1
GG	3,277	4.8	32,778	10.9
HH	4,694	6.8	44,042	14.6
II	4,104	6.0	36,554	12.1
JJ	1,944	2.8	16,802	5.6
Total	**68,928**	**100.0**	**301,476**	**100.0**

Source: Calculated from the merged database

After presenting the newly created database on which our calculations are based, the next section describes the estimations made on the database between the real estate characteristics and the calculated energy demand.

2.2. Regression fitting

Fitting was performed with the following variables, where the explained variable was the calculated aggregated primary energy consumption per square metre ("E_p"). The regression specification is similar to the hedonic regression used for dwelling prices, which is used in a number of statistical analyses, including the Technical Manual on Owner-Occupied Housing and House Price Indices (*Eurostat 2017*) and the HCSO Dwelling Survey for dwelling price indices (*HCSO 2016*). While in the case of explanations of dwelling prices, the simple specification has a deep economic content behind it in terms of demand (*Kain – Quigley 1970*), in this case we can assume a relationship between the explained and the explanatory variables on the basis of technical connections. As the full technological properties were not available, we included geographical proxy variables similarly to the regressions explaining dwelling prices. A separate model was estimated for detached houses and condominium flats (buildings with at least three flats). In the regressions, we weighted the observations based on the Microcensus. For both, the following explanatory variables were considered:

Geographical variables:

- 7 regions
- 4 settlement sizes: regional centre (Debrecen, Pécs, Szeged, Győr, Miskolc); towns with county rights; city; rural municipality
- the proportion of taxpayers with a tax base of over HUF 5 million in 2020 in the municipality (the reason to include this is that the presence of higher income households increases the chances of having high quality residential buildings)
- personal income tax base per resident in the municipality in 2020

General variables for the building:

- floor space
- building era:
  - built before 1919
  - built between 1920–1945
  - built between 1946–1960
  - built between 1961–1970

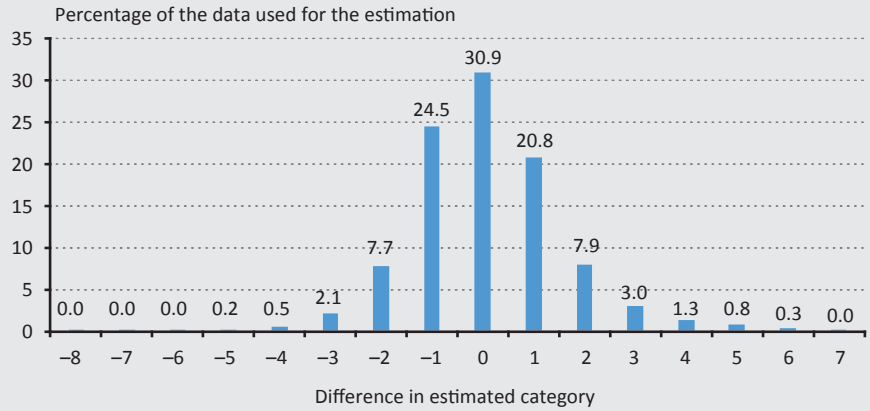
- built between 1971–1980
- built between 1981–1990
- built between 1991–2000
- built between 2001–2011
- built between 2012–2016
- built after 2016

Variables related to the energy of the building:

- Has there been any renovation? (As renovation those works were identified where insulation, window replacement or heating system retrofitting was carried out in the real estate in the ten years prior to 2016, according to the Microcensus, i.e. the answer to Question 13.3, 13.6 or 13.12 of the questionnaire in *Annex 1* was Yes)
- Masonry type: brick, concrete, concrete panel, other
- heat pump, air conditioning, solar panel, existence of centralised ventilation, use of alternative energy
- heating system: separately for each room, one dwelling heated by boiler (central, circle) or other device, more dwellings of a building heated by boiler (central, circle) or other device, district (block) heating
- air conditioner: according to the Microcensus, the owner had an air conditioner installed during the ten years before 2016 (Yes to Question 13.8 of the questionnaire in *Annex 1*)
- heat pump: according to the new dwelling survey, a heat pump was installed in the real estate.

In the regression, we also used cross products in relation to the implementation of the renovation, whose coefficients were found to be significant. The coefficients were estimated using level OLS estimation based on the specificity of the real estate characteristics on the energy demand. According to more traditional fitting indicators, the Adjusted R^2 was 73 per cent for detached houses and 65 per cent for condominiums. By fitting the regression, in addition to the traditional indicator, we also examined how much (by how many categories) the energy category defined on the basis of the predicted energy consumption per square metre differs from the actual rating. This connection is shown in *Figure 1*. In 76 per cent of the cases, our model is at most one category wrong.

Figure 1
Errors of the OLS regression explaining energy consumption per square metre by category difference



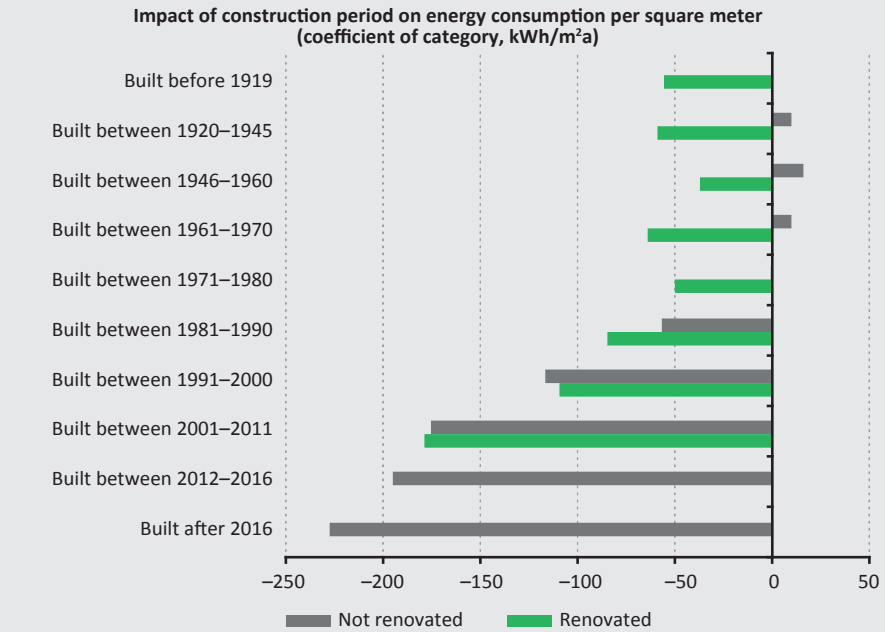
Note: Positive numbers: the energy consumption per square metre predicted by the estimation is in a worse category than the actual certificate (AA++, AA+, AA and BB categories are combined).

Source: Calculated based on the merged database

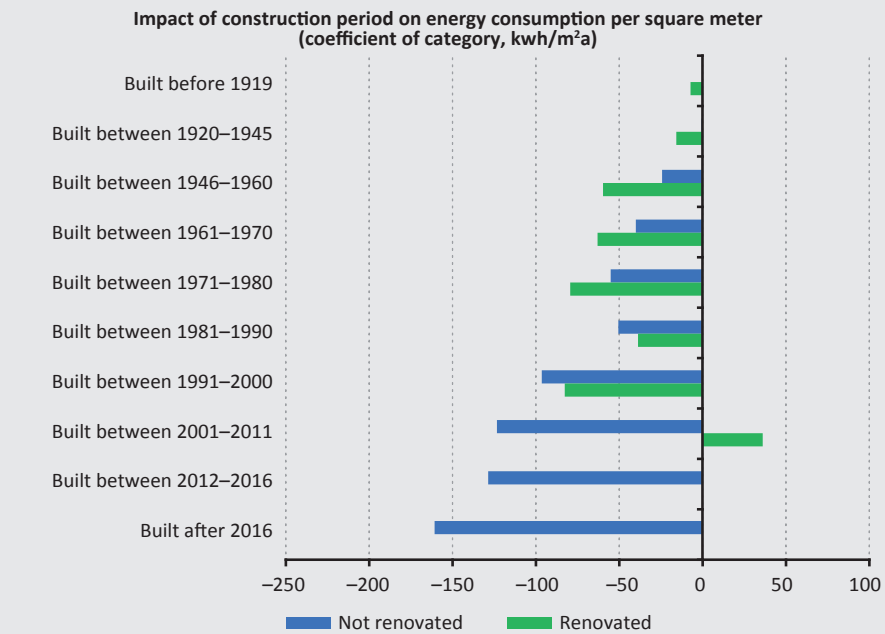
Beyond the general fitting characteristics, it is worth highlighting the magnitude of some estimated coefficients. In the building typology used in the Long-Term Renovation Strategy, the period of construction of buildings plays an important role. The coefficients for the periods defined in the Microcensus were also significant in our estimation (see *Figure 2*). The energy consumption per square metre of modern buildings can be up to 200 kWh/m^{2}a lower than that of old buildings. The differences are slightly larger for detached houses than for condominium flats. Renovated dwelling units show a 50–100 kWh/m^{2}a lower energy consumption compared to non-renovated units. This estimated impact is larger if the building is older and more outdated, and statistically almost negligible in our database if the building is post-2000. For condominiums built after 2000, the coefficient is not significant due to the low number of units.

Figure 2
Estimated coefficients for the year of construction in the OLS regression explaining energy consumption per square metre

a) Detached houses



b) Condominiums



Source: Calculated based on the merged database

In terms of geographical variables, it is worth highlighting the higher energy consumption of real estate in the Northern Hungary and Northern Great Plain regions compared to other regions. It can be assumed that the unobserved real estate characteristics in these parts of the country are also worse than in other regions, because the owners have less money to spend on construction and maintenance. These coefficients explain an average difference of about 35 kWh/m^{2}a between the categories.

Condominiums built with panel technology require around 20 kWh/m^{2}a less energy than the average condominium.

The energy demand of homes without hot water supply from pipeline is much higher, reflecting the impact of other factors such as outdated construction and neglect. The proportion of dwellings without hot water in the sample is 4.5 per cent of the total dwelling stock.

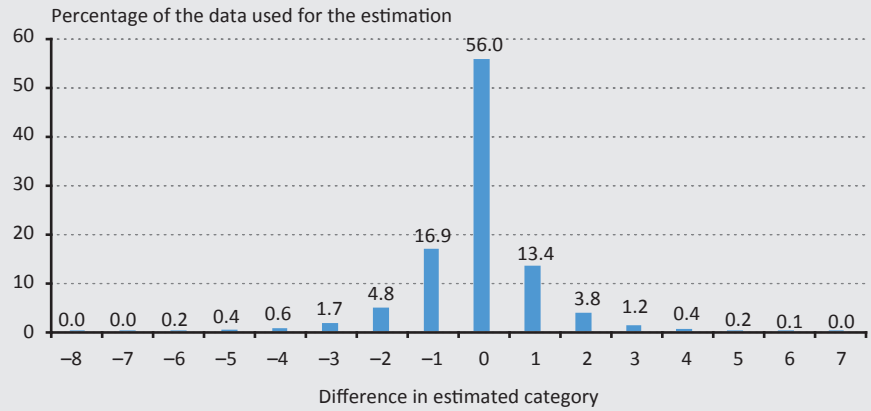
The coefficients of the regressions and the standard errors of the estimates are given in *Annex 2*.

2.3. Fitting a random forest model

Since the aim of our work is to estimate as accurately as possible the calculated energy demand based on the dwelling characteristics in the Microcensus, we also used a popular model in the field of machine learning. We chose random forest, which can capture more flexible relationships in terms of function shape and interactions than OLS. The model incorporates the explanatory variables listed in *Section 2.2.*

The algorithm grew 1,000 trees, with a minimum depth of 5 for each tree, and no limit on the maximum depth was set. The results obtained from the algorithm were tested on both teaching and test sets. The results of fitting are again presented in *Figure 3* based on the estimation of categories. Our model is at most one category wrong in 86 per cent of the cases.

Figure 3
Errors of the random forest model explaining the energy consumption per square metre by category difference



Note: Positive numbers: the energy consumption per square metre predicted in the estimation falls into a worse category than the actual certificate (AA–BB categories are combined).

Source: Calculated based on the merged database

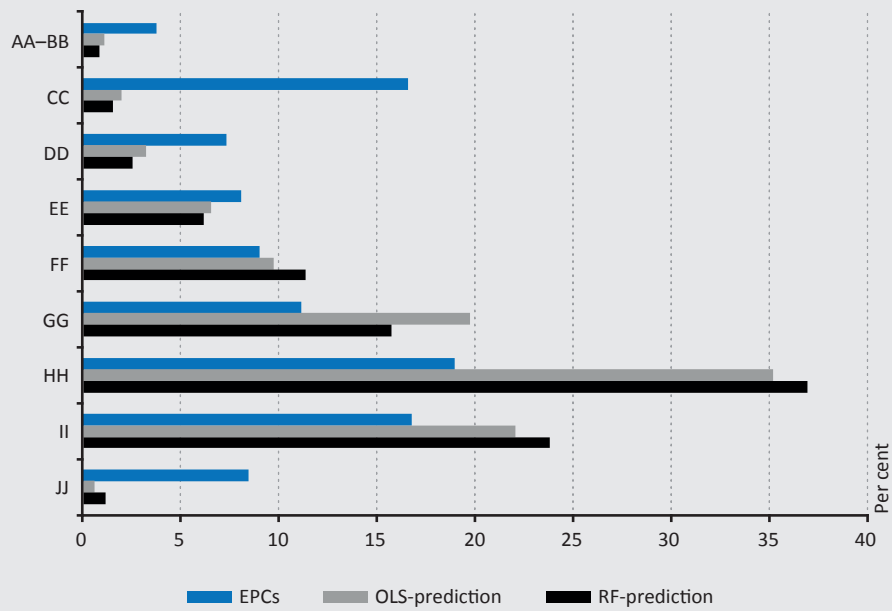
3. Results on the energy performance of the Hungarian dwelling stock

3.1. Estimates on the dwelling stock

After estimating the relationship between the energy demand and dwelling characteristics, the relationship was used to estimate the energy demand of dwellings for which no energy performance certificate data were available. Thus, using the original weighting of the Microcensus, an estimate was made for the energy consumption per square metre for the approximately 4.5 million residential real estate units in Hungary. The estimated distributions are similar for the OLS and random forest methods, but both show a less favourable picture than the certificates issued. This result is not surprising, as the real estate units that come on the market are generally better than the stock as a whole. This is mainly because energy performance certificates are issued for all new real estate, and roughly half of this (except for owner-occupied real estate) is put on the market. Another difference in the composition of certificates is that condominiums in large cities change hands more often and are therefore more likely to be certified than detached houses in small towns. However, our statistical method allows us to quantify this difference. While the most common category among the certificates issued is *CC*, the most common category in the stock is probably *HH*. This distribution is mainly the result

of the dominant *HH* category among detached houses. In the case of detached houses, category *II* is also frequent, with an estimated number over 650,000 of such houses in Hungary, while the *GG* and *HH* categories include approximately 1.5 million houses out of 2.8 million detached houses. Although the *AA–BB–CC* category accounts for 20 per cent of the certificates, the projection for the stock shows that only 3 per cent of detached houses in Hungary are in the "modern" or better energy category (*Figure 4*).

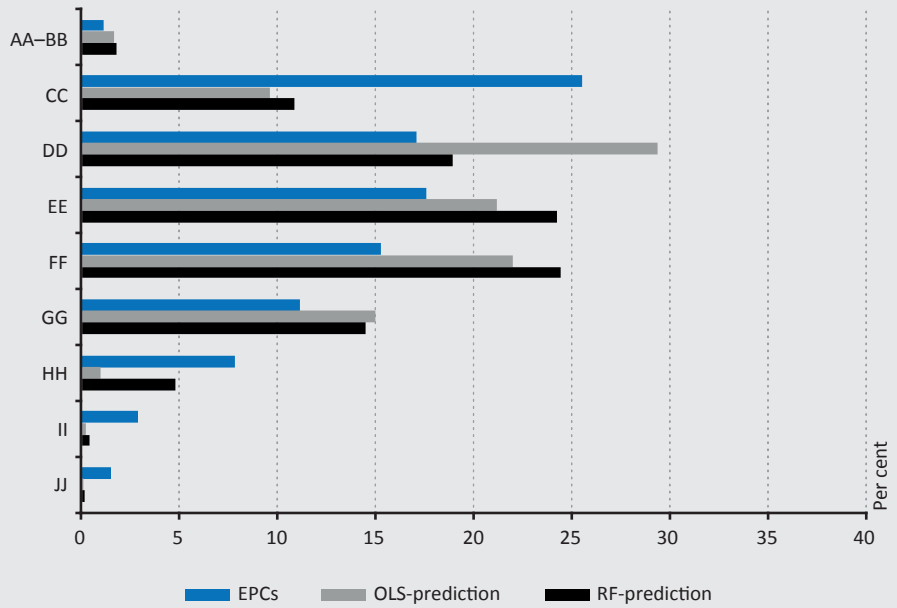
Figure 4
Estimated energy classification distribution of the Hungarian residential real estate stock, detached houses



Source: Calculated based on the merged database and the Microcensus

In the case of condominium flats, the estimation and the projection redraws the distribution shown by the certificates to a slightly less pronounced degree (*Figure 5*). The proportion of real estate that is at least "modern" (categories *AA++, AA+, AA–BB–CC*) can be estimated at over 10 per cent. The *DD–HH* categories show characteristics in lesser proportions. The difference between the OLS and the random forest procedure mainly appears in the *DD* and *HH* categories, which reaches 10 per cent in the case of *DD*. This surplus occurs at the expense of the *EE* and *FF* categories in the distribution of the condominium category.

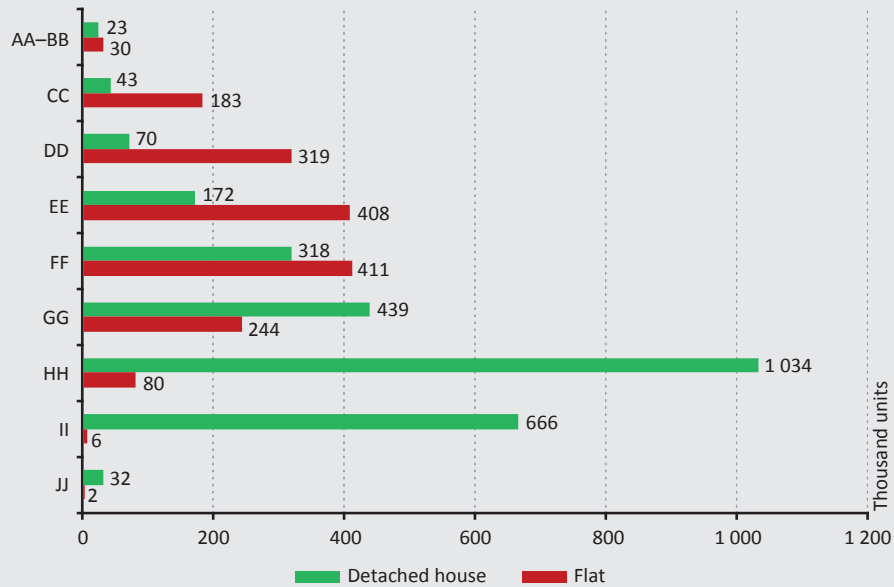
Figure 5
Estimated energy classification distribution of the Hungarian residential real estate stock, condominiums



Source: Calculated based on the merged database

According to the OLS estimation, the most common category for flats is *DD*, which is the "close to modern" rating. Based on the Random Forest procedure, the *EE* and *FF* categories are the most typical among condominiums (see *Figure 5*). The following *Figure 6* combines the RF estimates for the two property types. The distribution between categories shows a striking difference between houses and flats. It is instructive that we estimated 280,000 Hungarian residential real estate in the "modern" category (*CC* and above).

Figure 6
Estimated energy classification distribution of the Hungarian houses and flats



Source: Calculated based on the merged database

3.2. Estimates for the best 15 per cent limit

Since the projections assign an energy demand to every domestic residential real estate unit, the method is suitable for answering any question related to distribution. In the Taxonomy rules, the limit of the best 15 per cent plays an important role, so these data are published in *Table 6*. The OLS estimate puts the limit for the best 15 per cent of residential real estate slightly lower in terms of energy efficiency (total primary energy demand: 149 kWh/m^{2}a). While for flats the OLS and the random forest estimates predict almost identical limit values, for houses the OLS estimate is 9 kWh/m^{2}a lower.

There are differences also in the geographical distribution. The limit value for houses is the lowest in Budapest. For flats, Southern Transdanubia shows even lower values than the capital. The highest limit values for houses are shown in the table in Northern Hungary. The highest values for flats are in Northern Hungary (OLS) and Northern Great Plain (RF).

The difference between the lowest and highest values can be as much as 100 kWh/m^{2}a for houses, while for flats it is around 20–30 kWh/m^{2}a.

Table 6
Limit of the lowest 15 per cent in terms of estimated energy demand in the Hungarian stock for the prediction based on OLS estimation and random forest (RF) (total primary energy demand, kWh/m2a)

Region	RF			OLS		
	House	Flat	Total	House	Flat	Total
Budapest	169.9	128.8	132.1	153.8	130.6	131.6
Pest county	178.0	132.0	163.0	174.1	129.4	156.0
Central Transdanubia	217.6	143.0	164.6	215.5	138.0	150.2
Western Transdanubia	198.4	143.7	161.5	186.5	137.4	150.5
Southern Transdanubia	251.6	112.8	164.0	233.6	119.9	142.3
Northern Hungary	264.2	144.7	186.8	263.7	148.2	182.6
Northern Great Plain	255.0	152.6	184.5	246.9	144.6	176.0
Southern Great Plain	262.0	135.0	185.7	247.1	136.8	169.0
Country level	222.9	133.3	160.3	214.0	133.6	149.4

Source: Calculated based on the merged database

4. Discussion

The estimates of the domestic building stock in the National Building Energy Performance Strategy and the Long-Term Renovation Strategy are based on 23 building types. Compared to this, in this study we have estimated the energy condition of domestic residential buildings using much more detailed estimation and statistical methods. A more detailed estimate also gives an idea of the relationship between the energy demand and some characteristics of the real estate. Projection to the whole stock is also suitable for displaying geographical and distributional characteristics.

Unfortunately, comparing our results internationally is very difficult. This is due to the limitations of the databases available to researchers, as explained in the introduction. This is particularly true for Hungary's neighbours, and more broadly for the countries that joined the EU in 2004, which we believe may provide a more relevant basis for comparison, both in terms of housing construction traditions and climatic conditions, than, for example, Scandinavian or Mediterranean countries. On the other hand, this fact underlines the innovative nature of our research and its contribution to the assessment of the energy status of the Hungarian residential real estate stock, and makes it suitable to inform domestic decisions on EU Taxonomy.

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Annexes

Annex 1: Microcensus 2016 – Dwelling Questionnaire

The questions and response options contained in the electronic Dwelling Questionnaire

The correct address of the dwelling

1. What is the type of the building?
− family house, 1–3 dwelling residential building
− residential building of 4 or more dwellings
− holiday resort
− not residential building (e.g. public institute, office building, factory building)

2. What is the type of the housing unit?
− dwelling (family house as well)
− holiday home
− other (e.g. shop, caravan)

3. When was the dwelling built?
− before 1919
− 1919–1945
− 1946–1960
− 1961–1970
− 1971–1980
− 1981–1990
− 1991–2000
− 2001–2011
− in 2012 or later
− not known

4. What was the dwelling built of?
− brick, stone, manual walling element
− middle or large block, cast concrete
− panel
− wood
− adobe, mud, etc. with solid basement
− adobe, mud, etc. without solid basement
− other
− not known

5. How is the dwelling used?
− habitually, for everyday life as a home
− seasonally only or as a second home
− for other purpose (e.g. office, doctor's office)
− vacant dwelling, no occupants

6. Owner of the dwelling:
− natural person(s) of Hungarian citizenship
− natural person(s) of foreign citizenship
− local government
− other institution, organisation (e.g. company, enterprise, church)

7. What is the total floor space of the dwelling?

Do not count the size of the cellar, attic, garage, open balcony or terrace. If the dwelling has more than one floor, consider all the floors.

…m^2

8. Rooms of the dwelling:

Multi-purpose rooms must be divided by use (e.g. American kitchen into kitchen and room).

8.1. number of rooms over 12 m^2 (e.g.: living room, bedroom, dining room): …
8.2. number of rooms of 12 m^2 or smaller (e.g.: living room, bedroom): …
8.3. number of kitchens of 4 m^2 or larger: …
8.4. number of kitchenettes under 4 m^2: …
8.5. number of bathrooms: …
8.6. number of flush toilets (in bathroom or separately): …

9. Type of

9.1. water supply in the dwelling
− from public pipeline
− from private pipeline (e.g.: from well by pump)
− no piped water in the dwelling

9.2. hot water supply in the dwelling
− from pipeline
− from electric or gas boiler, kitchen water heater or other way
− no hot running water

10. Sewage disposal from the dwelling
− into a public sewer
− into private sewer (closed reservoir, cesspit)
− into another place or there is no sewage disposal

11. Heating
− separately for each room with convector, stove, etc.
− one dwelling heated by boiler (central, circle) or other device
− more dwellings of a building heated by boiler (central, circle) or other device
− district (block) heating
− no heating

12. Energy used for heating – Two answers can be given.
− piped gas
− LPG gas (container)
− LPG gas (bottle)
− wood
− coal
− electricity
− fuel oil
− alternative energy, namely (e.g. solar energy, geothermal energy): …
− other, namely: …

13. In the last 10 years what kind of maintenance, renovation or updating works have been done in the dwelling?

In case of a building of more dwellings, consider also insulation, renovation works on the building.

13.1. interior decoration, painting, wallpapering: yes/no
13.2. changing or repairing tile, floor-tile: yes/no
13.3. insulation (e.g. insulating walls, joist, floor): yes/no
13.4. exterior renovation (e.g. painting, whiting): yes/no
13.5. installing new meters (do not consider changing meters): yes/no
13.6. replacing mechanical installation (e.g.: radiator, electric boiler, air-conditioner): yes/no
13.7. installing air-conditioner: yes/no
13.8. installing public utilities (e.g.: gas, drainage system): yes/no
13.9. forming new rooms or other parts of dwelling (e.g. building bathroom, increasing the number or size of rooms, attic conversion): yes/no
13.10. changing doors, windows: yes/no
13.11. other renewing works in the dwelling, namely: …

Annex 2
Results of the OLS prediction

Explained variable: Energy consumption per square metre in the energy performance certificate

	Detached house		Condominiums	
	Coefficient	Standard error	Coefficient	Standard error
Constant	462.072***	1.842	433.484***	3.486
Pest county	–4.938***	0.699	–17.542***	1.014
Budapest	–33.199***	1.020	–27.720***	1.530
Central Transdanubia	–3.795***	0.746	–9.029***	0.759
Western Transdanubia	–14.608***	0.716	–6.188***	0.762
Southern Transdanubia	–22.252***	0.763	–24.679***	0.780
Northern Hungary	3.676***	0.693	1.577**	0.689
Northern Great Plain	–10.217***	0.702	–6.931***	0.751
Southern Great Plain	–4.047***	0.426	–5.062***	0.900
Built between 1920–1945	10.029***	1.303	–0.748	1.039
Built between 1946–1960	16.039***	1.249	–24.511***	1.092
Built between 1961–1970	10.027***	1.256	–40.108***	0.928
Built between 1971–1980	–0.864	1.322	–55.087***	0.865
Built between 1981–1990	–56.754***	1.378	–50.903***	0.941
Built between 1991–2000	–116.697***	1.460	–96.681***	1.170
Built between 2001–2011	–175.683***	1.417	–123.356***	0.941
Built between 2012-2016	–195.378***	3.023	–129.133***	3.791
Built after 2016	–227.622***	1.265	–161.130***	1.006
Built before 1919, renovated	–28.045***	2.381	–0.406	1.551
Built between 1920–1945, renovated	–41.298***	2.255	–8.169***	1.548
Built between 1946–1960, renovated	–25.855***	2.231	–28.685***	1.230
Built between 1961–1970, renovated	–46.569***	2.256	–16.455***	1.066
Built between 1971–1980, renovated	–21.577***	2.283	–17.909***	1.165
Built between 1981–1990, renovated	–0.363	2.389	18.856***	1.998
Built between 1991–2000, renovated	34.518***	2.452	20.296***	1.904
Built between 2001–2011, renovated	23.898***	4.876	166.359***	9.697
Concrete walls	–1.041	0.898	–6.310***	0.552
Other walls	2.752***	0.512	1.999	1.507
Panel walls	–89.733***	4.162	–20.631***	0.561
Heating separately for each room with convector, stove, etc.	–39.615***	0.460	–29.993***	0.515
More dwellings of a building heated by boiler (central, circle) or other device	–64.345***	1.227	–43.190***	0.629

Annex 2
Results of the OLS prediction

Explained variable: Energy consumption per square metre in the energy performance certificate

	Detached house		Condominiums	
	Coefficient	**Standard error**	**Coefficient**	**Standard error**
District (block) heating	–49.669***	2.459	–58.655***	1.035
Hot water supply from pipeline	–16.304***	2.471	–87.709***	3.144
Hot water supply from electric or gas boiler, kitchen water heater or other way	23.250***	1.024	–90.057***	3.104
Dwelling area	–0.538***	0.012	–0.379***	0.012
Square of dwelling area	0.001***	0.000	0.001***	0.000
Region centre dummy variable (Debrecen, Pécs, Szeged, Győr, Miskolc)	–24.567***	0.844	–21.186***	1.434
Towns with County Rights dummy (non-region centre)	–20.168***	0.682	–16.357***	1.419
City/Town	–8.629***	0.420	–8.269***	1.412
Renovated	–27.416***	2.042	–6.680***	0.917
Has air-conditioning	–25.318***	0.587	–2.959***	0.404
Heat pump	–24.445***	1.530	–26.355***	1.523
Centralised ventilation	–3.054**	1.239	3.511***	0.887
Solar panel	–0.141	3.503	13.538***	2.884
Alternative energy (solar energy, geothermal energy, other)	–31.003***	2.628	–28.681***	2.243
Percentage of residents with a tax base of over HUF 5 Million in the municipality	–1.091***	0.088	0.227**	0.104
Tax base per capita in the municipality	–0.002	0.001	–0.006***	0.002

*Note: Significance: ***: 1%, **: 5%, *: 10%*

Source: Calculated based on the merged database

A New Vision for Electronic Payments in Hungary – the Payments 2030 Strategy*

Vivien Deák – Kristóf Takács

In this feature article, key elements in the development of payments in Hungary are presented and the challenges ahead are highlighted in light of the changes observed over the past 10 years. The recently published new electronic payments strategy of the Magyar Nemzeti Bank and the 18 indicators in the Payments Development Indicator Set, which is based on a wide range of data at the MNB's disposal to monitor the achievement of the targets, are presented. The MNB's main strategic goal for payments by 2030 is to achieve a 60 per cent ratio of electronic transactions in the overall economy, or, with targeted measures, even two thirds.

1. Introduction

On 30 May 2023, the Magyar Nemzeti Bank (MNB, the Central Bank of Hungary) published its new electronic payments strategy entitled Payments 2030 (*MNB 2023*). Based on the development of domestic electronic payments over the past decade, the MNB found that a new vision was needed in this area to maintain the current growth rate in the ratio of electronic transactions. To this end, it set new, measurable targets and identified areas for improvement, announced the development of 2–3 year action plans based on such, and will continuously measure and evaluate progress in these areas. The objectives for the development of electronic payments are in line with those for the security of cash supply. The MNB aims to provide a user-friendly electronic alternative to cash in all situations and to reduce asymmetric information on payment alternatives, as this will boost the ratio of electronic transactions and thus create a better distribution of payment methods from the aspect of society.

This feature article first reviews the MNB's objectives in the field of electronic payments and its previous payments strategy and then the developments and experiences in the past 10 years, supported by data. This is followed by a presentation of the pillars and objectives of the new payments strategy as well as the Payments Development Indicator Set, which allows the identification of areas

* The papers in this issue contain the views of the authors which are not necessarily the same as the official views of the Magyar Nemzeti Bank.

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This feature article is based on the publication *Payments 2030 – The payments strategy objective of the MNB and the introduction of the Payments Development Indicator Set (PDIS)*, and summarises its key findings.

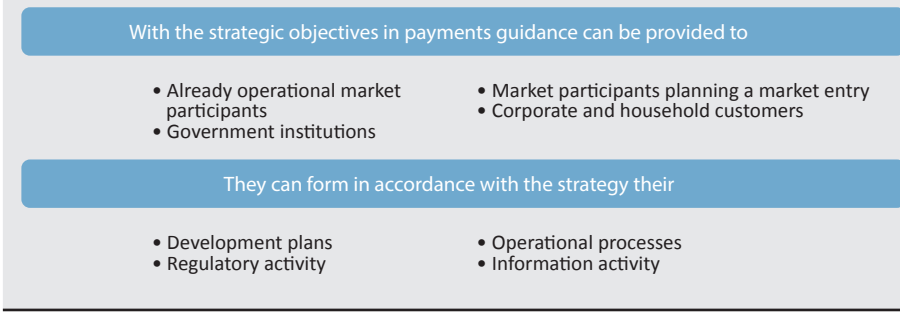
for improvement and the measurement of progress towards the targets. Finally, the key findings are summarised in the conclusion.

2. The MNB's motivations in the field of electronic payments

Electronic payments are a priority area for the MNB, as efficient, reliable and widely available electronic payment services are essential for the functioning of the economy. The wider use of electronic payments can support economic growth (*Ilyés – Varga 2016*), generally leads to higher GDP, trade, consumption and tax revenues (*Zhang et al. 2019*), and may reduce the social costs associated with payment transactions (*Schmiedel et al. 2012; Turján et al. 2012*) by reducing the manual processes required for cash payments and the need for face-to-face payment situations. In Hungary, the development of the payments infrastructure and the rapid growth in electronic payments led to a significant reduction in the social cost per transaction between 2009 and 2019 (*Deák et al. 2022*). In addition, easy-to-use, widely available electronic payment services support digitalisation processes emerging in all areas of life and help reduce tax evasion, thus contributing to increasing the competitiveness of the economy.

The motivation for the publication of the new payments strategy is that the development of electronic payments can only be achieved with the cooperation of stakeholders, and thus it is important that the MNB's development goals are clear to everyone. If they are clear to all stakeholders, they can adapt their own activities accordingly (*Figure 1*). Hence, the actors of the financial sector can base their own development plans and business objectives on the MNB's development strategy, new market entrants can define their business model accordingly, and public actors can take the payments development strategy into account in their regulatory activities or further public policy measures. These actors can thus actively participate in the design and implementation of the measures needed for development. In the future, the MNB will continue to work closely with these actors to successfully achieve the objectives defined in the strategy. It is also important that household and corporate customers are informed about the planned measures, as their activities may also be affected by the operation, availability and pricing of payment services. For example, a sales process is fundamentally determined by the way in which customers are able to deliver their payments to the companies and with what processing time.

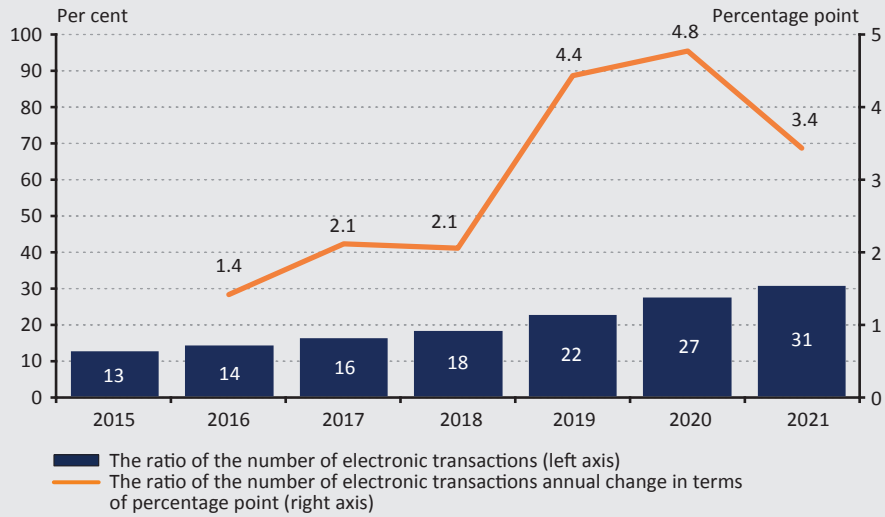
Figure 1
Actors involved in the MNB's payments development strategy



3. The previous payments strategy of the MNB and the development of payments in Hungary over the last 10 years

In order to increase the ratio of electronic transactions, the MNB had two objectives over the past decade: to enable electronic payment in all situations and to encourage the use of electronic payment solutions. This previous strategy resulted in a significant improvement in the payments infrastructure, and thus the first objective was met. Within this, the card acceptance network has seen a major expansion, both in shops and in online commerce, and the payment card contactless technology became widely used. By the end of 2021, 93 per cent of cards and 99 per cent of terminals were able to handle this solution. The processing of credit transfers accelerated significantly, and instead of the next working day, the transferred amount now reaches its destination within five seconds. Furthermore, additional functions related to instant payment, such as the service of request to pay, the management of secondary identifiers or the QR code payment option, ensure that the credit transfer service can be used in many new situations beyond the cases traditionally paid by credit transfer. It is now possible to pay electronically in addition to cash in virtually all payment situations, and electronic payment solutions, similarly to cash, are continuously available, allow instant processing and in many cases offer the added benefit of allowing payments to be made without the need for a personal presence. Significant progress was also made towards the target of usage stimulation, with a wide range of customers now using electronic payment services at least occasionally, with 80 per cent of the population using at least one of these solutions in 2020 (*Deák et al. 2021b*). As a result, the ratio of electronic transactions in the overall economy increased significantly, rising by 3–5 percentage points annually since 2019 to reach 31 per cent in 2021 (see *Figure 2*).

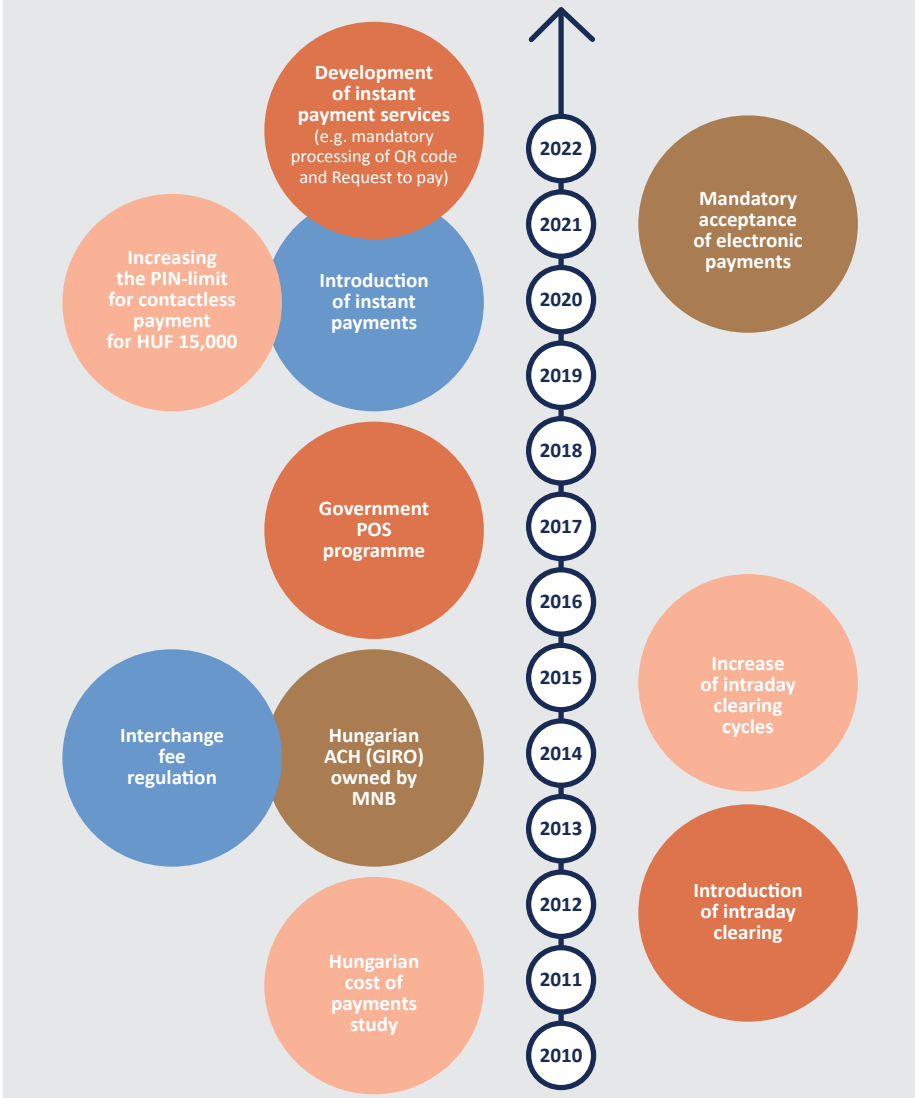
Figure 2
Ratio of the number of electronic transactions, and its annual change in percentage points in the total economy



Source: MNB (2023): p. 7

The achievement of these objectives was supported by a number of measures, in the design and implementation of which the MNB actively participated in several of its roles (*Figure 3*). In the area of payment card infrastructure, these included for example the regulation on interchange fees (*Kajdi – Kiss 2021*), resulting in a reduction of costs for merchants, programmes supporting the installation of POS terminals and the amendment of the Act on Commerce, which required shops that are obliged to use online cash registers to provide the possibility of electronic payment from 2021. With regard to credit transfers, the introduction of intraday settlement in 2012 and instant payment in 2020 led to major improvement and increased usage possibilities. The MNB initiated developments in a number of cases and supported their successful implementation by facilitating coordination among stakeholders. It was also directly involved in the development of the credit transfer infrastructure as the owner of GIRO Zrt. In its regulatory role, the MNB developed and made recommendations to other regulatory actors to formulate legal regulations that support the uptake of electronic payments. It is important to highlight that the adoption of electronic payments was significantly influenced by the coronavirus pandemic and the changing shopping habits both internationally (*Tut 2023; Jonker et al. 2022; ECB 2020*) and in Hungary (*Deák et al. 2021a*), due to the general digitalisation trends.

Figure 3
Key steps in the development of payments in Hungary in the last decade

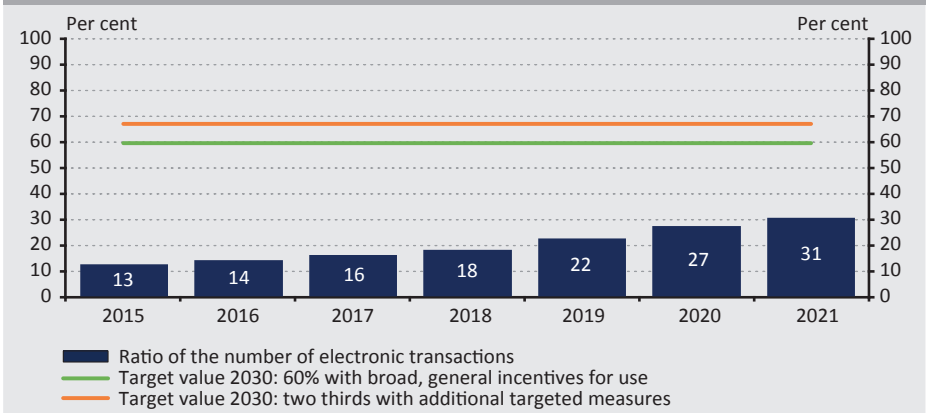


Source: MNB (2023): p. 9

3. The MNB's main payments strategy objective for 2030 and the areas of intervention identified to achieve it

By 2030, the MNB aims to achieve a ratio of electronic transactions of at least 60 per cent in the entire economy, in the case of an extensive, general usage stimulation and a ratio of at least two thirds with further targeted measures (*Figure 4*). Despite the progress in the last decade, there are still factors in some groups or payment situations that hinder the widespread use of electronic payment solutions. As a consequence, there are significant differences in the use of electronic payments: for example, while the ratio of electronic transactions for bill payments was 71 per cent in 2021, the ratio in shops using online cash registers was only 29 per cent. To remove the various hindering factors, new targets for electronic payments needed to be set, with a focus in the coming period on improving the awareness and knowledge of customers using the services and on stimulating their usage. In this area, it is possible, as in the past, to carry out expansive general usage stimulation activities targeting a wide range of payment situations and customers. In addition to these, there is also a need for usage stimulation activities that target specific areas of payments, aiming at specific payment situations or small groups of customers. It is important to note that the indicator measuring the achievement of the main strategic objective takes into account the total number of transactions in the economy as a whole, i.e. the number of purchases in shops and online, bill payments and transactions within and between different sectors (households, enterprises and public actors).

Figure 4
Ratio of the number of electronic transactions within the total payments



Note: MNB estimate based on the online cash register database of the National Tax and Customs Administration of Hungary, regular bank data provision and questionnaire surveys

Source: MNB (2023): p. 31

In order to achieve the main strategic goal, the MNB has identified seven areas where intervention is needed in the coming years, and further measurable targets have been set in the Payments 2030 strategy. Within these, areas that contribute directly or indirectly to development can be distinguished (see *Figure 5*). Those areas where interventions contribute indirectly to the achievement of the objective tend to promote the widespread use of electronic payment methods more slowly, over the medium term, and their impact is broad and may affect several areas. In addition, there are areas that have a direct and shorter-term effect on the achievement of the main objective.

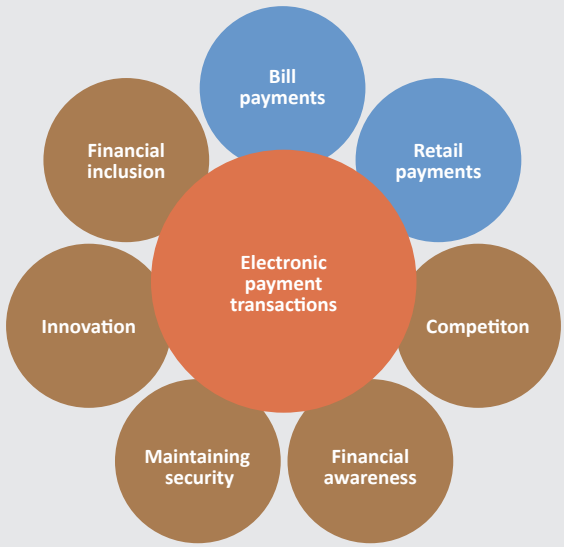
Areas that contribute indirectly to development:

- *Targeted improvements in financial inclusion*, both to further increase the number of potential users of electronic payment methods among the unbanked and to increase the activity of those who already have access.
- *Strengthening payments innovation* to accelerate the uptake of innovative payment methods and thereby encourage further improvements in payment services provided by market operators.
- *Strengthening competition,* which can both support innovation in the market and have an impact on the ability of customers to use modern payment solutions at lower costs.
- *Improving financial awareness,* which can improve access to services and increase the intensity of use as well as contribute to reducing consumer costs.
- *Maintaining security,* which is essential to maintain trust in electronic payment services and thus achieve widespread use.

Areas that contribute directly to development:

- *Development of retail payments* enabling a significant volume of cash transactions – up to several billions per year – to be replaced by electronic transactions both in-store and online.
- *Strengthening electronic bill payments,* through which operational efficiency can be further improved and the costs for service providers can be reduced, especially in the utilities sector.

Figure 5
Areas that support the achievement of strategic objectives



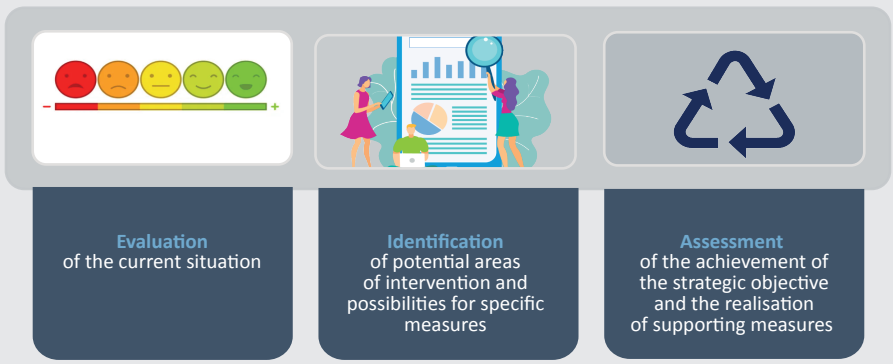
Note: In the figure, areas that may have a direct impact on the ratio of electronic transactions are shown in blue, and areas that may have an indirect impact are shown in brown.

Source: MNB (2023): p. 20

4. Payments Development Indicator Set

One key element of the Payments 2030 strategy is the Payments Development Indicator Set (*PDIS*)*, the main objective of which is to use the available data to evaluate the current situation of the Hungarian payments, identify potential areas of intervention and possibilities for specific measures, and assess the achievement of the strategic objective and the realisation of supporting measures* (*Figure 6*). In order to set up the PDIS, data from payment service providers, which are regularly collected for the MNB's central bank tasks, the online cash register database of the National Tax and Customs Administration and other ad-hoc surveys of the MNB were also used. In developing the indicator set, the MNB first assessed the current situation of domestic payments by examining the data in as much detail as possible. Building on this, the potential areas of intervention and specific options for measures were then identified more precisely. In addition, it is important to measure the achievement of the strategic objective and implementation of the supporting measures, and the indicator set will facilitate this on an annual basis, and, if necessary, new targeted measures will be formulated.

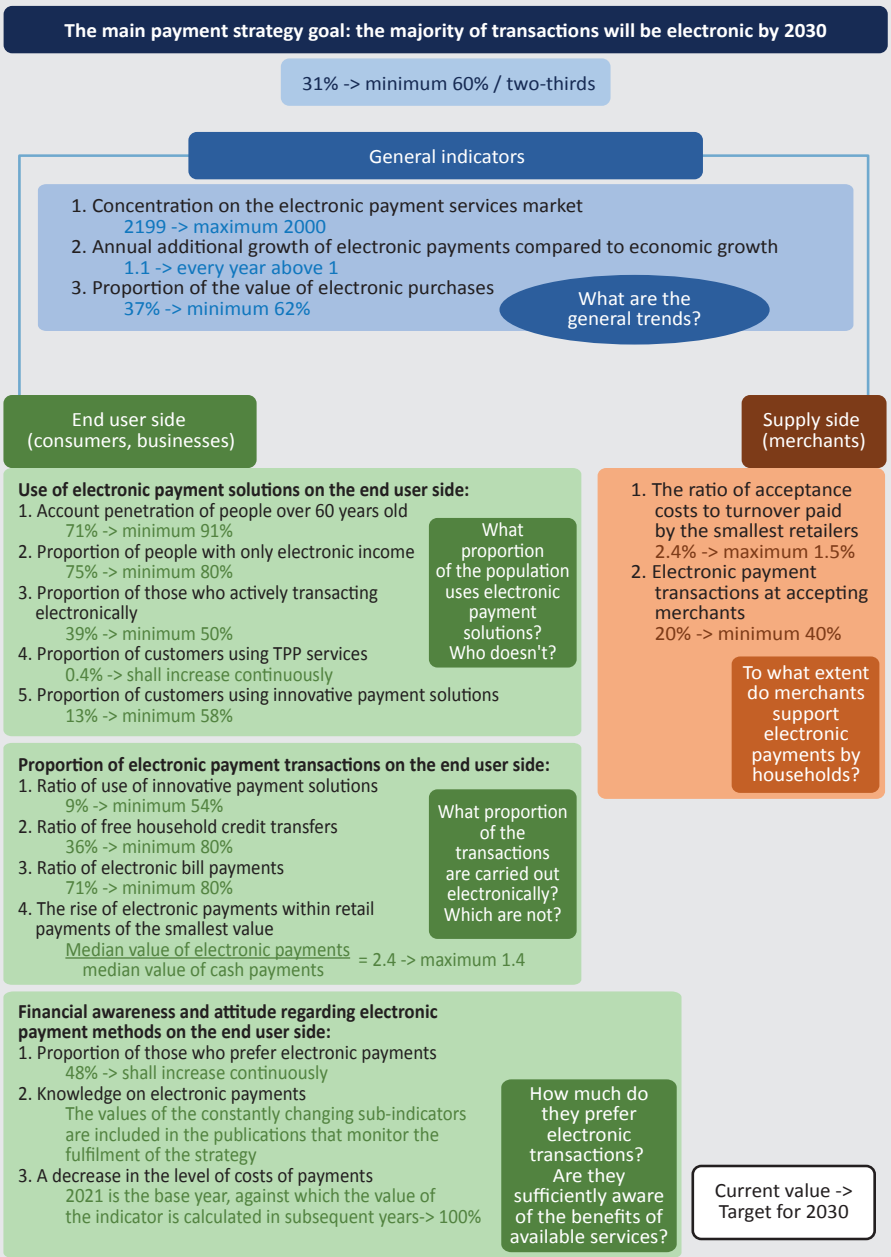
Figure 6
Objectives of the Payments Development Indicator Set (PDIS)



The indicator set consists of 3 indicator groups and 18 indicators. It includes general, end user and supply side indicators (*Figure 7*). The general indicators monitor overall trends and broader development of payments. The end user side indicators track the usage ratios of services available to consumers and businesses, ratios by transaction type and different attitudes and levels of financial awareness, while the supply side indicators measure the utilisation and costs of the acceptance network.

The MNB developed indicators that track the areas where improvement is needed, and thus a target is set for each of these areas, alongside the current value. In the assessment of the current situation, the final indicators were developed by selecting the areas for improvement, i.e. the areas where no intervention is needed on the basis of current information, such as the wide acceptance network for card payments or the retail account and cardholder coverage, are not taken into account. For most of the indicators, the MNB used the most recent full-year data available at the time of publication as the current situation, which in most cases means 2021 and for some indicators 2020. In addition, where available, the publication includes historical values of the indicator to give readers a clear picture of the trends in the area. In most cases, international comparisons of indicators are not possible, because much of the data required is not publicly available for other countries, and in some cases data sources similar to the domestic data are not even available.

Figure 7
Indicators of the Payments Development Indicator Set (PDIS)



Note: The figure shows the general indicators in blue, the end user side indicators in green and the supply side indicators in brown.

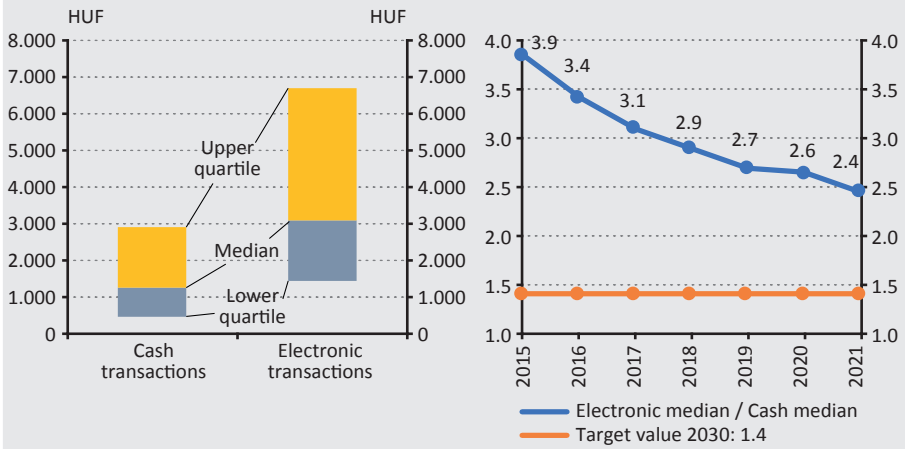
Source: Compiled based on the data in the figure on p. 28 and in the table on p. 53 in MNB (2023)

For each indicator, in addition to defining the current and target values, the content of the indicator, how it is calculated and why progress in the area is important from a public policy perspective are described in detail, along with its impact on the main objective of the payments strategy. The indicators have also been designed to be future-proof, so that future technological and business changes can be properly handled by the calculation method and the area can be well analysed in time series. Accordingly, in most cases, the indicators are independent of the payment solutions currently in use and aggregate the information, in order to be able to evaluate the use of emerging services in the future. In addition, for each indicator, a precise description of the data and the calculation methodology is provided to ensure that the indicator and associated targets are clearly understood, and this is supported by the graphs showing current values and target values.

As an illustrative indicator, it is worth taking a look, for example, at the indicator "The rise of electronic payments within retail payments of the smallest value". We see that higher value purchases have a higher ratio of electronic payments, and the highest cash ratio is therefore found for the smallest purchases with a value of less than HUF 5,000.[1] Moreover, it is these low-value transactions that dominate, with more than 80 per cent of all transactions falling into this category in 2021. This is why it is important to monitor and develop this area, as the more frequent use of electronic solutions for low-value payments can significantly increase the ratio of electronic transactions in the overall economy. Given the need for an indicator that is appropriate even several years from now to filter out the impact of inflation, the ratio of the median value of electronic transactions to the median value of cash transactions can be used to measure the rise of electronic payments within retail payments of the smallest value (*Figure 8, left panel*). In 2021, the value of this indicator was 2.4, and *the right panel of Figure 8* shows that over the years customers have started to use electronic payments more and more for low-value payments, as the value of the indicator was only 3.9 in 2015. In this indicator, the electronic and cash transactions in the online cash register database performed mostly in physical payment situations, are examined.

[1] The latest information on this can be found in the Payment System Report 2023: https://www.mnb.hu/letoltes/mnb-payment-systems-report-2023-final.pdf

Figure 8
Top quartiles of cash and electronic transactions in 2021 and median ratio of electronic and cash payments from 2015 to 2021



Note: MNB calculation based on tax registry data.

Source: MNB (2023): p. 45

5. Conclusion

The development of domestic electronic payments over the last decade has led to the need for a new vision for electronic payments, which the Magyar Nemzeti Bank summarised in the document "Payments 2030". It also forms the basis for specific measures to be defined later. The MNB's main strategic goal for payments is to achieve a 60 per cent share of electronic transactions in the economy as a whole by 2030, if widespread, general usage is encouraged, and up to two thirds if further targeted measures are taken. The MNB also created the Payments Development Indicator Set, in order to evaluate the current situation of Hungarian payments, identify potential areas of intervention and possibilities for specific measures, define strategic objectives and evaluate the implementation of the necessary measures to achieve the objectives.

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"*Respect the past so that you can understand the present and work on the future.*"

István Széchenyi

A Retrospective on the Early Period of the German Social Market Economy*

Bence Varga

During the 1950s and the first half of the 1960s, the social market economy produced significant long-term prosperity for German citizens, even though not only welfare measures were introduced in the early period. While from the second half of the 1960s the paradigm of the social market economy could no longer produce adequate answers to the emerging challenges (stagflation, impact of changing circumstances in the world economy), its main pillars, such as its "social" character, social responsibility and its aspects of sustainability, cannot be disregarded in other, dissimilar socio-economic systems either. In this article, we outline the operating model of the German social market economy and draw the conclusions applicable to our own era.

1. Introduction

We have already seen numerous examples of economic and social challenges in the 21st century. In relation to the handling of these challenges, the question arises about the extent to which such measures have been or will be successful in solving the emerging problems, or whether perhaps they themselves contribute to the rise of other, different types of problems. *We have seen that achieving and maintaining price stability, developing the right economic policy and finding a sustainable path for growth and development constitute an increasingly difficult challenge in our time, not only in Hungary but at the international level as well.* In response to the increasing number challenges (the importance of which is by no means diminishing), we would be well advised to revisit some earlier trends and paradigms, which (though obviously not as permanent solutions) successfully coped with the challenges appearing in their own time. It will be exactly 60 years ago this year that Ludwig Erhard (1897–1977) was elected Chancellor of Germany.

* The papers in this issue contain the views of the authors which are not necessarily the same as the official views of the Magyar Nemzeti Bank.

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He remained in office until 1966. Together with his predecessor, Konrad Adenauer, his policies played a decisive role in the practical implementation of the concept of the social market economy. It is also for this reason that we would like to offer a short introduction to Erhard's life and his most important measures, and provide an outline of the German model of the social market economy, which produced outstanding results in the 1950s and the early 1960s. We would also like to draw the relevant conclusions and lessons that may be useful in our own time.

Before reviewing the German programme of the social market economy, we need to briefly touch on the origins and development of the paradigm itself. While the basic idea of the social market economy originated in Germany of the 1930s, later members of the so-called Freiburg Circles and their followers (e.g. Wilhelm Röpke, Ludwig Erhard, Alfred Müller-Armack, Walter Eucken and others) tried to find a way out of the economic and moral crisis consequent upon defeat in the Second World War, keeping in mind the social requirements of German society. It was along these lines of thought that the theoretical framework for a social market economy was born. In contrast to the classical capitalist market economy and to a system based on planned economy, the theory offered a third solution – see Wilhelm Röpke, *Die Gesellschaftskrisis der Gegenwart* (The Social Crisis of Our Time), Hungarian title: *A harmadik út* (The Third Way). Röpke's book presents a kind of "intermediate state" between the two aforementioned economic systems (*Lentner 2015*), following ordoliberal notions, meaning principles based on order and state intervention, but upholding market principles. In his book, Röpke (1950) espoused the importance, among other things, of a humane society, the freedom of economic activity, the encouragement of market competition, the strict supervision of market actors, as well as (limited) state intervention. The principles of the social market economy concerning the market, the state and value systems differed significantly from the philosophical approaches of neoliberalism or those of the welfare state, because, while the social market economy essentially aims to create market competition as well as price regulation – a competition regulating state – inspired by the concepts of social partnership and individual responsibility, the neoliberal market economy promotes the freedom of contract, liberalisation and deregulation. In the latter approach, the state is a fundamentally inadequate proprietor; based on its value system, the aims can be identified primarily as the success of the individual, collective responsibility and marketisation (*Kocziszky 2023*). By contrast, the welfare state prioritises equal opportunity, equitable distribution of wealth and protection against social risks (Sandmo 1995) through the promotion and protection of the economic and social well-being of citizens.

The concept of the social market economy was first used in a study published in December 1946 by *Alfred Müller-Armack*, professor of economics at Cologne University, later Under-Secretary of State for Economic Affairs (*Glossner – Gregosz 2011*). The basis of the social market economy is a free, self-disciplined human being with a sense of responsibility and initiative, who strives to acquire private property and is able to fend for themselves. The human being as a free and independent citizen

is the ideal human exponent of the social market economy (*Diós – Viczián 1993*). Furthermore, it is important to note that, largely due to the influence of the Protestant pastor and theologian Dietrich Bonhoeffer, a Christian Social value system was also built into the paradigm of the social market economy. Thus, notions of "prosperity for all", social responsibility and the maintenance of healthy competition received special emphasis – even if, regrettably, these basic principles lost some of their importance in later decades. Reflecting on the above, *Erhard* (*1993:215*) who played a decisive role in the practical implementation of the social market economy, but not in the formulation of its theory, also underlined: *"Perhaps – I should like to say certainly – many of us in concentrating all our human energies in regaining and securing the material basis of our life may have gone wrong, and in so doing the sense of a true and proper scale of values has been lost."*

2. Ludwig Erhard, influential advocate of the German social market economy

Ludwig Erhard was born in 1897 in Fürth, a town close to Nuremberg, into a family of textile merchants. After elementary school, he became an apprentice in a textile shop in Nuremberg, which ended with his conscription into the army upon the outbreak of the First World War. He was seriously wounded by shrapnel at Ypres in western Belgium in 1918. Following his recovery, he continued his tertiary education in the Nuremberg Commercial College and subsequently studied economics and sociology at Goethe University in Frankfurt. He received his doctorate in 1925; in his dissertation he mainly investigated the economic schools discussing theories of value. He joined the Economic Observation Institute in 1928 and from 1945 he served as Minister for Economic Affairs in the Bavarian State Government. In 1947, he became responsible for the financial affairs of the united British-American Occupation Zones (Bizonia), where he, among other tasks, was charged with preparations for the currency reform of 1948 (introduction of the Deutsche Mark). From 1949 to 1963, he was the first Minister for Economic Affairs in the West German government and subsequently successor to Konrad Adenauer as Chancellor from 1963 to 1966. From the spring of 1966, for one year, he was Vice-President of the CDU (Christian Democratic Union of Germany). He died in 1977 in Bonn at the age of 80.

Ludwig Erhard's main work also appeared in Hungarian under the title *Jólétet mindenkinek* (*Prosperity for All*). The English title, *Prosperity Through Competition*, indicates perfectly that in Erhard's view the road to prosperity leads through competition. Therefore, his argument already ran counter to several schools of thought (for instance, those advocating monopolistic solutions). In his introduction written in 1957, the author warns that copying the methodology of achieving economic prosperity in Germany does not necessarily guarantee economic success in other countries. In light of the results of this policy – for instance, that by 1957 production had increased by nearly two and a half times compared to the pre-war

years, that industrial output rose sixfold following the currency reform, and that between 1949 (when the social market economy was introduced in the Western half of Germany) and 1957 more than 4 million homes were built with significant simultaneous increase in gold and foreign exchange reserves – it appears worthwhile to survey the main cornerstones of this economic programme. All the more so, since the economic problems and challenges facing Germany at that time, i.e. increasing and preserving the value of the currency, achieving price stability, formulating an economic policy in times of war, and sustaining economic growth are economic difficulties that we also face today in Hungary as well as the rest of the world.

3. The model of the social market economy in Germany in the second half of the 1940s and during the 1950s

In order to secure market competition, the German social market economy was characterised by a strong emphasis on the statutory regulation of monopolies. In the absence of such regulation, as Erhard puts it, the social market economy would quickly come to an end. "Prosperity for all" can only be achieved through the concept of "prosperity by means of competition". While the first maxim indicates the aim, the second identifies the road leading to it. At the same time, Erhard issues a strong warning against revolutionary reforms, which, in his view, may lead to "economic paralysis". (We would use the term "stagflation" today, but the concept had not yet been current at the time.) The word "social", as the first part of the concept of the social market economy, implies that those who cannot participate in production for reasons beyond their control (e.g. because of their age or illness or due to injuries suffered in war) should still be furnished with the means of creating the basic living conditions. Accordingly, social expenditures also grew significantly in the Western half of Germany: from 10 billion marks in 1949 to 21 billion in 1955, in which the pension reform introduced at this time played an important part. Due to the pension reform, the amount of the pensions disbursed rose significantly; thus the amount of pension contributions increased from 17.7 billion German marks in 1954 to 22.0 billion marks in 1956.

Erhard also rejected the planned economy and price regulation (he called the latter "price-frozen inflation") (*Erhard 1954*). As a first step, he recommended the introduction of a prudent budget policy involving budget cuts (e.g. a wage freeze, reducing the number of foreign trips to the necessary minimum, job cuts) and then he would only envisage tax cuts in line with increased revenues resulting from increased production. We need to call attention to yet another important change in taxation; the incentives that were introduced in order to increase industrial productivity. Extra income earned during overtime was exempted from tax in this scheme, and thus the total number of weekly hours worked increased from 39.1 hours in 1947 to 48.6 hours in 1954. A reduction can be seen in the figures by 1956 as the weekly number of hours worked by women and men decreased to 48.0 hours

as a result of a rise in the general living standards as well as in real wages. Erhard's view on early tax cuts was that even though the cuts may appear, in themselves, to make a positive contribution to economic reconstruction, in a later phase, due to conflicts with economic policy, they are more likely to hinder it. The temporary wage freeze, another highly controversial measure at first, also contributed to stabilisation in the long run. The result was that the general increase in price levels was not followed by a similar increase in wages. Because of this, the policy measure led to the general strike of November 1948, but in the long run it contributed to reducing inflation as it prevented a price-wage spiral. To measure inflation, the ministry regularly published a so-called "price mirror", in which they followed the changes in inflation on the basis of prices posted by the various service sectors. Unemployment also posed a problem in Germany at the time. To address this problem, Erhard advocated the creation of "real" jobs. In his opinion, the creation of "non-real" jobs was not beneficial either for employees or for the German economy in the long run, and non-real full-time employment made no contribution at all. The large numbers of foreign "guest workers" arriving in Germany added significantly to unemployment; but even for them, Erhard argued for the creation of genuine jobs. In relation to unemployment, Wilhelm Röpke contended – at least under the gold standard – that rigidly aiming for full employment could be expressly harmful for the economy, because it opened the way to economic nationalism, which he thought had doubtful value in maintaining economic growth. In *Röpke's* (*1950*) view, such a policy may result in turning away from foreign markets, leading to an extreme degree of economic isolationism. Besides, as early as 1957, Erhard warned of the dangers of overconsumption, adding that *"the luxury of today is in general demand tomorrow and in general consumption the day after"* (*Erhard 1957:57*); therefore, aspects of sustainability already appeared in the social market economy.

The Korean War, which lasted from 1950 to 1953, had some temporary positive effects on the German economy (e.g. higher production due to increased demand), but on the whole the negative impact dominated (e.g. renewed increases in price levels and the cost of living). Thus, the trajectory of development of the German economy broke, opening the way to critical opinions concerning the social market economy (lasting to this day). However, at least temporarily, the system withstood the test of time and the years between 1958 and 1964 were also characterised by marked economic prosperity (See *Table 1*).

Table 1
Per capita gross national product (GNP) in Germany from 1950 to 1964 (in German marks)

	1950	1958	1960	1964
Per capita gross national product (GNP)	5,754	9,707	13,200	15,106

Note: From 1960 includes the Saarland and West Berlin.
Source: Erhard (1993:62)

Ferenc Jánossy (1914–1997) offers an interesting interpretation of Germany's development during this period in his book about trendlines. Having examined the reconstruction periods of several countries in the aftermath of the Second World War, Jánossy came to the conclusion that the period of reconstruction does not end when production reaches the pre-war level, but only when the volume of production once again matches the economic development trendline of the given country. Thereafter, it will follow a growth trajectory as if the war had not taken place. If the economic development had been uninterrupted prior to the outbreak of war, then the actual pre-war development of production coincides with the trendline. Therefore, production will continue to grow until it has reached the trendline of economic development. Thereafter, the growth of production will again – at least for some time – share the trendline trajectory (*Jánossy 1966*). New challenges appeared from the second half of the 1960s (e.g. stagflation, negative impacts of changes in global market conditions, and then the oil and raw material price explosion in the 1970s), to which, as Erhard himself admitted, the paradigm of the social market economy could not respond adequately. As a result, a new kind of economic system, neoliberal market economics came to replace the social market economy.

4. Conclusions

As shown above, the German social market economy – at least in a short perspective – was not always particularly social in character. Among other things, the freezing of wages and the tax exemption for overtime were not altogether favourable measures for the citizens since in many instances these led to excessive work, employees being overdriven and mentally as well as physically exhausted. Nonetheless, the achievements of the social market economy during the 1950s and the first half of the 1960s (also, obviously, due to the Marshall Plan) are undeniable. They produced a significant level of prosperity for German citizens and for many years Erhard was Germany's most popular politician. From the second half of the 1960s, however, it failed to offer solutions for the newly emerging problems.

Recent economic and social developments (economic crisis, energy crisis, bank failures, pandemic, war) may lead us to wonder whether we have yet again arrived at a turning point and a necessary new paradigm shift, as neoliberal market economics is seemingly unable to respond to the numerous new challenges. It is still an open question whether the solution lies in rethinking the current economic paradigm or if there is a need for the development of a totally new one, but we can be fairly certain that there is a need for comprehensive change, and the sooner the better. Regardless of whether we prefer to remodel the existing economic paradigm or to adopt an entirely new one, we will definitely need the "social" components of the social market economy and its social responsibility, as well as the long-term

elements, such as regarding economic policy in a long perspective, in this system of thought that broadly corresponds to the concept of sustainability.

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A Fascinating History of Chile's Economic Reforms and Reversals*

David R. Henderson

Sebastian Edwards:
The Chile Project: The Story of the Chicago Boys and the Downfall of Neoliberalism
Princeton: Princeton University Press, 2023, 343 pages.
ISBN: 9780691208626

Introduction

On November 3, 1970, Marxist Salvador Allende was elected president of Chile. He quickly acted to move Chile's economy far towards socialism. He nationalized major industries, expropriated farmland, imposed price controls, imposed heavy restrictions on imports, and substantially increased the money supply. The results were what an economist would expect. Price controls caused shortages in a number of markets and increasing the money supply by 136 per cent in 1971, 178 per cent in 1972, and 365 per cent in 1973 caused triple-digit inflation. The disruption of the economy, the high inflation, and the government confiscation of private property led to widespread dissatisfaction and strikes. On September 11, 1973, Chile's military, led by its Commander in Chief, Augusto Pinochet, overthrew Allende. That same day, Allende, rather than being captured, committed suicide. There followed 16 years of dictatorship until democracy was reintroduced in late 1989.

Even before Allende was elected, several economists who had received their graduate economics training at the University of Chicago had worked in the background to reform Chile's economy in direction of free markets. Of course, Allende did not listen to them, but once Allende was gone, General Pinochet was more open. Over the years, a number of reforms they advocated were implemented and had mainly beneficial economic effects.

* The papers in this issue contain the views of the authors which are not necessarily the same as the official views of the Magyar Nemzeti Bank.

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One economist who was a teenager in Chile during the Allende years was *Sebastian Edwards*, now an economics professor at the University of California at Los Angeles. Edwards has written a book that has been badly needed: a fairly objective analysis of the economics and politics of economic policy in Chile over the last number of decades. Edwards documents the harmful effects of Allende's interventions, the economic reforms proposed by and somewhat implemented by Pinochet and even by later nominally socialist governments, and the effects of these reforms on Chile's economy. He shows that the reforms made Chile's economy the jewel of Latin America. He also shows, though, how the reformers dropped the ball. They failed to stay active in the debate over policy and they paid little attention to the increasing demand for reducing economic inequality. The result was a strong and violent backlash. One of the main lessons from his book is that economic freedom is always at risk and must always be vigorously defended.

What follows is taken from Edwards's book, with occasional commentary by me.

The Chicago Boys

In 1956, the University of Chicago made an agreement with the Pontifical Catholic University of Chile, often called Catolica. The idea was to bring promising students from Chile to the University of Chicago where they could learn economics from Chicago's fairly free-market oriented economics professors and then return to Chile. One of the Chicago stars, even then, was *Milton Friedman* who was to later win the 1976 Nobel Prize in Economics. In September 1956, the first cohort of students arrived in Chicago. Just two years later, they returned to Chile where they became full-time members of the economics faculty of Catolica. The students, all but one of whom were male, came to be called "the Chicago Boys."

In 1969, in preparation for the 1970 presidential election that Allende ended up winning, the Chicago Boys put together a set of economic proposals for the presidential campaign of conservative Jorge Alessandri. They proposed reducing tariffs, deregulating the economy, ending most price controls, and allowing the exchange rate to adjust in response to market forces. Their proposals were not well received. In fact, when Alessandri heard the proposals, he said to his aides, "Get these crazy men out of here; and make sure they never come back."

The "crazy" Chicago Boys, though, had the last laugh. Their 1969 proposals were the basis for the proposals they made in late 1973 to the military government that had deposed Allende. One prediction they made during the Allende years gave them credibility. In early 1972, when inflation was "only" 35 per cent, the Chicago Boys applied the tools they learned at Chicago to predict inflation. When they had studied there, they learned the view that monetarist Milton Friedman believed:

if the money supply increases by a large per cent, the price level will, with a lag, increase by a large per cent. On that basis, with the money supply having grown by 136 per cent in 1971 and even more in 1972, they predicted a 180 per cent inflation rate for 1972. In response, the Allende government had accused them of a "campaign of terror." In fact, they had *underestimated*: the inflation rate for 1972 was a whopping 260 per cent.

The Brick

Three days after the 1973 coup, the leader of the Chicago Boys, *Sergio de Castro*, was appointed as senior adviser to the new minister of economics, General Rodolfo Gonzalez. According to Edwards, de Castro quickly realized that this was not a job offer but, rather, a military order.

De Castro rose to the task. They put together the earlier-mentioned proposals that had built on their 1969 proposals. The result was a massive document that came to be called El Ladrillo (the Brick.) When de Castro first met Gonzalez, the General had a copy of the document in his hands but didn't, at that time, know that de Castro was the Brick's main author. The authors of the Brick had made proposals in many areas, too numerous to list here. The highlights were the elimination of import quotas and a reduction of tariff rates to a uniform 30 per cent, a devaluation of the currency, and elimination of many price controls. Edwards puts these proposals in perspective, arguing that they were "middle-of-the-road."

One good effect fairly quickly was that businessmen no longer had to approach the government to justify price increases. Edwards tells an amusing story about businessmen from the cooking oil industry having to meet with de Castro three times before they finally believed his statement at the first meeting that they were free to raise prices and that imports would constrain their ability to set supracompetitive prices.

Milton Friedman's Proposed Shock Treatment

On March 21, 1975, Milton Friedman, probably the most famous economist of the last half of the 20th century, visited Chile and spent an hour talking to General Pinochet. During that meeting, Friedman said that the only way to get Chile's 350 per cent inflation rate down quickly was to apply a "*shock treatment*". Friedman argued correctly that inflation was so high because Chile's central bank was printing money to finance a budget deficit that was 10 per cent of GDP. Friedman calculated that to run a balanced budget and thus avoid the need to print money would require a 25 per cent cut in overall government spending. Friedman argued that the short-run pain, in the form of high unemployment, would be high, but that the

long-run gain – low inflation and higher economic growth – would make the pain worth bearing. Friedman also advocated opening Chile's economy to free trade, ending price controls, deregulating the economy generally, and privatizing state-owned enterprises. In short, Friedman advocated, and went beyond, much of what was in the Brick although, according to Edwards, Friedman had not read the Brick.

Pinochet did not take all of Friedman's advice, but he did cut domestic government spending by 15 per cent across the board. Also, price controls were ended, the requirement to get a license to import was abolished, import quotas were eliminated, and tariffs were reduced substantially. Also, most of the firms that Allende had nationalized were privatized. The unemployment rate rose from about 10 per cent in 1974 to over 20 per cent by 1977 and then fell to about 15 per cent by 1980. My guess is that Friedman did not expect the unemployment pain to last as long as it did. At the same time, economic growth increased. Real GDP grew by 9.8 per cent in 1977 and 8.5 per cent in 1978.

Friedman's visit led to a lot of controversy, a controversy that was heightened by the announcement of his Nobel Prize in October 1976. A number of previous Nobel prize winners, although none of them recipients of the economics prize, denounced Friedman in a letter to the *New York Times* because he had spoken to a dictator who had killed and/or tortured thousands of people. But Friedman, always the scrapper, defended his visit. He pointed out that he had visited the Communist leaders of China, whose government had killed millions of people, and had heard not a peep from the same people who denounced his Pinochet visit.

Edwards' treatment of the aftermath of the Friedman visit was the one part of the book that I found unsatisfying. Edwards writes, "But deep inside, Friedman was bothered by the Chilean episode." How did Edwards know what was deep inside Friedman? He doesn't say. The closest he comes to explaining his conclusion is his observation that every time he talked to Friedman about Chile and Pinochet, he "noticed some discomfort and uneasiness." Could it be that Friedman was tired of being attacked for, or even asked about, this? Edwards doesn't seem to consider that possibility.

Edwards does highlight one nice thing that Friedman did for someone whom Pinochet oppressed. In July 1976, three months before Friedman was announced as the Nobel Prize winner, Albert Fishlow, an economic historian at the University of California, Berkeley asked Friedman to help obtain the release from prison of Chilean economist Fernando Flores, a former minister of economics and finance in Allende's government. In August 1976, Friedman wrote an impassioned letter asking for Flores's released and he was released later that month.

Friedman's Exchange Rate Contradiction

Milton Friedman was known for being one of the earliest advocates of floating, rather than fixed, exchange rates. In a famous 1959 article, he made a strong case for floating rates determined by changes in supply and demand. In doing so, he argued against the mainstream view that the Bretton Woods system of fixed exchange rates was better. Therefore, I would have expected Friedman to argue for Chile's government to allow its peso to float. But, notes Edwards, he didn't do that. In a 1981 paper that he presented at the Mont Pelerin Society meetings in Chile, Friedman argued that Chile should peg its currency to that of a major country and that *it had done so*. But Edwards points out that it hadn't done so and, in fact, had a "crawling peg," an exchange rate that was designed to change in discrete steps. Moreover, notes Edwards, in his 1998 autobiography, *Two Lucky People*, co-authored with his wife Rose, Friedman wrote, "I have consistently taken the position that a country like Chile with a central bank should let its currency float. The alternative is to abolish the central bank and unify its currency with that of its major trading partner." As noted above, Friedman was not consistent. I'm genuinely puzzled. I knew Milton Friedman well from when I first visited him in 1970 to a last conversation with him a year or two before his death in 2006, and I've never known him to compromise his views to fit those of others. Is it possible that he thought he would undercut some of his former students if he advocated a float? We may never know.

What Friedman did point out that was absolutely correct is that if you keep your exchange rate fixed, then a decline in demand will force down domestic prices and wages. The problem was that in 1979, Jose Pinera, the minister of labor, had persuaded Pinochet to change the labor law to make wages inflexible. Specifically, during contract negotiations, firms were required to offer wage increases that were at least as high as the inflation since the previous contract. When the demand for copper, Chile's main export, dropped during the early 1980s worldwide recession, wages for copper workers and workers in related industries couldn't drop. As a result, the unemployment rate shot above 25 per cent in the early 1980s. To put that in perspective, I note that the peak U.S. unemployment during the Great Depression was 25 per cent.

One other major reform, also due to Jose Pinera, that seemed reasonable in prospect but didn't work out well, was pension reform. In the early 1980s, Chile's government allowed private pensions to which workers could contribute 10 per cent of their pay and could invest in assets. This was very different from the pay-as-you-go Ponzi schemes that the United States and many other countries have. The problem, writes Edwards, was that 10 per cent was too low if workers' goal was

to have a retirement income anywhere close to their income in their last years of work. As it turned out, the pensions were typically only about 25 per cent of the workers' previous pay.

Edwards notes several problems with the private pension funds. He points out that the managers of the fund charged an excessive fee for managing. He doesn't give the number though. If it were as high as one per cent per year, that would have reduced returns substantially. One per cent per year doesn't add up; it compounds up. Another problem is that the assets in which the funds could invest were severely limited. For the first nine years, they were prevented from investing in foreign assets. The limit was gradually increased to a paltry six per cent in 1996, 30 per cent in 2004, and 45 per cent in 2008. Requiring that most investments be in domestic assets prevented people from investing in the booming stock markets of the United States and other countries.

How Chile's Economy Performed

Between 1973 and 1990, before Chile went back to a democratically-elected government, freer trade, ending most price controls, and privatization worked. During that time real GDP per capita rose by 33 per cent, which amounts to 1.7 per cent per year, not high, but respectable. Inflation fell from 508.1 per cent to 27.3 per cent. The per cent of the population in extreme poverty fell from 21 per cent to 13.8 per cent. The unemployment rate rose from 4.8 per cent to 7.8 per cent, which is bad but not terrible. Real wages rose by 143 per cent.

The Left Takes Over

In 1990, Patricio Aylwin of the Christian Democratic Party was elected president. He was followed by a series of leftists: Eduardo Frei Ruiz-Tagle of the Christian Democratic Party and Ricardo Lagos and later Michelle Bachelet, both members of the Socialist Party. As would be expected, all four expanded the size of the welfare state. Interestingly, though, both Lagos and Bachelet carried out some of the reforms advocated by the Chicago Boys. They cut tariff rates and privatized water and sewage provision, for example.

The economic results of staying the course on trade, inflation, and privatization were generally quite good. Between 1990 and 2019–2020, real GDP per capita rose by 131 per cent, for an average annual growth rate of 2.8 per cent. Inflation fell from 27.2 per cent to 2.9 per cent. The unemployment rate did rise, from 7.8 per cent to a worrying 10.8 per cent. Real wages rose by 112 per cent, a 2.5 per cent annual average growth rate.

But there was trouble. The far left didn't like free markets and argued against them. Rather than being happy about the dramatic fall in extreme poverty – it had hit 0.7 per cent by 2019–2020 – they focused on income inequality. The Chicago Boys hadn't cared much about inequality; they presumably thought that as long as virtually everyone was becoming better off, inequality didn't matter. On that, I agree. Unfortunately, a very vocal and somewhat violent group in Chile disagreed.

As a result, Gabriel Borice, a former left-wing student activist, was elected president in December 2021. Presumably, he thought he had everything going for him. But he did get one surprise. A constitutional convention had begun its work on July 4, 2021, at the same time that 2021 presidential election campaign was beginning. The members leaned heavily left and the final document showed it. It contained provisions for a dramatic increase in the size and expense of the welfare state, weakened property rights, and increased monopoly power for labor unions, to name three. But then Chileans started reading it and, when they got to vote on it on September 2022, rejected it by a lopsided vote of 62 to 38 per cent. This has put the brakes on the more extreme policies that many pro-freedom people had feared.

An Aside on Arnold Harberger

One of the University of Chicago economists who was very important in teaching the Chicago Boys and in helping free the Chilean economy from government control was Arnold Harberger. Edwards got to know Harberger in 1976 when he was assigned to be his assistant, and his affection for Harberger shows. I've gotten to know him too and I understand the affection. Harberger is a great economist and a passionate believer in freeing economies so that they work for everyone.

The Debate Never Ends

Nevertheless, Edwards is pessimistic about the future of freedom in Chile. In his final chapter, he predicts that Chile will move even further away from free markets.

Why? One main reason, Edwards argues, is that the pro-market side has abandoned the debate. He writes, "While Far-Left activists mastered Instagram, Twitter, and TikTok and used them brilliantly to get out their gospel, the old guard of free-market supporters stood on the sidelines, and, at most, wrote an occasional letter to the editor." One ominous indicator, writes Edwards, is "Catolica's almost complete disappearance from day-to-day economic policy debates." The younger faculty are immersed in a publish-or-perish culture.

What should be done? Edwards quotes from an interview he did with free-market economist, Deirdre McCloskey, who was an important faculty member at the University of Chicago in the 1970s and 1980s. The answer to the attacks from far-left activists, she stated, is to “preach, preach, and preach”. Amen.

"State of the Art" Research on Bounded Rationality*

Eyal Winter

Sanjit Dhami – Cass R. Sunstein:
Bounded Rationality: Heuristics, Judgment, and Public Policy
MIT press, 2022, 552 pages.
ISBN: 9780262543705

Dhami and *Sunstein's* book is a highly comprehensive and thorough presentation of the "state of the art" research on bounded rationality. It brings together empirical evidence with theoretical modelling and discusses the implications of these findings for public policy and law.

One important objective of the book is to challenge the currently dominant framework in economics, which assumes perfect rationality and builds on the Bayesian approach to the study of decision-making under uncertainty. In spite of the elegance and the simplicity of the Bayesian approach, its theory was developed by Von Neumann and Morgenstern in the 1940s without reflecting on empirical evidence about actual human behaviour. To address the weakness of this perfect rationality approach, the authors of the current book first clarify the term "rationality". This concept is prone to create much confusion in popular discourse and is interpreted differently in different disciplines (prominently Philosophy and Economics).

In the past few decades, the development of behavioural economics has been taking two different routes. The first one can be called the incremental approach, which seeks to replace selected assumptions and features that are embedded in the Bayesian model to make it more realistic and more consistent with empirical results, with the hope of gradually obtaining a general theory, which is better behaviourally founded. The other route can be called the "big push" approach. This approach practically deserts the Bayesian model as a benchmark and attempts to generate behavioural insights, and sometimes also full-fledged models, directly from the empirical evidence. It is fair to say that that, unlike the incremental route, the big

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push route is not attempting to develop general models of human behaviour and is largely motivated by cognitive biases and emotional effects. The incremental approach puts more weight on general modelling and often uses quite involved mathematical and game theoretical tools to study bounded rationality. Perhaps unsurprisingly, these two routes of research are pursued by different researchers scattered across two disciplines (mainly Economics and Psychology), with little interaction across routes. Perhaps the most important contribution of Dhami and Sunstein's book is in bringing these two approaches together in a very cohesive manner.

Another important achievement of the book is that it manages to make the frontiers of the subject accessible to the lay reader. This is often done through examples, without compromising on accuracy and on the understanding of the relevant theory. In spite of the fact that a significant part of the literature on bounded rationality uses mathematical modelling, the mathematics requirements to read the book do not exceed a serious high school mathematics course. Nevertheless, the book provides substantial material to keep the advanced reader interested, explaining concepts in evolutionary game theory, stochastic social dynamics, epidemiological models and the axiomatic approach to decision-making.

The material in the book is highly interdisciplinary. In addition to economists, it may be of interest to readers from other social science disciplines including business administration, law, psychology, political science, sociology and public policy. Readers who enjoyed "*Nudge*" by *Thaler* and *Sunstein* stand to benefit from a great deal of interesting material on libertarian paternalism and a defence of the theory behind nudges.

Bounded Rationality by *Dhami* and *Sunstein* is an important book that benefits a broad academic audience from a wide range of social science disciplines.

Budapest as Eurasia's Emerging Financial Hub – Report on the Budapest Renminbi Initiative Conference*

Ildikó Nagy – Györgyi Puhl – Dávid Szabó – Dániel Szakács

On 4 May 2023, the Magyar Nemzeti Bank (MNB, the central bank of Hungary) hosted the Budapest Renminbi Initiative Conference on "Financial Interconnectivity and the Green Transition" for the seventh time. To strengthen good relations with China, this year the series of events launched by the Magyar Nemzeti Bank in 2015 focused on renminbi financing, Budapest's role as a financial hub in the Central and Eastern European region, and the green and sustainable financial activities of central banks, with the participation of renowned domestic and international experts. The speakers agreed that financial cooperation is one of the catalysts for relations between China and Central and Eastern Europe, which is increasingly emphasised, inter alia, in the framework of the Belt and Road Initiative announced by China. The event also confirmed the important role central banks can play in ensuring the stability of the green transition, which contributes to energy security and stabilising supply chains through price stability and the promotion of green investment.

Hungary's geographical location places it in a strategically important position in terms of East-West relations in the Central and Eastern European (CEE) region. With its developing infrastructure, favourable business environment, and stable political and economic situation, the country has the potential to grow into a trade and financial centre linking the two continents, promoting to the competitiveness of the CEE region. Recognising the potential of the region and the country, in recent years Hungary and the region have become a preferred investment destination for an increasing number of Asian countries, including China.

In March 2015, the Magyar Nemzeti Bank launched the Renminbi Programme to support the internationalisation of the Chinese currency, with a view to reinforcing the increasingly close economic and financial ties between Hungary and China, and to strengthen Budapest's regional role. The MNB's Renminbi Programme rests on four pillars: investing part of the MNB's foreign exchange reserves in Chinese

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currency, maintaining a swap agreement with the Chinese central bank to prevent and manage potential liquidity problems, contributing to the development of the renminbi payment infrastructure, and supporting the use of the renminbi and the cross-border activities of Chinese banks in financial stability and supervision. In the same year, as a development of this initiative, the Monetary Council of the Hungarian central bank took a decision to enter the Chinese bond market.

In parallel with the launch of the programme, the central bank launched the Budapest Renminbi Initiative Conference, which aims to strengthen the relationship with the People's Bank of China (PBoC) and to encourage dialogue on the importance and impact of the internationalisation of the renminbi. The initiative was intended to take part in the growth of the international weight of the renminbi, to contribute to the development of Hungarian-Chinese foreign economic relations, and to reinforce the position of Budapest in Chinese and Central European relations. With this initiative, the Magyar Nemzeti Bank aims to broaden the range of domestic investment and financing sources and to encourage the growth of cross-border economic activity. In line with these objectives, the Budapest Renminbi Initiative Conference, held for the seventh time in 2023, focused on the situation and vision of Chinese banks operating in Hungary, the internationalisation of the renminbi and the green finance tasks that are increasingly important for central banks as well.

The conference was opened by *Mihály Patai*, MNB's Deputy Governor responsible for international relations, cash logistics, financial infrastructures, digitalisation and lending incentives, who stressed that the Chinese economy had quickly recovered from the recession caused by the coronavirus pandemic thanks to its outstanding crisis management. The PBoC's various instruments had successfully counteracted the negative effects of the pandemic, thus helping to stabilise domestic and international renminbi markets. He also pointed out that China was at the forefront of many aspects of today's megatrends. These included the development of digital central bank currency, which could undoubtedly reshape the way we think about money and central banking, and the importance of developing green finance. The Deputy Governor also referred to the growing links between the Hungarian and Chinese financial systems and the cooperation between the two countries' central banks to ensure financial stability. As a result of Hungarian-Chinese cooperation, Chinese financial institutions and the financial innovations they brought with them had made Budapest an emerging financial hub in the Central and Eastern European region.

He was followed by *Yang Chao*, Minister-counsellor and Chargé d'Affaires ad interim of the Embassy of the People's Republic of China in Hungary. In his speech, Yang first praised the importance of the conference, which he believed could play a leading role in the development of financial relations between Hungary and China. According to Yang, in today's fast-changing and uncertain world, the

internationalisation of the renminbi (RMB) could be particularly important, as the diversification of different currencies could ensure stability in international payments and reduce dependence on a single country. The PBoC had signed swap agreements with more than 40 countries, and in 2022 it provided the opportunity to engage in RMB clearing to 31 clearing banks in 29 countries. He added that in 2022 the value of cross-border RMB payments exceeded RMB 42 trillion (equal to USD 6.05 trillion). Furthermore, in March of this year, the renminbi took first place in Chinese payments for the first time, pushing the US dollar into second place. He stressed that China's economic and financial stability could further boost confidence in the renminbi, as some countries, taking advantage of the hegemony of their currencies, generated strong dependency in international finance, especially with regard to developing countries. Yang also stressed in his speech that China remained committed to common global development and peace, and highlighted the three global initiatives launched by the Chinese President to provide Chinese solutions to global problems. These included the Global Development Initiative, the Global Security Initiative and the Global Civilisation Initiative. China and Hungary had a comprehensive strategic partnership based on mutual respect and common interests. In his view, the relationship between the two countries had become even closer during the pandemic.

The next featured speaker at the conference was *Xu Chen*, Chairman of the Bank of China (Europe) S. A. In his presentation, he mentioned issues of global concern such as supply chain fragmentation, inflation, climate change risks and the Russia-Ukraine war, all of which were leading to fragmentation and regionalisation of the global community. To avoid this, cooperation could be the key and a more balanced and diversified global financial system was needed to minimise risks. He noted that the global use of USD had become a sort of weapon that undermines the credibility and stability of the global financial system. He explained that international use of the renminbi similar to the euro could significantly reduce these risks. In addition, he pointed out that an increasing number of countries were tending to settle transactions linked to China in renminbi. However, with regard to the international use of the renminbi, he pointed out that it still lagged significantly behind the US dollar and the euro.

The last speaker at the opening ceremony was *Zhang Jun*, Dean of the School of Economics at Fudan University. According to Zhang, the gravity of the world economy was shifting eastwards, mostly due to the rapid development of the Chinese economy. In his speech, he highlighted China's economic strengths, which both justify and encourage the global use of the Chinese currency. He believed that the One Belt, One Road programme initiated by the Chinese government and the connectivity and financial cooperation that was developing through it both encouraged and made the increasing use of the renminbi inevitable.

Budapest as a financial hub in the Central and Eastern European region – Renminbi financing and Chinese banks in Hungary

The first panel of the conference, organised in cooperation with the Hungarian subsidiary of the Bank of China, focused on Budapest as an emerging financial hub in the Central and Eastern European region, and examined the opportunities for renminbi financing in Hungary and the role of Chinese banks. Panel participants discussed the business opportunities for Chinese players in the CEE region and provided insights into the domestic and regional activities of the world's largest financial institutions.

As a lead-in to the panel discussion, *Li Kexin*, CEO of the Bank of China (CEE) Zrt., praised the favourable business environment in Hungary, which was attracting an increasing number of Chinese financial institutions and companies to the country. He explained the operations of BOC Budapest and its role in the internationalisation of the renminbi as the first clearing bank in the region, and the importance of the Central and Eastern European region in these processes.

Li Kexin's presentation was followed by a moderated panel discussion. The panel was moderated by *László Vastag*, Executive Director of the MNB's Prudential and Consumer Protection Supervision of Money Market Institutions. Panel participants were *Chen Zhangqing*, Deputy General Manager of China Construction Bank (Europe) SA, *Zhao Xiaowei*, Assistant General Manager of ICBC (Europe) S. A. Luxembourg, and *Fang Ruixue*, Chief Representative of the China Development Bank Budapest Representative Office. Chen Zhangqing explained that a country's geographic location, regulatory and business landscape, and similar policy stance with partner countries were key factors in becoming a regional centre or in playing a HUB role in cooperation between two regions. Fang cited Hong Kong as an example, which had also made significant progress in internationalising the renminbi thanks to its role as an intermediary between East and West.

Next, Zhao cited the example of Chinese commercial banks operating in Europe, which also acted as a bridge between China and Europe, as an example of the internationalisation of the renminbi. He said that Chinese banks in the region aimed to support Chinese customers and to develop relations between the two regions. In terms of international engagement, Fang noted that China Development Bank, unlike commercial banks, was a development bank that provides medium- and long-term financial support for infrastructure and rural development projects, and supported Chinese companies' entry into international markets. At the end of the discussion, concerning the regulatory environment and supervision, the Chinese speakers agreed that cooperation between the Chinese and Hungarian central banks, with particular focus on digital technologies, could make a major contribution to overcoming regulatory barriers.

Sustainable finance, green finance and the potential of central banks

The second panel explored the opportunities for sustainable finance, green finance and central banks. Participants addressed the issue of environmentally sustainable financial transition and the key role of central banks in the further development of green finance asset markets.

As a featured speaker in the panel, *Ádám Banai*, Executive Director of the MNB's Monetary Policy Instruments, Financial Stability and Foreign Reserve Management, outlined the Hungarian central bank's green mandate and its green monetary policy instruments and strategy. In his presentation, he stressed that the MNB applied its green instruments not only in the areas of monetary policy, reserve management, macro-prudential policy and financial supervision, but also aimed to reduce emissions from its own operations. In his presentation, Banai explained the Green Home Programme, the Green Mortgage Bond Purchase Programme and the sustainable directions of collateral management. He pointed out that green bonds accounted for around 10 per cent of the mortgage loan portfolio. He highlighted that the annual Task Force on Climate-related Financial Disclosures (TCFD) report published by the MNB had been well received by the market. The report covered 98 per cent of the MNB's activities and was therefore considered to be very comprehensive.

To open the panel discussion, moderator *Péter Pál Kolozsi*, Head of the MNB's Directorate Monetary Policy Instruments, Foreign Exchange Reserves and Risk Management, highlighted that the focus of the global economy was shifting towards Asia, and the continent could provide guidance on sustainability solutions. He added that climate change was already underway and therefore adaptation and implementation tools must be put in place in the very short term. Next, *Wing Thye Woo*, Distinguished Professor of economics at the University of California, Davis, said that the current decline in greenhouse gas emissions was mainly the result of production losses due to the pandemic. Moreover, most of the money that could be spent on climate change had been spent by governments to deal with the pandemic. He stressed that climate change was only one aspect of sustainable development, but that economic dynamism and stability should not be neglected, as that leads to increased inflation.

Zhang Bei, Deputy Director-General for Research Bureau at the PBoC, agreed with Adam Banai that there was currently no established formula for achieving sustainability, and that it was the total amount of work in different areas that would determine the extent of success. He noted that China's central bank was currently working on developing green financial standards, not only to support the sharing of environmental information, but also to establish a green financial rating system for financial institutions, provide structural policy tools for green

and low-carbon development, and conduct risk analysis and testing on climate change. He emphasised that green loans accounted for 10 per cent of total loans in China's financial system at the end of 2022, representing a 4.4 per cent increase compared to 2018.

Alain Naef, Research Economist at Banque de France, said that the analysis of the green measures introduced by the Chinese central bank in 2018 was also important as it well illustrated the mechanism of the measures' impact on green bonds. He added that so far, only China and Europe had developed relevant taxonomies, but their weakness was that due to the specificities of the energy mix, clean coal and natural gas were still part of them.

Professor Woo went on to explain that while Europe and China were working hard to achieve net zero emission targets, their success was not enough to curb the process, as developing countries need to achieve it as well, and they were not able to do it on their own. As a potential solution, he suggested that if China were to provide them with a larger amount of renminbi subsidies, it would not only help them achieve their green targets, but would also contribute greatly to the internationalisation of the renminbi. In his speech, Professor Woo also underlined that real success could only be achieved through private sector involvement, but that a leading state was needed that creates opportunities to finance the objectives by expanding the portfolio of development banks. This could be China, which had already shown the way by setting up the Asian Infrastructure Investment Bank (AIIB).

Following the panel discussions, a speech by Deputy Governor *Mihály Patai* concluded the conference, reflecting on the speeches, noting that China had grown into a major global player in trade both as a supplier and as a market, and by the mid-2010s it had become the world's largest trading country, the largest export destination for nearly 40 countries and the largest source of imports for some 70 nations. This shift was also marked from a financial perspective: while the dollar continued to dominate global trade, the share of Chinese renminbi-denominated trade had increased nearly fivefold over the past decade. He also pointed out that the RMB had been playing an increasingly important role in central banks' international foreign exchange reserves in recent years, and the number of central banks investing in renminbi-denominated assets was also rising.

The full event can be viewed on the conference website: https://www.youtube.com/watch?v=yeIbxMKq7IQ

Inflation in History*

Pál Péter Kolozsi

One of the most pressing economic policy challenges of our time is the need to break the persistence of inflation, since sustainable convergence is not conceivable without price stability. In addition to theories, experience gained from the real economy may well become a weapon in the fight against inflation. It was this consideration that inspired the conference entitled "*Inflation in History*" organised by the Rubicon Institute together with the Research Institute of Competitiveness and Economy of the University of Public Service at the Ludovika campus on 17 June 2023. With contributions from both historians and economists, this interdisciplinary conference examined the most relevant and enlightening inflationary periods in history spanning from ancient Rome through the Middle Ages and Early Modern times right up to the 20th century.

What means have been used to curb inflation throughout history? What methods proved successful and which ones failed to deliver results? What did the depreciation of the currency mean in the Roman Empire or at the time of the French Revolution? And how was this phenomenon tackled in Hungary during the Horthy period and later in the aftermath of the Second World War? The participating scholars delved into the aforementioned questions in eight lectures. The first speaker of the conference was *Géza Sebestyén*, Head of the Center for Economic Policy at Mathias Corvinus Collegium and Associate Professor at Corvinus University of Budapest, who delivered a lecture entitled "*Inflation as a Financial Phenomenon*". By way of introduction, Sebestyén reviewed the essential tenets of the economic literature on the causes of inflation and then went on to discuss the context of the present inflationary data, explaining that the current inflation is essentially a supply-side phenomenon and its origins can be traced to the war between Ukraine and Russia. He emphasised that idiosyncratic factors also need to be taken into account in the analysis of inflationary data (such as the influence of the phase-out of petrol price caps on the Hungarian indicators), as well as the fact that in comparing the current inflation rates geographical location has a striking significance – inflation is highest in the countries in Europe that are situated closest to the military conflict. This confirms the importance of the supply side.

* The papers in this issue contain the views of the authors which are not necessarily the same as the official views of the Magyar Nemzeti Bank.

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György Németh, classical scholar, former Head of the Department of Ancient History at Eötvös Loránd University and professor, gave a lecture with the title "*Inflation in the Roman Empire: Diocletian's Edict on Prices*". The professor explained how silver coins lost value from Augustus to Diocletian and what characterised the economic crisis that developed in the 3rd century in the Roman Empire. The Emperor Diocletian, who as a military man believed in the power of orders and regulations and was not particularly educated, chose a course of action that was without precedent: he prescribed maximum prices for virtually all goods available for sale at the time. The Edict on Maximum Prices, which is an exceptionally important historical source as it provides a minutely detailed picture of the economy and relative prices in the early 4th century Roman Empire, did not achieve its desired objective because the dread of the death penalty prescribed for violators of the edict emptied the marketplaces and drove prices to sky high levels. In contrast to the failure of price regulation, Diocletian also made a successful financial policy decision on monetary reform – this was the time when the gold coin called *solidus* was first minted. This coin remained in use for centuries, first in Rome and later also in Byzantium.

In her lecture, *Boglárka Weisz*, Head of the "Momentum" Hungarian Economic History Research Team of the Hungarian Academy of Sciences, journeyed through the topics of the medieval monetary system and of gold hunger from Saint Stephen's *denarius* to the *moneta nova* issued by King Louis II. She gave a detailed account of the history of gold mining in Hungary, of the rise of the gold mining towns, the measures taken to prevent the outflow of gold from the country and of the construction of the Hungarian monetary system based on the gold florin and the silver denarius. The scholar delivered a case study of the problem of mine water inflow afflicting Hungarian gold mines in the second half of the 15th century, which offers an early but excellent example of the connection between financial affairs and technical innovation. The lecture described the water lifting devices suitable for handling the water inflow and unsuccessful schemes designed by János Thurzó to deal with this problem.

In the closing lecture of the morning session, *Péter Hahner*, Director General of the Rubicon Institute, spoke about the role played by the *assignats* (paper money) in the French Revolution. He argued that while we often think that crises obviously lead to revolutions, it is also possible that certain revolutions consciously bring about crises with which to steer political processes in certain directions, for instance, in the direction of terror. In Dr Hahner's opinion, it is useful to start the economic analysis of the French Revolution with the question of France's sovereign debt. He argued that the "the French monarchy collapsed when it decided to pay its debts" because the government could not risk the tax increases necessary for managing the high national debt while bankruptcy appeared as an unacceptably dishonourable

option (even though it eventually came to pass in 1797). It was in these constrained financial circumstances that Talleyrand, who later became a renowned statesman, made his recommendation according to which the state should take over the functions of the Church, and then in turn sell the Church Lands, the proceeds of which could finance the state debt and expenditures. Finally, the "solution" was that the state issued interest-bearing securities (bonds), in possession of which, as promised by the issuers, the confiscated Church assets could be purchased in the future. These were the *assignats*, which, within a short time, turned into paper money. Already at that time, Talleyrand and du Pont de Nemours, a well-known economist of the period who was influenced by Adam Smith's ideas, warned against the inflationary dangers of issuing unbacked fiat (paper) money. Yet, their words of warning went unheeded. The currency issue was effectively uncontrolled which led to hyperinflation. A law passed in 1793 that capped prices was suspended in 1795, allowing the unchecked resumption of price increases. Inflation finally came to an end in 1803 when Napoleon introduced the Franc Germinal – the *assignats* had practically lost all their value by that time.

Róbert Hermann, Head of the Doctoral School of History at Károli Gáspár University of the Reformed Church in Hungary, examined the degree to which food price increases may be regarded as principal reasons for the onset of the 1848 Revolution. The speaker provided an overview of the economic and food crises that preceded the revolutions of 1848 in European countries. Virtually the entire continent was affected by the drought and potato blight which occurred during the second half of the 1840s, causing a significant increase in staple food prices, resulting in destitution and social unrest. This was compounded by typhoid fever in the German Confederation, by cholera in Russia and by cattle plague in the Austrian Empire and thus also Hungary. The above factors resulted in general food insecurity by 1847–1848 in practically all parts of the European continent, often threatening the very survival of the lower sections of society. The best known example is that of Ireland, where between 1841 and 1850 the population decreased from 8.2 million to 6.5 million, partly due to the famine, which claimed 700,000 victims, and partly to forced emigration. The gravity of the economic and food crisis is shown by the fact that it also reached the Papal State where the declining number of pilgrimages resulted in significant financial difficulties, including inflation. In summary, Hermann concluded that the increase in food prices provided the right breeding ground for the uprisings, yet political reasons were also necessary as shown by the example of Russia (one of the countries most involved in these events) where political power remained stable, making it possible for Russian troops to participate in the suppression of the Hungarian War of Independence in 1849.

Mihály Nánay, senior research associate at the Rubicon Institute, described how inflation was curbed at the beginning of the Horthy period (early 1920s).

The hyperinflation emerging in the aftermath of the First World War had several reasons, the most important of which were the shortage of goods due to the war, the significant purchasing demand stemming from the army and the printing of money which constituted an estimated 20–50 per cent of GDP. Monthly inflation during the war still "only" amounted to 2–3 per cent. By 1919 the figure was 30 per cent. There was no dispute about the necessity to end the printing of money, yet they did not know what to replace it with. The possibility for foreign loans remained severely restricted for a considerable period of time due to the unresolved status of the country, because of war reparations and the liens connected to the reparations. The crisis could not be contained by tax rises, reduced expenditure or interest rates raised by decree. Three finance ministers, Frigyes Korányi, Lóránt Hegedűs and Tibor Kállay were "consumed" by the crisis management. By 1923–1924, following speculation against the Hungarian crown (currency) and the uprising in Western Hungary, the Hungarian economy descended into hyperinflation, as a result of which, for instance, the price of brown bread, highly important as a staple food, jumped to 23,000 times (!) its former cost. Stabilisation finally came in 1924 when, by significant reductions in state expenditure and general austerity, the establishment of the Central Bank of Hungary (Magyar Nemzeti Bank – MNB) as well as the introduction of the gold crown and later the pengő, not least through borrowing a loan from the League of Nations, the country could overcome the runaway price levels.

The economic adversities faced by Hungary during the 20th century may be well demonstrated by the fact that little more than two decades later the aforementioned hyperinflationary period was followed by yet another episode of hyperinflation. The financial crisis of 1946 also stands out in this sad series of events because the price increases then reached such record levels which no other country has experienced to this day. *Károly Szerencsés*, Associate Professor at Eötvös Loránd University, explained that the astounding levels of price increases had similar reasons to those that followed the First World War, compounded by the enormous destruction caused by the war as well as plundering. The professor provided a revealing demonstration in an example from everyday life what hyperinflation was like: the price of a glass of beer before WWII was 28 fillérs (0.28 pengős), which rose to 15,000 pengős by February 1946. But even this figure appears "small change" compared to the price of 45 billion (!) pengős by June of the same year. Szerencsés argued that the hyperinflation could be explained not only as a spontaneous process, but also as a consciously induced one. An intense political battle was taking place in Hungary during this period in the course of which the devaluation of intellectual work and the destruction of middle-class savings served the purposes of certain political forces, particularly those of the Soviets and of the Communist Party.

The closing lecture of the conference was delivered by *Zsuzsanna Borvendég*, research associate at the Research Centre for History in the Institute of Hungarian Research, who described the oil price explosions of the 1970s. The crisis arrived in Hungary on a specific calendar day, on 22 July 1979, when János Kádár announced drastic increases in consumer prices. The average increase in food prices was 20 per cent, while fuel prices rose by an average of 34 per cent. This adjustment, resulting in an aggregate inflation of 9 per cent, was a particularly significant change because it ended the era of prosperity driven by low and stable prices that had given legitimacy to János Kádár's government. Borvendég gave a detailed account of the geopolitical changes that led to the oil price explosions of 1973 and 1979 and explained their consequences for Hungary. She pointed out that the cheap Soviet energy sources and the Bucharest price-formation principles which provided stability led to a false sense of security. Yet, as early as 1972, it was revealed that living standards could only be maintained at the cost of deteriorating external balances, while it also became known that the earlier economic data had been doctored. A decision was made according to which price increases could not exceed 2 per cent, the terms of trade continued to deteriorate and price subsidies grew significantly. The first tentative price increases were carried out in 1976, but Kádár got cold feet and promised a 3.5–4 per cent increase in real incomes. However, by 1978 the looming insolvency led to negotiations with the IMF. In her closing argument, the expert from the Institute of Hungarian Research pointed out that, frightened by the ominous example of Poland, the Kádár regime chose the path of indebtedness to foreign lenders.

By examining the subject of inflation, the joint conference of the Rubicon Institute and the Research Institute of Competitiveness and Economy of the University of Public Service focused on an exceptionally important and topical issue of current economic policy. The conference unquestionably provided added value since, as seen from the varied affiliation of the participants, approaching the question of price increases from an interdisciplinary angle and underlining the fact that understanding historical patterns can be particularly important, especially in times of crisis, when earlier models may become less applicable. Interconnected thinking among historians and economists is evidently forward looking in this field and offers a good chance to help us get control of inflation which is Hungary's economic public enemy No. 1 today.

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Manuscripts should be submitted in accordance with the following rules:

- The length of the manuscripts should be limited to 40,000 characters (including spaces) but a ± 50 per cent deviation is accepted. Manuscripts should be written in Hungarian and/or English.
- The unnumbered footnote of the author's name contains his/her position, the institution the author works at, his/her email address and any other relevant information and acknowledgment regarding the article.
- Papers always begin with an abstract which should not exceed 800–1,000 characters. In the abstract a brief summary is to be given in which the main hypotheses and points are highlighted.
- Journal of Economic Literature (JEL) classification numbers and keywords should be given (three at least).
- Manuscripts should be written in clear, concise and grammatically correct Hungarian and/or English. Chapters and subchapters should be bold.
- Manuscripts should contain the list of references with the first and surname of the authors (in case of non-Hungarians the initials of the first name is required), the year of publication, the exact title of the book, the publisher, the place of publication. In case of papers, the exact title of the journal, the year, the volume, and the pages should be indicated. References in the text should contain the surname and the year. When citing the exact page should be indicated.
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Thank you!

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