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Brave New Digital World? – Financial Technology and the Power of Information*

Ádám Kerényi – János Müller

In this paper we focus on the development of FinTech, how is it evaluated and managed in selected areas, in the European Union, in China and in Hungary. Some of the pertinent questions in this field are the following: How can regulators keep up with the rapid pace of development? Can regulation be based on a precise definition and can a level playing field be ensured between traditional banks and FinTech start-ups? What are the risks? How can they be handled by supervision and regulation? We can conclude that FinTech is in the initial phase of a "revolutionary" process, and the definition of this phenomenon is broad and changing. Regulators and supervisors must influence the conditions in a way that a level playing field and risk assessment should be the same for traditional banks and FinTech companies. All of the actors have responsibility, including central banks, regulators, supervisors, incumbent banks, consumers and FinTech companies. Information is power, and several economists claim that digital is the new normal. In our paper we partly justify the first part of the sentence and we put a question mark at the end of the second part.

Journal of Economic Literature (JEL) codes: D74, G21, O33, N74

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* 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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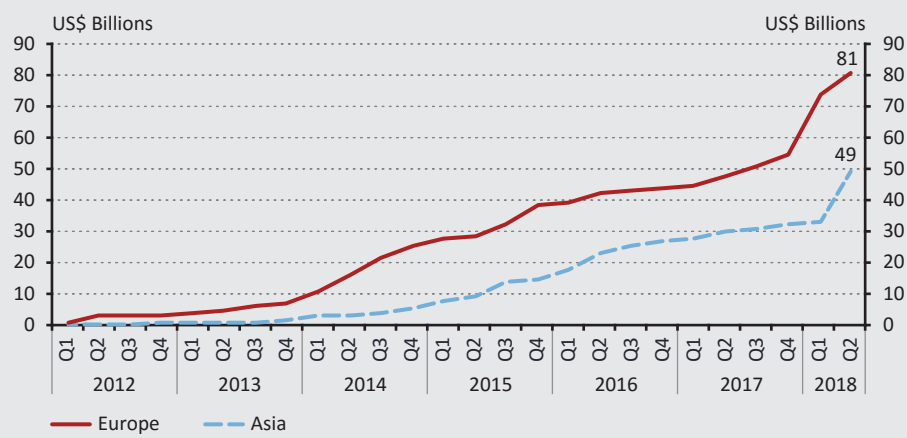
1. A new round of technological and digital revolution is knocking on the door

One of the most exciting phenomenon in the world right now is the development of digitalisation. The space, emergence and social effects of this development are so rapid and so deep, that it is considered to be part of the 4th industrial revolution. One minor part of this phenomenon is the penetration of the financial and banking sector, which is mostly referred to as the FinTech hype, because of its important role.

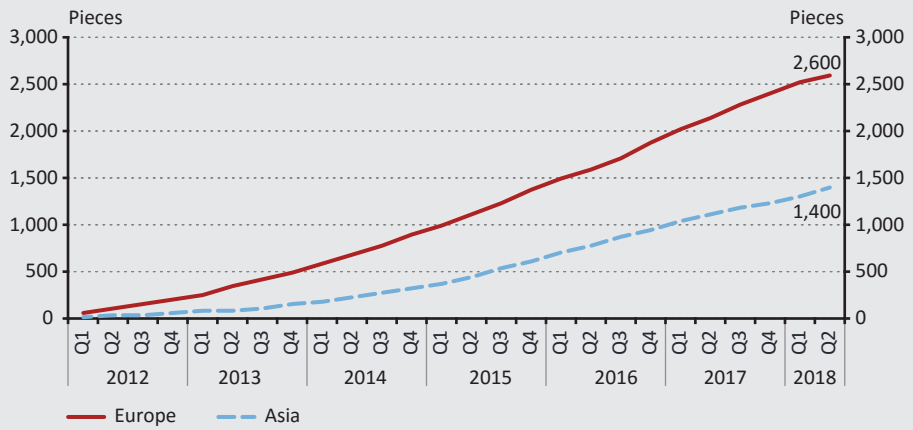
In order to better understand this development we briefly review the outcome of the second and third industrial revolutions and then focus on three areas – the European Union, China and Hungary – to study the present status and approach of the FinTech hype. The reason behind our research selection is that the European Union is playing a very important role not only in the development of FinTech, but also in the definition, its regulation and supervision aspects. The Chinese approach is also important since experience shows that China is facing the same or similar challenges in supervision and regulation, and on the other hand the support of FinTech development is strong. This is why we present the recent data on FinTech investment in Asia and in Europe below. The charts and figures support two important conclusions: FinTech investments are growing and reaching higher and higher levels both in Asia and in Europe (see *Figure 1* and *2*). It can also be seen that for the time being the European development is higher than in Asia. However, one must be careful making this comparison because the Asia line in the chart reflects the whole Asian region and we do not have equivalent data for China to compare the Chinese and European development in this respect.

Figure 1
Cumulative FinTech investment in Asia and in Europe
(2012–2018)



Source: KPMG (2018, p.34, p. 47)

Figure 2
Cumulative FinTech closed deals in Asia and in Europe
(2012–2018)



Source: KPMG (2018, p.34, p. 47)

Later, we also present the Hungarian case, where for several reasons FinTech development started with some delay, but in recent years has progressed a good bit to catch up with the international level.

Since the beginning of the 21st century, we have been experiencing a digital transformation – changes associated with innovation in the field of digital technology in all aspects of society and the economy. The 4th industrial revolution is already underway. Industry 4.0 will be an answer to the challenges lying ahead. Several economists claim that digital is the new normal. We suggest putting a question mark at the end of this statement. In this period of rapid changes, we do not know what the final shape of "the new normal" will be. "In the news, financial technology is described as 'disruptive', 'revolutionary', and armed with 'digital weapons' that will 'tear down' barriers and traditional financial institutions" (*World Economic Forum 2017*). This revolutionary phenomenon is inexorably occupying more and more space in our everyday lives. Naturally, these changes – some revolutionary and others perceived as such – have also reached the financial and banking sector. Financial technology ('FinTech') is a broad concept. What are the main concerns of the European legislators and supervisors? First of all, the development of digital financial technology is very rapid. So rapid indeed that even the exact definition of the FinTech phenomenon is difficult. If the definition is broad and mostly an umbrella concept, then elaborating the legal framework and proper supervision is also difficult and cannot be sufficient. Supervisors are not ahead of

the developments, but rather trailing behind them. For the time being, the principle of "same risk, same regulation" cannot be enforced.

Referring to the definition problem, examples of FinTech include digital ledger technology, robo-advice, RegTech (technologies that can be used for compliance and reporting requirements) and virtual currencies. This paper focuses on facilitating a better understanding of the FinTech phenomenon and the possible relations between traditional banks and FinTech start-ups.

Financial technology[1] is one of the most innovative, increasingly important and potentially the most rapid change in financial services, and is revolutionising the way financial services firms operate. It is transforming debt and equity markets, payments, credit assessment, regulatory compliance, personal finance and many other facets of financial services. Although some may think that FinTech is just another "buzzword", we believe that technology creates the possibility to dramatically reshape finance as we know it. Digitisation is taking place in all areas of business and life, transforming services, and creating new ones accelerated by new FinTech companies (*Deloitte 2016*). The Golden Age of FinTech has come according to FinTech evangelists, but on the other hand the current hype about FinTech is not due to the allegedly revolutionary character of the technologies, but to their better visibility. Without questioning the tangible positive results, we would like to focus on the current situation of the FinTech phenomenon and its international assessment, the difficulties involved in forecasting its future prospects, and the necessity of a paradigm shift in the traditional banking system. In close relation to the latter, we review the expected evolution of the relationship between banks, FinTech companies and – last but not least – their current and future customers. Finally, the important question is whether or not there are risks related to the use of the FinTech services. If there are, how should these risks be mitigated or remedied by new regulatory and supervisory measures? One of the first questions to be answered is where do we stand in the digital technology process? Are we at the beginning or have we arrived at a balanced, calm phase of continuous development? Where is the place of the traditional banks in this process? In our opinion, the short and correct answer is: we do not know exactly. Answering this question could be helped by reviewing the lessons of the past.

[1] A group of researchers define the FinTech phenomenon as technology-enabled financial solutions (*Arner et al. 2015*). In their reading, the FinTech phenomenon is not limited to certain banking activities (e.g. financing) or business models (e.g. peer-to-peer lending, applications), but encompasses the kinds of products and services that have traditionally been provided by banks to their customers. Others (*Kerényi – Molnár 2017*, *Kerényi – Molnár – Müller 2018*, *McAuley 2015*, *Kim et al. 2016*) interpret the phenomenon more broadly, defining it as an economic industry composed of companies that use technology to make financial systems more efficient. The ECB's position is that "FinTech" is an umbrella term encompassing a wide variety of business models. In line with the ECB's responsibilities, a guide has been produced relating to technology-supported banking products and services (*ECB 2017*).

When we investigate the possible outcome and impact of digital, AI and FinTech developments on human and social relations it is almost self-evident to compare the consequences of the third industrial revolution with the present fourth one since the latter involves the so-called digital age. Western civilisation has already witnessed three industrial revolutions, which could also be described as disruptive leaps in industrial processes resulting in significantly higher productivity. The first improved efficiency through the use of hydropower, the increasing use of steam power and the development of machine tools. The second brought electricity and mass production (assembly lines), and the third and most recent further accelerated automation using electronics and IT. The fourth industrial revolution is already underway.

We know the consequences of the first three revolutions, but we do not yet know the possible outcome of the fourth one (*Li 2017*).

While some areas will see fast and disruptive changes, others will change slowly and steadily, at a more "evolutionary" pace. In either case, there is no going back. In this revolution, physical objects are being seamlessly integrated into the information network. The internet is combining with intelligent machines, production systems and processes to form a sophisticated network. The real world is turning into a huge information system. This is the reason why we focus on the financial sector's role in this new revolutionary phase.

Several decades after the beginning of the third industrial revolution philosophers were still trying to summarise the relation between machines and human beings and to depict their views on the impact of the machine age on human thinking and behaviour. In our view, these questions are or could be justified in the age of digital transition and are also valid when assessing the metamorphosis of traditional banks and their clients.

Technical progress is accelerating. The empirical observation known as Moore's Law states that technical development, or certain partial processes within it, can be described by a high exponential growth path (*Brock 2006*, *Kurzweil 2006*). Nowadays, the digital transformation of financial services is a common topic in the investigation and analysis of the financial system and the banking sector. Today, a financial conference would not meet the expectations of the mainstream if it missed an item on the agenda as the word "FinTech" was not present. In many respects, the emerging opinions and findings agree: welcome the newcomer, the improving efficiency, the rising standard of consumer services, the acceleration and enforcement of competition. All of these unquestionable changes are warmly welcomed. There are, however, many aspects of the already ongoing developments and tendencies where the agreement and common understanding is not so great, and that is where important FinTech-related issues are not formulated (*Taylor 2017*).

However, in addition to established financial organisations, incumbent banks are also subject to structural inertia that limits their capacity to adapt to environmental change (*Buenstorf 2016*). Start-ups have certain advantages over financial behemoths. The legal capital requirements for their establishment, their small size, lean culture, technological progress, and ability to attract top talents give them a competitive advantage that is inherent in their very nature. New, more convenient, customer-centred services are changing the landscape. More and more experts are thus saying that the time has come to dramatically change the incumbent banks' attitudes. The main reasons for this change are the following:

- High penetration of mobile devices,
- Growing number of digitally native customers (so-called Millennials),
- Persistent distrust towards banks, let it be real or presumed,
- Customers in general are becoming more demanding,
- Growing inequality – the need to reduce financial illiteracy, and financial inclusion stimulus,
- The popularity of FinTech hubs, labs, accelerators by local and national politicians and financial institutions.

2. The challenge of approaching FinTech

There is no widely accepted definition of FinTech (financial technology) in the academic economic literature. The Basel Committee of Banking Supervision (BCBS) has opted to use the Financial Stability Board's (FSB) working definition for FinTech as "technologically enabled financial innovation that could result in new business models, applications, processes, or products with an associated material effect on financial markets and institutions and the provision of financial services". This broad definition is considered pragmatic by the BCBS in the light of the current fluidity of FinTech developments. That being so, the focus of the analysis and implications of this paper is on the effects of FinTech that are particularly relevant for banks, bank supervisors and – at the end of the day – their consumers. It is also worth noting that the term FinTech is used here to describe a wide array of innovations both by incumbent banks and entrants, be they start-ups or larger technology firms.

From the above it can be seen that the definitions of both the central banks and the Basel Committee have a common feature: that FinTech (financial services) are widely interpreted and defined in a way that permits continuous change and expansion.

The term FinTech also includes digital services and technological development-based business models that have already emerged in the financial market. The spread of the FinTech sector is a global phenomenon: the mass launch of new, non-bank participants and start-ups is being observed both in the developed markets (e.g. United States, United Kingdom) and in the dynamically developing markets (e.g. India, China). Service providers offering FinTech solutions have appeared in many banking fields, most frequently in payments, lending and investment advice.

As a matter of course, the permissive and broad definition outlined above has serious consequences. Since the definition does not precisely identify the content and scope of FinTech services, it creates difficulties in establishing a legislative framework to indicate the boundaries of supervisory controls, and in maintaining equal conditions for competition between traditional banks and FinTech companies.

FinTechs have an influence on how financial services are structured, provided and consumed, but have not successfully established themselves as dominant players.

Innovation is on the rise. As FinTechs have struggled to scale, banks have entered into a number of partnerships with them, and several are already bearing fruit. Banks have invested heavily for the satisfaction of their customers, and many are building compelling experiences that will meet customers' needs as never before. Furthermore, a number of institutions are effectively building new cultures, turning the page on disappointing experiences over the past decade (*McKinsey 2018*).

Many FinTechs came into existence with the goal of overtaking incumbents as the new dominant players in financial services, but they have shifted more towards building partnerships since they struggle with scale and customer adoption. Although FinTechs have failed to disrupt the competitive landscape, they have laid the foundation for future disruption. Some financial institutions have turned the threat of FinTechs into an opportunity (*WEF 2017*). Accepting the innovative importance of FinTechs, one key question is how the supervisory and regulatory institutions will approach this challenge.

As mentioned above, the FinTech phenomenon has emerged in the first phase of the fourth industrial revolution. Following the 2007–2008 international financial crisis, the primary task of traditional banks was to overcome the consequences of the crisis: they were forced to clean up their balance sheets, strengthen their capital base and cut NPL rates. They had to adapt to the strict and sometimes overly-eager regulatory conditions resulting from the crisis. They had to make significant cost reductions. As a result, traditional banks were only able to concentrate on internet services and digital developments with a delay, in recent years. Their primary focus was to recover and strengthen trust and confidence. In this situation, a market gap

opened up for FinTech companies, as real market demand emerged. Less capital was needed to launch the operation of FinTech start-ups, and their development of financial technology in the field of payment services was fast. Furthermore, some traditional banks were open to outsourcing certain financial services[2] and digital developments. Regulation and supervision of FinTech services mostly followed the rapid, changing events, consequently the regulation of third party payment (TPP) services was less strict then that of the incumbent banks.

Over the next ten years, banking will experience a higher degree of change than probably in the last 100 years. It is up to market incumbents to face this challenge. In particular, banks should rethink their business models and should look at the new wave of innovation as an opportunity to reach out to new customers, to increase efficiency, and to upgrade their business models.

However, there is a risk that the FinTech phenomenon could follow the already known pattern of shadow banking.

Speaking about the future of banking, *Hatami* (*2015*) considers five scenarios.

1. Scenario — The better bank. The digital revolution has run its course and almost all customers see digital as their main engagement mode with their bank. The incumbent big banks perceived the opportunity and reshaped their businesses to meet the new digital requirements. They restructured their IT platforms and processes, delivered new propositions internally and through partnerships, but most importantly they made the most of their key assets. They were able to retain most of their customers and retrained their people to become more digitally literate.

2. Scenario — The new bank. Incumbents were unable to survive the digital disruption. They were not able to meet the needs of their customers. These left in droves to go to the new challenger banks. These are new, full service banks built for the digital age. They provide services similar to those of the old banks, but they do it faster, cheaper and better that they ever could.

3. Scenario — The distributed bank. As the FinTech revolution progressed, large numbers of new businesses emerged to provide customers with better banking services. They did not attempt to be universal retail banks – they simply focused on providing specific products extremely well. They initially focused on payments, loans, savings products, forex, but slowly they moved into mortgages, investments, pensions and more.

[2] In this sense, Fintech services and products might be considered as nichetech solutions.

4. Scenario - The relegated bank. In this scenario, banks become a back office service provider for front office customer-facing platforms, with banks providing the necessary licenses, access to payment networks and maintaining deposits and access to funding. There is a risk that banks and bank supervisors will have limited ability to monitor end-to-end transactions and systemic risk. The loss of the customer relationship and the dependence on these new platforms that channel financial products may have adverse consequences for risk management functions and revenue streams (revenues would need to be shared with the new intermediaries).

5. Scenario — The disintermediated bank. As customers became increasingly disenchanted with their bank, they became increasingly comfortable with going through their favourite social network or hardware provider to buy financial services. It started with payments, followed by sales finance, then investment advice, loans and savings products, until eventually all of the banks' products could be accessed by these providers. Customers felt that going through a provider they love and trust was a guarantee that they wouldn't be taken advantage of, like they felt they had by the banks (*Hatami 2015*, *BCBS 2018*).

For the traditional banks, there is also a present challenge on the human side. How do they close the digital gap in their services and also in relation to FinTech service providers?

The shortage of digital skills pits company against company in the fight to fill positions in data analytics, user experience design, artificial intelligence, cybersecurity and other areas. Half of banking institutions have a difficult or very difficult time accomplishing that task.

One new aspect of the same question is revealed in the annual banking reports of McKinsey. In 2015, they documented the potential for FinTechs and digital platform companies to erode banks' margins. However, according to their last report banks have made a lot of good news for themselves recently. One area where McKinsey is seeing radical compression is in remittances — a profit centre for banks worldwide. New firms such as Azimo, TransferWise and TransferGo have built superior technology and are able to price their services as much as 78 per cent below incumbents. As they struggle to compete, incumbents' margins are taking a pounding. Over the past two years, in markets around the world, digital entrants and new analytical firms have gained a foothold, and banks' margins are indeed falling — despite their massive cost-cutting efforts.

The digital entrants are changing too. With most retail businesses (except investing) already fully explored, at least for now, FinTechs are moving into commercial and corporate banking. McKinsey's Panorama FinTech database, which tracks over 1,000 financial start-ups, shows that one of the fastest-growing segments is

payments solutions for large companies. The spate of alliances and acquisitions between retail banks and FinTechs has helped to solidify the notion that the land grab is over. FinTechs are also making strides in capital markets and investment banking, especially advisory — although here, the emphasis is more on enabling traditional business processes, rather than disrupting them. The threat from platform companies is real and must be addressed. McKinsey's analysts do not think, however, that it is existential for the global banking industry. The long history of banking strongly suggests that there will always be a need for financial intermediation and a profit to be made by providing capital to others, although it may take many years for the industry to return to profitability in a global economy that is undergoing profound changes. As a first step, banks can take advantage of a range of actions over the next three to five years to reclaim their rightful ownership of the customer relationship, improve productivity and industrialise their operations using digital tools. In essence, banks can deploy some of the same technologies that digital companies are using against them. These steps can lift revenues, improve capital usage, and, especially, cut costs (*McKinsey 2018*).

3. The approach to FinTech in the European Union

In the European Union, the importance of digital technology has been realised and it is considered an issue of paramount strategic, economic and social importance. The European Commission declared that the new digital technology will be a key element in the future competitive edge of the EU.

As a consequence of this development, since May 2015 the European Union has been delivering on an ambitious and comprehensive Digital Single Market Strategy which was accomplished by 2017. The SDM Strategy is built around improving access to goods, services and content, creating the appropriate legal framework for digital networks and services, and reaping the benefits of a data-based economy.

It has been estimated that the Strategy could contribute €415 billion per year to the EU economy and create hundreds of thousands of new jobs. Thus, it would be hard to understate the importance of timely implementation (*European Commission 2017*).

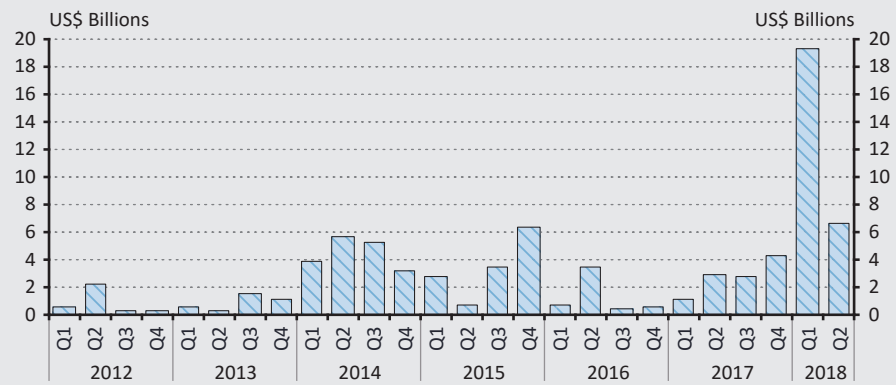
With the strategic aim of building a more competitive, innovative financial market, in March 2018 the European Commission unveiled a FinTech Action Plan focused on harnessing the opportunities presented by technology-enabled innovation in financial services (FinTech).

"Europe should become a global hub for FinTech, with EU businesses and investors able to make most of the advantages offered by the Single Market in this fast-

moving sector. As a first major deliverable, the Commission is also putting forward new rules that will help crowdfunding platforms to grow across the EU's single market. The Action Plan envisages to enable the financial sector to make use of the rapid advances in new technologies, such as blockchain, artificial intelligence and cloud services. At the same time, it seeks to make markets safer and easier to access for new players. This will benefit consumers, investors, banks and new market players alike. In addition, the Commission is proposing a pan-European label for platforms, so that a platform licensed in one country can operate across the EU. The Action Plan is part of the Commission's efforts to build a Capital Markets Union (CMU) and a true single market for consumer financial services. It is also part of its drive to create a Digital Single Market. The Commission aims to make EU rules more future-oriented and aligned with the rapid advance of technological development" (*European Commission 2018*).

This strong intent of the European Union to support and motivate FinTech development is confirmed by the data below, where we can see an immense growth after 2017, when the SDM concept was accepted (see *Figure 3*).

Figure 3
Total European FinTech investment activity
(2012–2018)



Source: KPMG (2018, p.34)

The importance of the FinTech issue in Europe is clearly reflected by the next development: the day after the EU FinTech Action plan was published, in March 2018 the European Banking Authority published its FinTech Roadmap under the title "Designing a Regulatory and Supervisory Roadmap for FinTech."

The EBA Roadmap is an important summary of the necessary and envisaged regulatory approach related to the services provided by the incumbent banks and FinTech start-ups.

"Most of the current regulatory approaches are situated between these two extremes: "let it happen" and "regulate and restrict". They are generally based on three components:

(i) monitoring of innovation,

(i) assessment of risks vis-à-vis the public interest (micro-prudential, financial stability, consumer protection and market integrity), and

(ii) selective application of the existing rulebook, where needed adapted to capture the innovation.

In general, this pragmatic attitude revolves around a tiered regulatory structure, with differentiated regulatory requirements according to the risks for the firms, their customers, the financial sector and the economy at large. In principle, the objective is to deliver "same risk – same rules" expectations.

Let us quote another important view of this document: "Even though FinTech firms may offer some bank-like products and compete with banks for the same customers, this doesn't necessarily mean that they should be licensed, regulated and supervised as banks. We need to make a key distinction, here, between the cluster of services that represent the essence of banking, and as such should be reserved to licensed banks, and those additional services that may be offered, on a standalone basis, also by other intermediaries, in competition with regulated banks". The EBA's FinTech Roadmap describes its priorities for 2018/2019 and provides an indicative timeline for the completion of these tasks. The priorities are:

- monitoring the regulatory perimeter, including assessing current authorisation and licensing approaches to FinTech firms, and analysing regulatory sandboxes and innovation hubs in order to identify a set of best practices to enhance consistency and facilitate supervisory coordination;
- monitoring emerging trends and analysing the impact on incumbent institutions' business models and the prudential risks and opportunities arising from the use of FinTech;
- promoting best supervisory practices on assessing cybersecurity and promoting a common cyber threat testing framework;
- addressing consumer issues arising from FinTech, in particular in the areas of unclear regulatory status of FinTech firms and related disclosure to consumers,

potential national barriers preventing FinTech firms from scaling up services to consumers across the single market, and the appropriateness of the current regulatory framework for virtual currencies;

- identifying and assessing money laundering/terrorist financing risks associated with regulated FinTech firms, technology providers and FinTech solutions (*EBA 2018*, *Enria 2018*).

In a paper "*Sound Practices on the implications of FinTech developments for banks and bank supervisors"*, in February 2018 the Basel Committee's Financial Stability Board summarised "how technology-driven innovation in financial services, or 'FinTech', may affect the banking industry and the activities of supervisors in the near to medium term".

This extensive analysis provides an excellent understanding of financial technology developments and the presently known FinTech business models. "Against this backdrop, current observations suggest that although the banking industry has undergone multiple innovations in the past, the rapid adoption of enabling technologies and emergence of new business models pose an increasing challenge to incumbent banks in almost all the banking industry scenarios considered".

The Basel Committee summarised the ten most important possible implications of the suggested supervisory approach related to the relations of traditional banks and FinTech service providers:

1. the overarching need to ensure safety and soundness and high compliance standards without inhibiting beneficial innovation in the banking sector;
2. the key risks for banks related to FinTech developments, including strategic/ profitability risks, operational, cyber- and compliance risks;
3. the implications for banks of the use of innovative enabling technologies;
4. the implications for banks of the growing use of third parties, via outsourcing and/or partnerships;
5. cross-sectoral cooperation between bank supervisors and other relevant authorities;
6. international cooperation between bank supervisors;
7. adaptation of the supervisory skill set;
8. potential opportunities for supervisors to use innovative technologies ("suptech");

9. relevance of existing regulatory frameworks for new innovative business models; and

10. key features of regulatory initiatives set up to facilitate FinTech innovation.

Looking at the latest developments, it is obvious that decision-makers in the EU are aware of the importance and global competitive impact of the development of financial technology. The efforts are concentrated on strengthening the development of the European Monetary Union and the European Capital Markets Union. On the one hand, they confirm that digital applications, the availability of FinTech services should be supported, but on the other they urge an improvement of supervisory risk assessment, consumer protection and strengthening the relevant legal framework. It is strongly emphasised that a level playing field between traditional banks and FinTech (TPP) service provider should be ensured.

The lack of a precise definition most probably required the present standpoint of the European Central Bank, stating that the regulation and supervision of FinTech services should remain – for the time being – in the sphere of national competence. The next challenge is how to ensure a level playing field between the traditional banks and FinTech service providers. It is not easy to find a balanced solution. Establishing a FinTech start-up requires less capital, the acquisition of clients is cheap, and the regulation and supervision is mild or non-existent. The incumbent banks had just emerged from the consequences of the international financial crisis, with demanding budget constraints, and for this reason they had less resources available for digital developments, are subject to a strict and sometimes overregulated functional environment and face strict risk assessment criteria. On the other hand, the FinTech challenge is motivating traditional banks to catch up and to invest in financial and digital technology. The game is on: we just hope that the final outcome will be a win-win situation, offering and providing better services.

Death and taxes may have been the only certainties in the words of Benjamin Franklin two centuries ago, but today only death remains undeniable. With the rise of the digital economy, more and more economic value is derived from intangibles such as the data collected from digital platforms, social media, or the sharing economy. And because company headquarters can now be moved between countries with ease, governments are finding it ever harder to raise taxes. At the same time, public spending will likely have to increase to meet the demands of those left behind in the era of globalisation and digital technologies.

That may be about to change. One idea currently gaining traction is to tax firms offering free-to-use digital services differently, so that their intangible value receives the same tax treatment as the tangible value produced by manufacturers and traditional service providers.

The competent EU decision-makers also realised the importance of a well-controlled digital (FinTech) development even from the taxation point of view. As part of building the architecture of the EU Single Digital Market, the European Commission suggested a Council Directive laying down the rules relating to the corporate taxation of a significant digital presence. According to the Commission's proposal: "The digital economy is transforming the way we interact, consume and do business. Digital companies are growing far faster than the economy at large, and this trend is set to continue." (*European Commission 2018*)

However, digitalisation is also putting pressure on the international taxation system, as business models change. Policy makers are currently struggling to find solutions which can ensure a fair and effective taxation as the digital transformation of the economy accelerates, and the existing corporate taxation rules are too outdated to capture this evolution.

The current corporate tax rules are built on the principle that profits should be taxed where the value is created. However, they were mainly conceived in the early 20th century for traditional "brick and mortar" businesses and define what triggers a right to tax in a country ("where to tax") and how much of corporate income is allocated to a country ("how much to tax") largely based on having a physical presence in that country and without reflecting the value created by user participation in that jurisdiction.

This proposal aims to address the issues raised by the digital economy by setting out a comprehensive solution within the existing Member States' corporate tax systems. It provides a common system for taxing digital activities in the EU which properly takes into account the features of the digital economy. First, this proposal lays down rules for establishing a taxable nexus for digital businesses operating across borders in case of a non-physical commercial presence (hereinafter: a "significant digital presence"). New indicators for such a significant digital presence are required in order to establish and protect Member States' taxing rights in relation to the new digitalised business models. Second, this proposal sets out principles for attributing profits to a digital business. These principles should better capture the value creation of digital business models which rely strongly on intangible assets. This Directive, once implemented in the Member States' national legislation, will apply to cross-border digital activities within the Union, even if the applicable double taxation treaties between Member States have not been modified accordingly. As soon as it enters into force, this EU Directive will have a positive impact on the desirable level playing field between traditional banks and FinTech start-ups.

4. The approach to FinTech in China

"Competition in the FinTech space is developing at the global level. As often occurs in innovative markets, the key to success lies in a large domestic market, which allows successful companies to achieve a scale enabling them to aim for global leadership. In the long term, European FinTech players would be at a significant disadvantage vis-à-vis their US and Chinese competitors, if the European markets remain segmented along national borders, with different sets of rules and uncoordinated actions by local authorities" (*Enria 2018*).

In this chapter on the Chinese experience, we survey FinTech in three dimensions: the Chinese government, the People's Bank of China (the Chinese central bank) and the financial supervision authority Chinese Banking Regulation Committee (CBRC)[3], and the Chinese commercial banks.

In order to make a short summary we refer to the FinTech approach of China, which was presented by excellent high-level financial experts at the AFCA CEE Financial Summit Forum – New Chapter of Asia-Europe Financial Cooperation in Budapest, Hungary in November 2017. The FinTech sector in China has been developing rapidly and is the global leader by several measures. The country's digital payments account for almost half the global volume and online peer-to-peer (P2P) lending accounts for three quarters of the global total. China's FinTech sector is now at a critical juncture. The Chinese government's attitude towards FinTech has become progressively more complex, as risks have piled up around P2P platforms and the number of underground fund raising and financing activities have grown. The authorities remain generally supportive, despite some recent tightening measures (*Hu – Yin – Zheng 2016*, *PWC China 2017*).

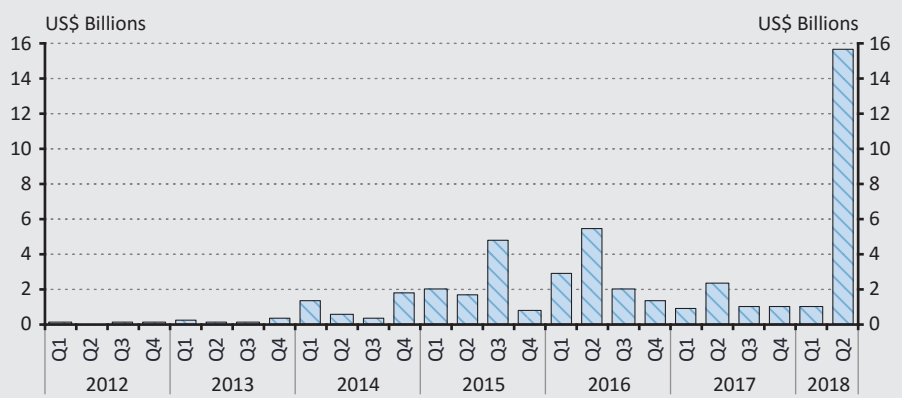
In relation to internet finance, Premier Li Keqiang made some important statements: "We will encourage internet finance to seek a healthy development path with the backing of proper regulatory coordination and supervisory mechanisms" and "We will work to see that internet finance develops in line with regulations". The Chinese government gave players a free hand to experiment. Light-touch – or, more accurately, late-touch – regulation of digital activities and players in China has encouraged entrepreneurship and experimentation. While the response of regulators lagged behind market developments, China's internet giants were relatively free to test and commercialise products and services and to gain critical mass. For example, regulators took 11 years after Alipay introduced online money transfers in 2005 to set a cap on the value of the transfers. It was five years after Alipay introduced barcode-based payment solutions that Chinese regulators produced an official standard on management requirements (*McKinsey 2017*).

[3] In April 2018, CBIRC took over the role of CBRC, and its activity covers not only the banks but insurance companies, as well.

On the side of the commercial banks let us quote the approach of some of the major Chinese financial institutions. Liu Qiang, Vice President of the Bank of China urged to take the lead in technological innovation and improve the efficiency of financial services. FinTech can improve the quality serving the real economy. The development of FinTech has enriched the content of finance and expanded the market. The combination of new technologies, capital and market can create astounding power. Banks on both sides should vigorously step up innovation and cooperation in technology and promote the transformation and upgrading of banking service efficiency. Everyone can see that technical progress is continuously pushing forward the resolving of information asymmetry, which is of great importance to financial development. FinTech has rich connotations, and will become a trend of financial development within the ceaseless technical progress.

While the growth phenomenal of traditional and non-traditional digital financial services has been fostered in recent years by technological innovation, advancement, rapidly changing consumer behaviour and adaptation to forms of finance, China's regulatory environment has also provided fertile conditions for growth. This statement is confirmed by the data below (see *Figure 4*).

Figure 4
Total FinTech investment in Asia
(2012–2018)



Source: KPMG (2018, p. 47)

Mr Huang Yi, Executive Vice President of China Construction Bank, delivered a speech titled Financial Technology and Strategic Transformation of the Banking Industry in China. According to Yi, instead of leading to a shrinkage of the banking industry, the rapid development of China's internet finance has brought about competitive and cooperative development through two-way interaction and complementation of advantages. The breakthrough and maturity of technical fields laid a solid foundation for the technology-driven transformation of the banking industry. He also mentioned that financial technology was a more direct, powerful and effective driving force for transformation. Intuitively, the development of financial technology first broke through physical limitations effectively, and drove the integration of banking channels. Besides, the application of financial technology drove the reform of banking business modes, and gradually popularised the service modes based on scenarios and platforms. Furthermore, financial technology had enriched risk control means, making risk management more effective. He continued as follows: as financial technology had advantages, China could work to develop core technologies and set patent standards. China's commercial banks and some large internet enterprises stayed ahead in the international market in terms of financial technology practices. They should take the advantage to integrate related technologies and make these technologies their patents, and use these patent advantages to change the process of the international financial industry, to form new industrial standards and to enhance the core competitiveness of China's banking industry (*Kerényi – Müller 2018*).

Strengthening regulation and supervision is the focus of the CBRC, the Chinese Banking Regulatory Committee. Based on the framework, the fundamental principles governing the regulation of Digital Finance are "tolerate, encourage, guide and standardise" and the associated supervisory requirements can be summed up as "comprehensive, timely, professional and effective" (*Varga 2017:134*)

In 2018, at the Budapest Renminbi Initiative Conference[4] Mr Ren Zhe, Representative of the Peoples Bank of China, spoke about the recent development of FinTech Regulation in China. He emphasised that the definition of internet finance is broad, and internet payments, digital currencies and digital infrastructure require different approaches. Changes are needed in the regulatory and supervisory requirements and related changes in business incentives of incumbents and new players. In his opinion, "there is no unified approach to FinTech activities; improvement the ecosystem of FinTech can help mitigate some significant risks; new ideas and approaches to improve regulation efficiency should be incorporated". Since there is

[4] More information on this event: https://www.mnb.hu/en/pressroom/press-releases/press-releases-2018/budapest-renminbi-initiative-2018-conference-at-the-central-bank and (*Mészáros 2018*).

no unified regulatory approach on FinTech activities he emphasised the importance of self-discipline.

5. The approach to FinTech in Hungary

After reviewing the EU and Chinese approaches to the FinTech development, we briefly summarise the Hungarian attitudes.[5]

As a matter of course, the Hungarian FinTech approach is closer to that of in the European Union and rather to that within the euro area. However, there are some country-specific features. The global financial crisis also impacted the Hungarian financial sector: lending activity and profitability decreased, NPL rates rose, there was a heavy burden of FX-denominated retail loans, and internal hard budget constraints were faced within the banks. Due to the absorption of these developments, the banking sector could return to the normal development of IT and other services. Digital innovations and FinTech expansion was started in the past three to four years. Although foreign ownership is relatively high in the banking sector, at around 50 per cent, most of the FinTech developments are made at Hungarian subsidiaries and are not taken over from the parent banks. It is also a special, although not unique feature, that the Magyar Nemzeti Bank (MNB), as Hungary's central bank, has both the supervisory and regulatory competence.

Against this background, FinTech regulation is high on the MNB's agenda. When the idea of regulating FinTech first appeared to the MNB, their first step was to look for information on the best practices of other central banks around the world. The MNB considers the support of FinTech development so important that "the MNB established an Innovation Center (Multilateral Consultation Platform) to help FinTech start-ups in the initial phase, or even those already on the market, to navigate regulatory issues" (*Thurzó 2017*).

The MNB also prepared a targeted questionnaire to assess the attitude and proposals of market participants which are developing and offering FinTech innovations. According to this survey "banks believe that they will continue to play a central role in financial intermediation. On the other hand, the overwhelming majority of FinTech firms are in regular contact with banks or have turned to banks since their launch. This is due to the fact that in addition to financial support, banks can also provide assistance through the expertise gained during their operations. Access to banks' extensive datasets is crucial for newly established FinTech firms and banks have thorough knowledge of the detailed legal requirements pertaining

[5] This section is based on the Consultation Document of the Magyar Nemzeti Bank (*MNB 2017*, *Fáykiss et al. 2018*), which published the results of a market survey on FinTech innovations and their potential regulation and also based on an interview by the authors with representatives of the MNB.

to the industry. Banks' systemic thinking can probably also provide more accurate guidance on potential operational and financial risks. Traditional banking actors mainly foresee partnership solutions with respect to FinTech innovations. Banks' motivation is based on their need to be familiar with efficient solutions and adopt them as soon as possible, and the flexibility observed in the attitude of FinTech firms and their ability to make decisions quickly may facilitate technological progress. One major element of cooperation is the provision of a business model which is sustainable over the longer term. Banks believe that cooperation and the development of incubation programmes can facilitate long-term thinking, and as a result of that, innovations can become part of the traditional banking system" (*MNB 2017*).

The MNB's Innovation Hub (which was recently founded) helps to identify actually arising legal obstacles and to improve feasibility of innovative ideas (*Fáykiss et al. 2018*). The online platform provides a connection between the regulatory and supervisory authority and the innovative domestic institutions (FinTech firms, banks, insurers, etc.), and supports the awareness of international best practices.

- Information repository
- Communication hub
- Regulatory support platform
- International cooperation platform

"However, some uncertainty also surrounds the Regulatory Sandbox, as 65 per cent of the institutions have not decided whether they wish to participate, whereas 29 per cent of the respondents would be willing and able to launch a testing phase with an innovative product or service even within a short period of time. Most FinTech firms already cooperate with traditional banking actors. FinTech firms typically do not feel rejected by banks. The market consultation confirmed that there are different types of cooperation. Over one-third of the Hungarian companies in the MNB's sample indicated that they are in a partnership with a bank, i.e. they are participating in a bank's incubation program or acting as suppliers to a bank with an agency agreement. Banks obtain FinTechs' know-how through acquisition fairly rarely. Openness on the part of the FinTech firms will typically continue, as half of the sample plan further cooperation. Complete rejection of cooperation was only indicated by three companies altogether" (*MNB 2017*).

Finally, it is also of great interest to see how the traditional banks consider the development of FinTech in Hungary. The Chairman of Hungarian Banking Association summarised his views on the digital and FinTech challenges as follows: "Digitalisation is a tremendous challenge and pressure for renewal in the banking

sector. Many people who are 20 or 30 years old today will not visit a branch office, and instead conduct all of their transactions on their mobile phones. Client attitudes and behaviour will change, the importance of branches will decrease and the importance of technology will increase. For many banks it's a real danger that their role will be taken over by new actors, for instance payment service providers. This development is seen by regulators all over the world, and if these actors want to have lending activities and will observe and comply with the relevant rules, they will have to meet the same capital requirements as traditional banks, then the banks will win and defeat them in competition. The danger is there, but banks will learn how to apply the new technologies rather than to let new actors take away their bread. Banks are ready for the serious integration of FinTech companies." (*Patai 2018*). For the time being it is a positive attitude even for the clients that the incumbent Hungarian banks do not have a hostile attitude towards FinTech start-ups.

6. Summary and Conclusion

Since the beginning of the 21st century, we have been experiencing a digital transformation – changes associated with innovation in the field of digital technology in all aspects of society and the economy. The fourth industrial revolution is already underway. Financial Technology represents one of the most innovative, increasingly important and potentially the most rapid change in financial services revolutionising the way financial services firms operate and transforming debt and equity markets, payments, credit assessment, regulatory compliance, personal finance and many other aspects of financial services. For a better understanding of this process, we have briefly compared the lessons from the previous three industrial revolutions. We can see similarities, as revolutions have a sudden start and mostly end up with positive changes and transformational powers, but they also have disruptive effects. In the initial phase it is difficult to predict the outcome, to foresee what will be a lasting positive effect and to assess the potential risks involved and their management.

In our day and age, one of the greatest challenges for the banking sector, for the regulators and for supervisors is the digital transformation of financial services. In this context, the future of traditional financial intermediation and the relationship between incumbent banks and FinTech start-up companies is a relevant question. These developments and the new actors on the market raise the question of potential risks, thus how regulation and supervision should be changed, and whether fair competition and a level playing field can be ensured and maintained.

In investigating the FinTech phenomenon, the first task is to find the exact definition. It is clear that there is no widely accepted definition of financial technology, not because regulators are ignorant or unknowledgeable, but rather because the

development is so rapid that supervisors and central banks are forced to follow the events. The inefficient status of the definition is common in all of the territories we examined. The most commonly used definition is the Financial Stability Board's working definition of FinTech as "technologically enabled financial innovation that could result in new business models, applications, processes, or products with an associated material effect on financial markets and institutions and the provision of financial services". This broad, "pragmatic" definition is considered as the basis of regulation.

The permissive and broad definition has consequences. Since the definition does not make it possible to precisely identify the content and scope of FinTech services, it creates difficulties in establishing the legislative framework to indicate the boundaries of supervisory controls, and in establishing equal conditions of competition between traditional banks and FinTech companies. If strict regulatory requirements are imposed on banking actors, FinTech firms would enjoy an unfair competitive advantage, and the lack of detailed rules also poses risks to stakeholders. If an immature solution reaches the market too soon, it may cause unexpected losses to both consumers and lenders. An excessively lenient regulatory approach may push financial intermediation into a segment where regulatory authorities only have limited influence.

After the chronological and global review, we focused our examination on three geographic areas: the European Union, China and Hungary. In our view the first two support our endeavour to identify the direction of the global financial digital development, to find similarities and differences in the approaches and ultimately to explore where Hungary stands in this process.

In the European Union, the importance of digital technology has been realised and it is considered an issue of paramount strategic, economic and social importance. The European Commission declared that the new digital technology will be a key element in the future competitive edge of the EU. This is why the European Union has been delivering on an ambitious and comprehensive Digital Single Market Strategy, which was shortly followed by FinTech Action Plan in 2018. In order to strengthen the accomplishment of these targets, the European Banking Authority published its FinTech Roadmap under the title: "Designing a Regulatory and Supervisory Roadmap for FinTech". The EBA Roadmap is an important summary of the necessary and envisaged regulatory approach related to the services provided by incumbent banks and FinTech start-ups.

The definition of FinTech used in the EU is broad, but regulators are struggling to mitigate risks and ensure fair competition. They follow a pragmatic attitude that revolves around a tiered regulatory structure, with differentiated regulatory

requirements according to the risks for the firms, their customers, the financial sector and the economy at large. In principle, the objective is to deliver "same risk – same rules" expectations.

The lack of an exact definition most probably required the present standpoint of the European Central Bank (ECB), which has stated that the regulation and supervision of FinTech services should remain – for the time being – in the sphere of national competence. This statement in itself shows how difficult it would be at present to centrally regulate this process and activity. The next challenge is how to ensure a level playing field between traditional banks and FinTech service providers. It is not easy to find a balanced solution. Another delicate problem is the question of taxation. As part of building the architecture of the EU Single Digital Market, the European Commission proposed a Council Directive laying down the rules relating to the corporate taxation of a significant digital presence.

The next chapter of this study is an overview of the FinTech approach in China, where the FinTech sector has been developing rapidly and is the world leader by several measures. The country's digital payments account for almost half the global volume and online peer-to-peer (P2P) lending accounts for three quarters of the global total. However China's FinTech sector is now at a critical juncture. Some years ago, problems emerged when risks piled up around P2P platforms and the number of underground fundraising and financing activities multiplied. This served as a lesson and a warning for the regulators and supervisors, and their changing attitude is moral and instructive to many other countries. Otherwise, the Chinese approach is similar in many ways to that of the EU. For example, in the view of the Peoples Bank of China there is no unified approach to FinTech activities; improving the ecosystem for FinTech can help mitigate some significant risks; new ideas and approaches to improve regulation efficiency should be incorporated. In this situation a self-discipline requirement is also inevitable.

After reviewing the EU and Chinese FinTech approaches it is refreshing to present the Hungarian case. One can state that Hungary is not lagging behind even if its regulators and traditional banks face similar tasks as in the EU or China. We relied on the latest surveys of the Hungarian Central Bank. There is a promising process to integrate innovative products and solutions in banking operations.

Banks in Hungary are confident that they will continue to play a central role in financial intermediation. On the other hand, the overwhelming majority of FinTech firms are in regular contact with banks or have turned to banks since their launch. According to the result of the MNB survey, the active involvement of regulators and supervisory authorities is necessary to promote competition or cooperation between various market participants and new entrants.

According to the Hungarian banking community, digitalisation is a tremendous challenge and pressure for renewal for the banking sector. Many of those who are 20 or 30 years old today will not visit a branch offices, but rather conduct all their transactions on their mobile phones. Client attitudes and behaviour will change, the importance of branches will decrease, and the importance of technology will increase. One general, real risk is that the role of some banks will be taken over by new actors, for instance payment service providers.

The title of this study was inspired by a famous book by Aldous Huxley (1894–1963), "Brave New World", published in 1931. Huxley, while ironically criticising the consumer society, manipulated and ruled by the world of machines, tried to forecast the future of mankind. A great part of his vision mixed with science fiction and scientific elements became reality in the following decades. One may even say that a better a brave new world was built up on the basis by the world of machines.

We are not evangelists, we are not trying to predict the final outcome of the digital financial transformation, but we do believe that this development might present mankind with positive changes. However banking and financial services are one of the most important elements of the economy and of society as a whole, and therefore we must carefully scrutinise FinTech developments. It must be seen if there are risks, how these can be controlled or mitigated.

Almost one hundred years after the beginning of the third industrial revolution, philosophers were still trying to summarise the relation between machines and human beings and to present their view of the impact of the machine age on human thinking and behaviour. In our view, these questions are or could be justified in the age of digital transition and are also valid when assessing the metamorphosis of traditional banks and their clients. At the end of the day, FinTech should serve a better life for human beings.

At this point, we sum up the major conclusions of our analysis. We can conclude that FinTech is in the initial phase of a rapidly changing and expanding global "revolutionary" development process. It is therefore in the era of disruptive changes, and the time of a calm, predictable development has not arrived yet. Although investments in FinTech have been expanding very rapidly in financial markets, their potential impact on banks and financial institutions is still far from clear. The tension between stability and competition underlies the entire debate over FinTech and how to regulate it, be it in the European Union, China or Hungary.

We can state at this point in the development process that financial technology is proceeding rapidly, and the definition of this subject is broad and changing. Because of the fast changes regulators and supervisors are not ahead but rather trying to catch up with this process. The broad and mostly permissive definition

makes it more difficult to ensure equal competitive conditions and a level playing field between traditional banks and FinTech start-ups, and in practical terms this means that banking regulation and supervision are more strict.

The relationship between traditional banks and Fintech start-ups is developing and changing. Several attributes characterise the possible relationship between traditional banks and FinTech companies, such as fatal attraction or dangerous liaisons. The acceptance is also different: evangelists loudly welcome the developments, while sceptics are cautious.

Whatever the outcome of the FinTech development is, the analysis above shows that we are witnessing a very fast and inevitable process, which has global and competitive implications. This paper was also focused on the wish for a better understanding of the FinTech phenomenon and the possible relationship between traditional banks and FinTech start-ups. In our view banks and FinTech firms have more common business interests than issues that divide them.

Even in the background of this digital development there are human beings, and therefore one great question is how will the society be transformed during and after the digital revolution. Retrospection sometimes helps to understand the future of present developments. Let us support our idea with the following quotation from Karl Jaspers: "The everyday complexity of the world flooded by technology forces us to reign over the world in the environment (Umwelt) that is accessible for us. Relationship to things has changed; things moved away from us, became indifferent while taking the form of unchangeable factors; technology has cut off man from the immediate presence. The new task that needs to be accomplished is that with the aid of technical creations to re-find the direct existence for all things that make up the world. The new conditions created by the development of technical possibilities should be applied in the service of man" (*Jaspers 1946*).

Several economists have claimed that digital is the new normal. We suggest putting a question mark at the end of this statement. In this time of rapid changes we do not know what the final shape of "the new normal" will be. "In the news, financial technology is described as 'disruptive', 'revolutionary', and armed with 'digital weapons' that will 'tear down' barriers and traditional financial institutions" (*World Economic Forum 2017*).

One may ask whether society and the economy are prepared or ready to face these challenges. The answer is no. All of the actors have responsibility: the central banks, regulators, supervisors, incumbent banks, consumers and FinTech companies alike. All of the regulators and supervisors are following the stormy development, applying a pragmatic definition, trying to ensure a level playing field for the main actors; incumbent banks and FinTech companies are testing each other and the

market, while working on more and more new FinTech applications. Consumers are happy about quicker, cheaper financial services, but they require safety from their traditional banks, and mostly have trust and confidence in the incumbent banks.

Most of the central banks and regulators warn about potential risks. Risk assessment is not easy in this rapidly changing world. Sometimes "machines" collect and evaluate the data for risk assessment. Earlier we mentioned that information is power. Regulators must strictly ensure that the digital data holdings of FinTechs and financial service providers are not misused against the customers.

The rapid development of FinTech services have also been supported by a grace period. By this we mean that the global financial sector has now enjoyed almost a decade of peaceful development. The real measure of the possible risks will emerge when a new recession or crisis period arrives. The financial sector should be prepared.

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Integrity of Financial Benchmarks*

Dániel Béres

This study presents how financial benchmarks have become beacons for the world of economy and finance. Through the example of the Budapest Interbank Offered Rate (hereinafter: BUBOR), the study evaluates the practical applicability of the methods that may be used to prevent or detect attempts at manipulating interbank rates used as financial benchmarks. It points out that a payment system-based financial benchmark model could contribute significantly to eliminating the manipulation risk associated with the fixing of benchmark rates. The author reviews the extent to which the given benchmark (BUBOR) is exposed to potential manipulation attempts in two different periods, each comprising 6 scenarios. He finds that a low interest rate environment and the low standard deviation of the fixing submissions combined with the methodology applied essentially reduced the manipulation potential to almost zero. This also means that in periods of less volatile fixing submissions it is justified and substantiated to reduce the resources spent on supervising and auditing the production process of benchmark rates. Introducing specific methods may prompt an adjustment on the part of the banks contributing to the fixing (panel banks), which may weaken or strengthen the efficiency of the method concerned.

Journal of Economic Literature (JEL) codes: B25, B26, C10, C52, D53, D69, G28

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1. Introduction

In Hungarian literature, interbank benchmark rates are often referred to as beacons for the financial community (*MNB 2000*; *Erhart – Mátrai 2015*; *Horváth et al. 2017*). This picturesque expression could not be more appropriate, as interbank rates exert an impact, whether directly or indirectly, on the price of numerous financial instruments. Accordingly, besides playing an important role in the implementation of monetary policy, they also carry key significance for market participants.

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Owing to their special nature, we rightly view benchmark interbank rates as public goods (*Horváth et al. 2017*) nowadays. Setting these rates requires active participation on the part of market participants. Similar to *Hardin's* (*1968*) concept, the tragedy of the commons phenomenon in relation to interbank reference rates arises from overuse. In this case, however, it is not the public good that loses its value (i.e. disappears) but the incentives to transform public good into private interest increase in number or change their nature. To put it simply, the greater the number of financial instruments whose pricing and value depend on the benchmark rates, the stronger the incentive to influence (manipulate) reference rates.

The LIBOR scandal erupting in 2008 around the London Interbank Offered Rate drew the supervisory authorities' attention to the vulnerability of financial benchmarks. As a result, the regulatory wave unravelling in the wake of the financial crisis could not ignore the need to strengthen the integrity of rates used as benchmarks.

This study aims to show how interbank offered rates have become beacons for the world of economy and finance, and to evaluate, through the example of the Budapest Interbank Offered Rate (hereinafter: BUBOR), the practical applicability of the methods that may be used to curb or detect attempts at manipulating interbank benchmark rates. The article also aims to launch a debate on a payment system-based model, which could, to a large degree, eliminate the manipulation risk arising with respect to the calculation of reference rates.

The first half of the study describes the evolution of interbank rates using LIBOR as an example. The second structural part describes the procedure developed for defining the manipulation potential of the interbank rate, and proposes a number of methods which may be applied to mitigate the manipulation potential or detect it once materialised. Subsequently, the practical applicability and efficiency of the methods discussed will be tested using BUBOR as an example. The paper ends with a summary of the author's conclusions.

2. Financial benchmarks and the manipulation incentives

In order to understand the incentives to manipulate interbank rates, it is important to shed light on the circumstances that led to the development of interbank rates and to grasp the original purpose of these rates. This chapter puts this topic in a historical context.

2.1. The development of interbank reference rates

The years following the end of the Second World War saw substantial capital flows (around USD 12 billion) from the United States to (Western) European countries, primarily within the framework of the Marshall Plan (*Tarján 2018*), which paved the way for dynamic growth in the countries concerned. By the beginning of the 1960s,

excess liquidity had accumulated in the Western-European and North-American banking sectors, which enabled the banking industry to shift its focus to riskier foreign investments. In addition to the upswing in trade and the abundant liquidity mentioned above, the dynamic rise of dollar-based lending was another important indicator of the international capital flows. This lending, however, fell outside the scope of the regulatory regimes applied both in the United States and in Europe. Interest collection (in the form of non-interest-bearing deposits) was practically unrestricted, and capping interest rates on deposits did not apply in the Eurodollar market (*Altunbas et al. 2006*).

The emergence of the Eurodollar market combined with the relative price stability that characterised currencies under the Bretton Woods system (*Borszéki 2009*) collectively provided fertile ground for international private investments. Internationalisation, however, also implied increased risk. Syndicated loans were created to mitigate this risk. Banks with abundant liquidity at their disposal were in a position to grant loans to foreign entities (mainly non-resident banks) while also being able to mitigate their own risks as well as lending costs. In syndicated lending a single bank (*administrative agent*) is designated to pool the funds and carry out the administrative tasks associated with the loan. Accordingly, the lending costs and lending risks are shared by a syndicate of lenders; moreover, smaller creditors for whom such lending was previously out of reach on their own may also join the syndicate. Repayment risk could be reduced even further if the country of the syndicate's administrative agent had close economic ties with the borrower's country, because this diminished the political risk associated with the repayment. Not only creditors but also borrowers enjoyed the benefits of syndicated loans, given that the level of lending costs was no longer determined by a single creditor (*Gadanecz 2004; Altunbas et al. 2006; Gyntelberg – Wooldridge 2008; Ridley – Jones 2012*).

Since syndicated lending was popular both among creditors and borrowers, both the market and the volume of syndicated loans grew dynamically (*Altunbas et al. 2006*), which deepened the relationships between the banks involved in syndicated lending.

The pricing structure of syndicated loans largely comprised three types of component. There were "permanent" fees, such as legal and administration costs, the creditor's funding costs, and a "spread" for profit (*Gadanecz 2004; Ridley – Jones 2012*).

In practice, in full awareness of the permanent fees of the agent bank, shortly before the lending transaction the creditors indicated their lending intention and their funding costs for the given transaction to the agent bank. The volume-weighted average of these costs plus the profit (spread) on the weighted average became the

price (interest level) of the syndicated loan. In fact, it was the weighted average of the funding costs of banks participating in syndicated lending that was first called the London Interbank Offer Rate, or LIBOR.

Due to the weighted average there was initially no incentive to underreport the fixing rate because any bank that submitted unreasonably low funding costs could have done so only to the detriment of the others, and was therefore ejected from the syndicate (*Ridley – Jones 2012*). There was no cap on the interest rate level (or more precisely, only market demand could put a limit on the rates). The interest rates were renegotiated every three or six months.

In 1986 the British Bank Association took control of the LIBOR calculation and renamed the rate BBALibor (British Bank Association London Interbank Offered Rate). The goal was to formalise the process of collecting interbank rates and to boost efficiency, transparency and governance (*Ridley – Jones 2012*). It was this process that made LIBOR a publicly available and widely used benchmark.

2.2. Appearance of manipulation incentives

Parallel to the rise in syndicated lending, banks were also keen on investing the largest possible portion of their own assets in the same way because the profits achievable through syndicated lending were higher than what could have been obtained by lending the same amount in their own country in accordance with the relevant (income-limiting) domestic regulations, at full risk costs and lending costs. In other words, the return on equity was maximised, which is understandable or necessary in the case of profit-oriented organisations. Banks' operating costs were increasingly financed from cheap external (mainly domestic) funds. This led to a situation where, thanks to the abundant liquidity, banks operated on cheap domestic funds while they realised higher than ever returns on equity through syndicated loans granted to foreign borrowers. Of course, the demand created by the export market of syndicated loans was far higher than the banks' capacity to supply. This increased the popularity of syndicated lending even further, since its profitability was able to remain high and stable. As banks increasingly borrowed their own funding from external sources, they had a growing interest in keeping their cost of funds at low levels. Ultimately, this process provided the incentive to push LIBOR rates as low as possible (*Ridley – Jones 2012*).

The innovation of financial products provided another impetus to the manipulation incentives. By the end of the 1970s the global economy had been through two oil crises and the gold standard system was long since consigned to the past as well. Accordingly, risks had also changed at the international level: the surge in oil prices gave rise to inflation which, in turn, raised interest rate and exchange rate risks to previously unseen levels. Interest Rate Swaps (IRS) and Forward Rate Agreements (FRA) were specifically developed with a view to mitigating these risks.

Trading in IRS began in 1981, while the first FRA contract was concluded in 1983 (*Kuprianov 1993*; *Farkas et al. 2004*; *Gyntelberg – Wooldridge 2008*). Floating rates play an important role in both transactions; they determine whether a transaction is settled with a gain or a loss for the investor. Initially, floating rates were represented by various indices, which were gradually replaced by LIBOR after it officially commenced in 1986. As a result, on the one hand LIBOR practically became the most important benchmark rate, while on the other hand key IRS and FRA trading days created a new incentive to manipulate the interest rates[1]. In all fairness, it should be noted that a number of other important financial benchmarks co-existed with LIBOR; however, LIBOR's status as the most recognised and most widely accepted rate was unquestionable.

Last but not least, it should be mentioned that the pricing of an increasing number of products was – and still is – linked to interbank rates in view of the interest rate risk involved (e.g. the interest level of mortgage loans or corporate credit) which, similar to the derivative transactions referred to above implies additional manipulation incentives with respect to the interbank rates (and thus LIBOR).

2.3. Manipulation of LIBOR and the counter-measures taken – the regulatory environment

Interbank benchmark rates came under the scrutiny of regulatory authorities for the first time in 2007 in relation to the manipulation scandal unfolding around LIBOR. It was in that year that Barclays alerted the US money market supervision that certain banks may be manipulating the value of the London Interbank Offered Rate LIBOR (*Cutler – Ridley 2013*). In order to rig the LIBOR rate, some banks submitted dishonestly low interbank rates. At the global level, however, the scandal erupted only in 2008 in the wake of a revelatory article published in *The Wall Street Journal* (*Mollencamp 2008*). The investigations launched in response to the LIBOR scandal found that the manipulation of LIBOR went all the way back to 1991 – since that year the 11 banks named in the conspiracy had manipulated the value of LIBOR on a regular basis (*Fliszár 2016; Cutler – Ridley 2013; Mollencamp 2008*).

In an effort to clamp down on manipulation, in July 2013 the International Organisation of Securities Commissions (hereinafter: IOSCO) issued its recommendations on financial reference rates (also known as financial benchmarks) (*IOSCO 2013*). IOSCO defined a set of recommended practices primarily for benchmark administrators but indirectly, the recommendations also affect the institutions submitting the fixings for the benchmark. The 19 recommendations essentially target the following three areas:

[1] The days on which traders settle the deal at the prevailing interest rate level.

1. Integrity of the data used for constructing the benchmarks should be protected.
2. Adequacy and transparency of the methodology used to make benchmark determinations should be ensured.
3. Conflicts of interest should be identified and eliminated and appropriate controls applied.

All three objectives are intended to ensure (restore) the reliability of financial benchmarks.

In the European Union, the requirements of benchmark determination were laid down by law on 8 June 2016 when the so-called Benchmark Regulation[2] (hereinafter: BMR) entered into force. The provisions of the BMR are directly applicable to both administrators – institutions responsible for calculating the reference rate – and contributors – institutions reporting their rates – in all Member States of the European Union.

3. Methods for preventing and detecting manipulation of interbank benchmark rate submissions

The BMR Regulation sets out numerous provisions that are intended to ensure the reliability of interbank reference rate submissions while curbing the incentives for their manipulation. One such provision, for example, is the requirement for the contributor to keep and preserve retrievable records of all external and internal communications of the persons participating in the fixing process (the contributors and the endorsers of reference rates). At the same time, no matter how strict the legislative provisions, they will never fully guarantee that the submissions are free of manipulation; they merely raise the potential costs of the intention to manipulate. For example, the recording of an institution's official communications may be circumvented by phone conversations on an employee's personal phone or by informal discussions in lunch breaks. Since controls involve costs which should be kept at a reasonable level, the preferred methods should be those that are likely to prevent manipulation or signal suspected manipulations of the benchmark rate. By doing so we can avoid the creation of unnecessarily long lines of defence.

However, it should be pointed out at the start that any method described below – irrespective of whether it was adapted from literature or reflects the author's own thoughts – is only suitable for signalling suspected manipulations or reducing the probability of manipulation occurring, as changes in the value of the reference rate

[2] Regulation (EU) 2016/1011 of the European Parliament and of the Council of 8 June 2016 on indices used as benchmarks in financial instruments and financial contracts or to measure the performance of investment funds and amending Directives 2008/48/EC and 2014/17/EU and Regulation (EU) No 596/2014.

may be – and are – influenced by the liquidity positions, strategic objectives and applied monetary policy instruments of the banks participating in the submission process of interbank benchmark rates (*Gereben 2000*).

The methods below are presented irrespective of whether they are applied by the administrator, the contributor or the external auditor.

3.1. Definition of manipulation potential

In their study, *Eisl et al.* (*2017*) examined the manipulation potential of interbank benchmark rates in such a way that they set the lowest LIBOR fixing rate of the current day equal to the highest observed fixing rate. With this scenario the authors attempted to simulate how much a single bank could move the value of the benchmark rate if it intended to manipulate it. The value of the manipulation potential was derived as the difference between the value of the original LIBOR and that of the modified LIBOR. In the context of this study the model constructed by *Eisl et al.* (*2017*) was adapted and applied under a number of different scenarios.

3.2. Trimmed mean (trimming procedure)

The LIBOR value was initially computed as the weighted average of the cost of funds of participants in the lending syndicate and the sizes of loans granted by them. After the first official publication of LIBOR in 1986, the weighting no longer had a base; consequently, it was removed from the methodology and the interbank rate was ultimately calculated as the arithmetic mean of the submissions. However, the drawback of the simple arithmetic mean method is that it is extremely sensitive to outliers. In practice, this means that even a single bank can alter the value of the interbank benchmark rate potentially significantly.

The trimming procedure is designed to eliminate this possibility. Essentially, this method means that in order to prevent outliers from skewing the mean excessively, the highest and lowest submissions (or a certain percentage thereof) are discarded from the calculation of the mean, and the resulting mean will be the final value of the official interbank benchmark rate.

In their study, *Eisl et al.* (*2017*) tested the efficiency of the trimmed mean. They sought to measure the extent to which underreporting (where the bank's submitted fixing is below the mean, i.e. the interbank offered rate) can move the value of the interbank rate. They demonstrated that the trimming procedure significantly improves the reliability of the benchmark rate, yet despite using a trimmed mean, manipulation by even a single bank could result in a shift in the interbank reference rate which, according to the authors' calculations, may amount to 0.48 basis points in the case of the 3-month USD LIBOR and 0.17 basis points in the case of the 3-month EURIBOR. This value grew progressively where several panel banks acted in concert to modify the submissions. The authors found that increasing the number

of contributors reduced the manipulation potential substantially. The study by *Choy et al.* (*2012*) confirms these findings: even a single bank can influence the reference rate despite the trimming procedure.

From an audit perspective, one key finding of *Eisl et al.* (*2017*) is that given the volatile nature of individual banks' submissions – underreported and overreported rates – detecting manipulation immediately is close to impossible.

3.3. Median fixing

In the course of median fixing, contributors (banks) submit the required data (fixings) to the administrator. The administrator institution puts the fixings in ascending order. The reference rate, in this case, will be the median of the submitted rates; i.e. the one that divides the data arranged in ascending order into two equal parts (with an even number of contributor banks, the value of the reference rate will be the simple arithmetic mean of the two fixings in the middle).

The analysis by *Eisl et al.* (*2017*) demonstrated that the median method reduces the potential for manipulation to a minimum (to one third compared to the value received for the trimmed mean method).

3.4. Dynamic extreme value analysis

The dynamic extreme value analysis examines the absolute difference between current day fixing submissions and fixing submissions on the previous day. The fixing submissions of the contributors with the highest absolute change (either in a positive or negative direction) compared to the previous day are discarded from the calculation of the reference rate. In this respect, the reference rate computed on the basis of the dynamic extreme value corresponds to a kind of trimmed mean.

One potential benefit of the method is its ability to screen for one-off effects whereby the value of the reference rate will flatten out across individual days. Such a one-off effect can be a data error or even an exceptional liquidity position of the contributing institution.

Under the dynamic extreme value analysis approach, a reporting agent can only manipulate if it keeps its submissions continuously within a value range that could be acceptable for it on a given day. In this case, however, the probability of being caught (in other words, the transaction cost of the manipulation) increases.

3.5. Analysis of the pricing of correlating products

According to Monticini – Thornton (*2013*), if the interbank reference rate is manipulated, there will be a positive or negative difference between the benchmark rate and the pricing of a product with a correlating return. In their paper, the authors explore the correlation between LIBOR and the yield on Certificates of Deposit

(CDs). Based on their hypothesis, there is a near-identical difference between LIBOR and CD rates over time (expressed in basis points); in other words, the correlation between the two points to a fairly constant difference (spread) that has a constant standard deviation. A marked change in the spread between LIBOR rates and CD rates (a mean value computed from the time series of the LIBOR – CD spreads) may signal a manipulation of the reference rate. Processing data for the period between 2004 and 2010, the authors found evidence that the spread between LIBOR rates and CD rates increased in the case of misreporting, and that after the manipulation the LIBOR – CD spreads eventually returned to their pre-underreporting levels. *Brousseau* et al. (*2009*) came to a similar conclusion in relation to the Overnight Index Swap (OIS) and LIBOR.

The method is suitable for ex-post audits, and an active market for the correlating product is an important prerequisite for its application.

3.6. Outlier analysis

The outlier analysis may be used to examine two aspects: firstly, the change in contributors' fixing submissions relative to their previous fixing submissions, and secondly, changes in the fixing submissions relative to the benchmark rate. When the difference between the current day fixing submission and the base date fixing submission exceeds a certain level, manipulation or error can be suspected in both cases, and the value of the current day fixing submission should be inspected.

The difference that triggers such an action once it has been exceeded can be defined using a number of approaches. The first and perhaps simplest procedure is to set a pre-defined time horizon which will be considered for the calculation of the standard deviation (with respect to the calculation of the standard deviation of an institution's own submissions and that of the benchmark rate). If the absolute value of the current day difference exceeds the standard deviation or twice the value of the standard deviation, the current day submission should be considered an outlier. Accordingly, the standard deviation should be defined every day for an identical horizon (lookback period), and the value of the current day submission should be compared to that.

A less dynamic solution is to define the standard deviation based on a longer time series (e.g. 10 years). The advantage of this method is the likelihood of having both stressed and unstressed periods, as well as low and high interest environments in the calculation. For longer time series, in view of the higher standard deviation value, the size of the change should be compared to only a fraction of the deviation.

It is a somewhat more sophisticated method to define the percentage of the submissions that should be brought under scrutiny. In that case, the change in the value of a fixing can be determined based on historic data in such a way that a pre-

defined percentage of the cases (the percentage that should be inspected) falls within the range. Despite its sophistication, the disadvantage of the latter method is its reduced ability to signal potential manipulation because it may also include cases where the change between the submissions of the two days is insignificant.

A common trait of these methods is their need to select the lookback period – the period to be considered for the purposes of the calculations – appropriately. Therefore the models presented here need to be calibrated before application.

3.7. Analysis of fixing dynamics

The analysis of fixing dynamics examines the rate at which an individual contributor submitted a rate which eventually ended up above or below the current day value of the benchmark. The differences between fixing contributing banks may result in the emergence of typically 'underreporting' or 'overreporting' banks. Obviously, this does not mean that this is always the case over the short term, so analysing fixing dynamics may be useful to identify signs of manipulation based on certain patterns. While this method is less objective in this regard, applying it together with other methodologies may be an efficient tool in signalling potential manipulation or confirming suspected manipulation. In addition, an analysis of fixing dynamics provides information about the liquidity of the contributors and about the extent to which liquidity is concentrated in the market.

3.8. Analysis of trading days that impact asset pricing

The greatest risk associated with misreporting the benchmark interbank rate arises with respect to the key dates on which derivative transactions are settled if an employee of the contributing institution is simultaneously authorised to conclude derivative contracts, because this allows the trader to influence the outcome (profitability) of his deals through the fixing submission. The manipulation risk associated with the trader involved in the derivative transaction is reduced if the counterparty in the given transaction is also a contributor in the fixing procedure of the benchmark rate, given that it will have a conflicting interest. However, the risk is exacerbated if traders who also act as contributors conclude a contract with a party who does not submit fixing rates.

In addition to the above, the days on which assets are substantially repriced at the contributing bank based on the interbank offered rate also carry risk in an indirect way. Such a case, for example, can be when the interest rate on the bank's (or all banks') housing loan or corporate loan portfolio is repriced on the same day (e.g. the 2nd working day preceding the end of the month[3]).

[3] Pursuant to Section 17/D (1) of Act CLXII of 2009 ("Fair Bank Act"), where loan contracts are tied to reference interest rates, the reference rate shall be adjusted at intervals aligned with the tenor of the reference rate defined in the loan contract to the reference rate effective 2 days before the last working day of the month preceding the anniversary date.

Based on the above, the essence of the method is to inspect the fixing submissions of the days that coincide with the settlement day of derivative transactions or with the days of large-scale asset repricing actions.

It should be noted and stressed emphatically that the mere fact a bank 'overreports' or 'underreports' the fixing on such key dates does not automatically mean that it is trying to rig the rate, because submissions are also influenced by market specificities, a bank's liquidity position and current monetary policy instruments. With that in mind, fixing submissions on such key dates should always be examined ex-post, on a time series basis and focusing on their trends.

Apart from the above, we refrain from discussing this method in further detail in this study as the data required to apply it, are not publicly available.

3.9. Cluster analysis

Choy et al. (*2012*) examined whether applying a multivariate statistical approach can be used to detect manipulation and collusion between banks. With a hierarchical cluster analysis on LIBOR submission data between 2005 and 2012 they successfully detected the cases where a bank's submissions differed excessively from those of the others (i.e. it misreported its funding costs). In the authors' view, the method may be suitable for identifying well-concerted interbank collusions. Indeed, in the case of concerted manipulation, the cluster analysis classifies colluding banks into the same group. The co-authors also warn not to draw definitive conclusions from the dendrogram (grouping) that illustrates the results of the cluster analysis, even though it is suitable for pointing towards potential manipulation. This is consistent with the wording of *Sajtos – Mitev* (*2007*), who indicated that cluster analysis is primarily an exploratory technique.

In practice, grouping with a cluster analysis should be performed based on two or more different distance and similarity measures. If two contributors display similar submissions consistently, the two different techniques will yield nearly identical results. Since collusion (manipulation) may be suspected in this case, further investigation is required.

One drawback of the methodology is that its applicability is limited to complete time series. Consequently, if a contributing bank appears or disappears within the review period (in other words, there is no full time series for the institution concerned), it needs to be excluded from the analysis. Moreover, the method is sensitive to outliers, which means that some procedure needs to be applied to address the outliers before the analysis.

3.10. Payment system operators as benchmark rate administrators

Defining the benchmark rate through the payment system is a new approach. Assuming that interbank rates are calculated on the basis of unsecured interbank loans, actual transactions executed via high-value payment systems provide the information required for setting the benchmark rate; consequently, the payment system operator can play the role of the benchmark rate administrator. In the case of the European Central Bank, the Euro Short-Term Rate (ESTER) – which is based on the high-value TARGET2 payment system – serves as such a reference rate (*ECB 2018*). A slightly different approach was proposed in the United States by *Frost* (*2017*) in relation to the Secured Overnight Financing Rate (SOFR). The difference is that Frost proposes to obtain the data required to produce the benchmark rate from a data repository rather than through the payment system.

In this context, the manipulation incentive will be eliminated on the bank side as the interbank offered rate is determined on the basis of actual transaction data. From a social optimum perspective, this could also reduce the resources expended by market participants and supervisory authorities to verify the integrity and market conformity of the submissions.

4. BUBOR

In this chapter, we present the methods discussed in detail in the previous chapter through the example of the Budapest Interbank Offered Rate (BUBOR), limiting the methods to those where sufficient data were publicly available.

4.1. Tenors under review

At the time the study was prepared, in its capacity as the administrator of BUBOR, the MNB published official BUBOR rates for nine tenors (maturities): overnight[4], 1 week, 2 weeks, 1 month, 2 months, 3 months, 6 months, 9 months and 1 year. Due to the limited scope of this study, we only address overnight fixings below; but the methodologies applied can be used for all tenors, including the 3 and 6-month tenors[5].

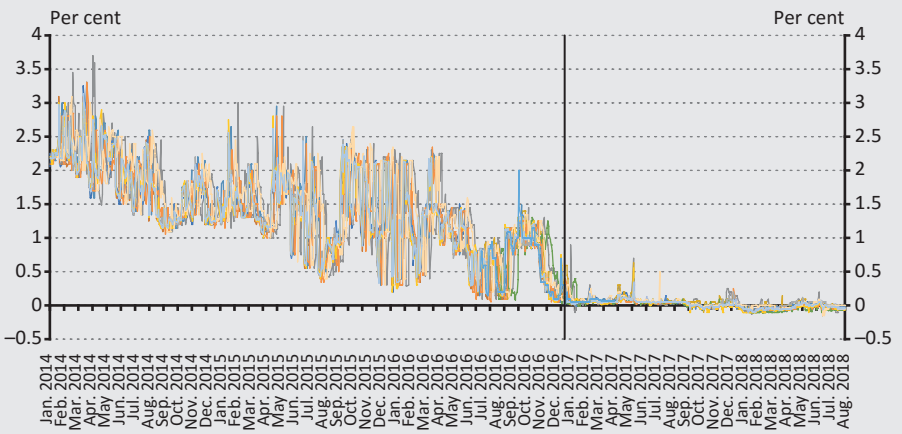
4.2. Period under review

The BUBOR time series was available – through REUTERS – from January 2014 to 15 August 2018 at the time this study was written; so this entire period was processed. Two periods should be examined separately within the review period because, given the near-zero interest environment, the standard deviation of BUBOR fixings decreased sharply compared to the preceding period from the beginning of

[4] O/N
[5] In their study, *Kocsis et al.* (*2013*) demonstrated that the 3 and 6-month tenors play an important role in the interest rate derivative market.

2017. The review period is therefore split into a pre-2017 and a post-2017 period (*Figure 1*).

Figure 1
O/N BUBOR fixings (individual panel bank submissions)
(January 2014 – August 2018)



Source: Based on REUTERS data

4.3. Mean, median, trimmed mean and trimmed median fixings

Based on *Eisl et al.* (*2017*), we sought to explore the manipulation potential of the interbank offered rate in the case of overnight unsecured interbank offered rate submissions as well. At the same time, however, in addition to 'underreporting', we also included the 'overreporting' potential in the analytical framework. Accordingly, the 'underreporting' and 'overreporting' potential was established for the two distinct periods, each comprising 6 scenarios as follows:

- collusion of three banks for overreporting;
- collusion of two banks for overreporting;
- overreporting by one bank;
- underreporting by one bank;
- collusion of two banks for underreporting;
- collusion of three banks for underreporting;

The mean, median, trimmed median and trimmed median values of the submissions were calculated under each scenario. Trimming was performed in accordance with the BUBOR Regulation in effect since 1 January 2018 (*MNB 2018*). Based on the calculations, the less the manipulation altered the originally computed result on average, the better the given method performed. *Table 1* summarises the results.

Table 1
Manipulation potential of O/N BUBOR according to methods applied

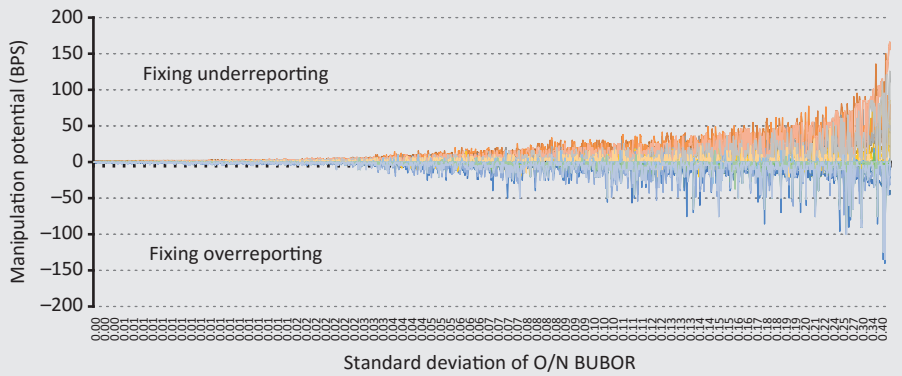
BUBOR O/N manipulation potential	High volatility of fixing submissions				Low volatility of fixing submissions			
	Difference (bp)		Name of method		Difference (bp)		Name of method	
	min	max	best	worst	min	max	best	worst
Overreporting (3 banks)	–9.64	–12.70	Trimmed median	Mean	–0.02	–2.06	Mean	Trimmed median
Overreporting (2 banks)	–5.46	–10.09	Trimmed median	Mean	–0.01	–1.21	Mean	Trimmed median
Overreporting (1 bank)	–0.92	–7.28	Trimmed mean	Mean	–0.01	–0.63	Mean	Trimmed median
Underreporting (1 bank)	1.19	7.28	Trimmed median	Mean	0.01	0.45	Mean	Trimmed mean
Underreporting (2 banks)	10.08	13.77	Trimmed median	Trimmed mean	0.02	1.11	Mean	Trimmed mean
Underreporting (3 banks)	18.16	25.27	Mean	Trimmed mean	0.02	2.02	Mean	Trimmed median

According to *Table 1*, when fixing submission volatility is low the smallest manipulation potential is produced by the arithmetic mean method, whereas the greatest manipulation potential is produced by the trimmed median and trimmed mean procedures. By contrast, with high fixing submission volatility the trimmed median method appears to be the most reliable (smallest manipulation potential) and the arithmetic mean method proved to be the worst (greatest manipulation potential). Supplementing the results of *Eisl et al.* (*2017*) we found that this manipulation potential increased in volatile periods (where the standard deviation of the fixings increased) and decreased in less volatile periods.

The values shown in the table also indicate that in the context of low fixing submission volatility, the 'underreporting' and 'overreporting' potential is nearly identical in all scenarios, whereas the 'underreporting' potential is higher in periods of high fixing submission volatility. This can be attributed to a number of reasons. The liquidity position of the panel banks (contributors) is at play as a factor, but the contributors' respective strategies should also be considered. For example, an

institution does not always wish to place its liquidity in the unsecured interbank market – in this case it will 'overreport', and according to the methodology used to measure the manipulation potential, BUBOR's value will shift downwards more sharply. A summary of the manipulation potentials calculated for each scenario under review clearly shows that the underreporting manipulation potential is stronger (*Figure 2*).

Figure 2
Manipulation potential of O/N BUBOR submissions in function of the standard deviation of the fixing submissions in each scenario under review



Note: Individual colours mark individual scenarios.

Last but not least, there is evidence that median-based fixing is more likely to reduce the manipulation potential when the trimming procedure leaves a greater number of bank submissions in the calculation basket. There is no exact number to show how many institutions should submit rates in order to reduce the manipulation potential to the minimum under median-based submissions. At the same time, with the median calculation methodology it is expedient to have a selection basis include at least three banks' submissions after the trimming procedure, which means that lined up in ascending order, the value in the middle would be the value of the benchmark.

4.4. Dynamic extreme value analysis

Since the dynamic extreme value analysis corresponds to a trimming procedure in itself, in this case only two methods were scrutinised: the dynamic mean and the dynamic median.

Table 2
Manipulation potential of O/N BUBOR according to the methods applied

BUBOR O/N manipulation potential	High volatility of fixing submissions				Low volatility of fixing submissions			
	Difference (bp)		Name of method		Difference (bp)		Name of method	
	min	max	best	worst	min	max	best	worst
Overreporting (3 banks)	–21.25	–24.62	Dynamic mean	Dynamic median	–0.02	–2.18	Dynamic mean	Dynamic median
Overreporting (2 banks)	–16.96	–19.89	Dynamic mean	Dynamic median	–0.02	–1.32	Dynamic mean	Dynamic median
Overreporting (1 bank)	–9.97	–10.27	Dynamic median	Dynamic mean	–0.01	–0.56	Dynamic mean	Dynamic median
Underreporting (1 bank)	10.09	10.26	Dynamic mean	Dynamic median	0.01	0.59	Dynamic mean	Dynamic median
Underreporting (2 banks)	17.63	21.72	Dynamic mean	Dynamic median	0.02	1.73	Dynamic mean	Dynamic median
Underreporting (3 banks)	22.69	28.47	Dynamic mean	Dynamic median	0.02	3.19	Dynamic mean	Dynamic median

Table 2 indicates the manipulation potential of O/N BUBOR values produced by the dynamic extreme value analysis. We found that the dynamic extreme value analysis carries a higher manipulation potential when the standard deviation of the submissions is higher. It should be added, however, that applying the dynamic mean approach carries lower manipulation potential than the trimmed mean method currently used, when the standard deviation of the submissions is low.

4.5. Analysis of pricing of correlating products

Horváth – Makay (*2015*) found that BUBOR did not present any additional information compared to the base rate. Moreover, consistent with the conclusions of *Csizmadia* (*2014*), *Horváth – Makay* (*2015*) concluded that all alternative benchmarks (with which BUBOR could correlate) either had some kind of methodological deficiency (e.g. FRA rates[6]) or they had no active market (e.g. CDs). As a result, applying this method to detect potential BUBOR manipulations would be subject to strong constraints. Moreover, the effects of one-off market phenomena and monetary policy instruments should also be considered in each case, which is beyond the scope and purpose of this study.

[6] They present market expectations but do not reflect credit risk.

4.6. Outlier analysis

In the framework of the outlier analysis we compared the difference between contributors' current day and base day fixing submissions to the standard deviation of their own submissions for the past 250 fixing days and to double its value on the one hand, and to the similarly computed standard deviation of BUBOR as well as double its value (standard deviation with a 250-day lookback period) on the other. If the difference between the current day and base day exceeds the standard deviation or double its value (selected at one's discretion), there is a suspicion of manipulation and the current day fixing procedure should be inspected at institution level. The results of the outlier analysis are displayed in *Table 3* and *Table 4*.

Table 3
Number of cases to be inspected at panel bank level according to outlier analysis between 2015 and 2018
(1 standard deviation)

Change is greater than 1 standard deviation	Change is greater than standard deviation of own fixing submissions				Change is greater than standard deviation of BUBOR			
	2018	2017	2016	2015	2018	2017	2016	2015
Bank 12	1	0	11	43	8	0	11	42
Bank 14	5	4	12	43	6	4	12	41
Bank 6	7	3	16	36	22	4	16	39
Bank 1	5	2	0	0	15	6	0	0
Bank 3	3	0	11	34	3	0	10	37
Bank 13	12	3	0	0	18	7	0	0
Bank 7	2	3	8	31	2	4	8	31
Bank 10	6	4	16	37	5	7	17	39
Bank 5	0	0	12	41	0	0	12	41
Bank 11	4	3	11	43	10	4	11	43
Bank 4	0	0	0	0	0	0	0	0
Bank 15	0	0	0	0	0	0	0	0
Bank 8	0	0	0	0	0	0	0	0
Bank 16	0	0	0	0	0	0	0	0
Bank 9	0	0	0	0	0	0	0	0
Bank 2	7	2	15	27	8	3	15	33
Total:	**52**	**24**	**112**	**335**	**97**	**39**	**112**	**346**

Note: The complete time series was only available for the BUBOR quoting institutions shaded in dark-grey.

Table 4
Number of cases to be inspected at panel bank level according to outlier analysis between 2015 and 2018
(2 standard deviations)

Change is greater than 2 standard deviations	Change is greater than standard deviation of own fixing submissions				Change is greater than standard deviation of BUBOR			
	2018	2017	2016	2015	2018	2017	2016	2015
Bank 12	0	0	1	14	0	0	1	13
Bank 14	2	0	1	7	2	0	1	7
Bank 6	1	0	2	8	5	1	2	14
Bank 1	1	0	0	0	2	2	0	0
Bank 3	0	0	0	9	0	0	0	11
Bank 13	1	0	0	0	4	0	0	0
Bank 7	0	2	2	10	0	2	2	9
Bank 10	0	2	3	10	0	4	3	11
Bank 5	0	0	1	10	0	0	1	9
Bank 11	0	0	1	8	2	0	1	8
Bank 4	0	0	0	0	0	0	0	0
Bank 15	0	0	0	0	0	0	0	0
Bank 8	0	0	0	0	0	0	0	0
Bank 16	0	0	0	0	0	0	0	0
Bank 9	0	0	0	0	0	0	0	0
Bank 2	4	0	1	8	4	0	1	11
Total:	**9**	**4**	**12**	**84**	**19**	**9**	**12**	**93**

Note: The complete time series was only available for the BUBOR quoting institutions shaded in dark-grey.

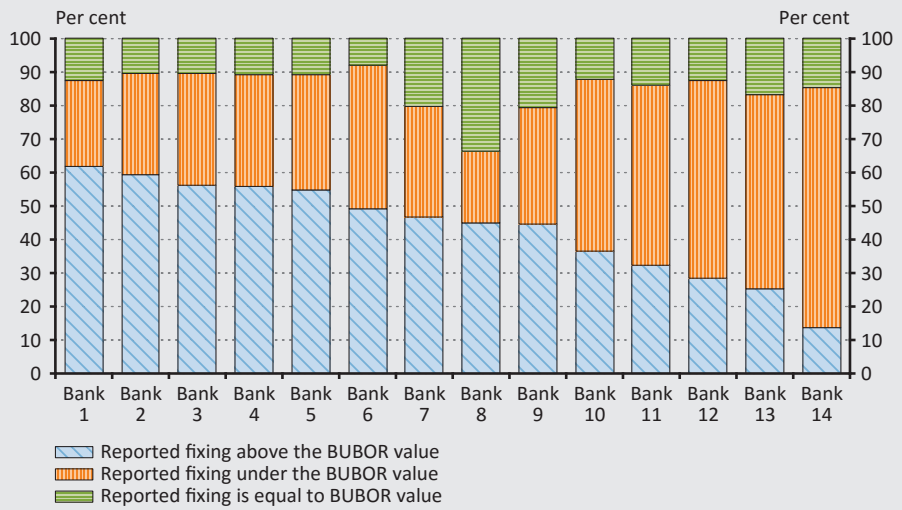
In a yearly breakdown, *Tables 3* and *4* provide a summary of the number of cases when individual contributors should have inspected the current day fixing procedure; i.e. the number of cases where manipulation could have been suspected based on the methodology.

With regard to this method, it is important to emphasise that the lookback period applied fundamentally influences the number of suspected manipulations, so the results should always be evaluated with that in mind. The 250-day lookback period applied in this article is a generally accepted horizon in risk management. Moreover, as is the case with the rest of the methods, this method only gives rise to the suspicion of manipulation and it is unsuitable in itself to serve as evidence.

4.7. Analysis of fixing dynamics

Compared to the methods presented above, the analysis of fixing dynamics is less objective as in the case of BUBOR it is more likely to reflect the liquidity position or risk management practice of the panel bank (contributor) rather than anomalies in the fixing procedure itself. The longer the horizon, the more stable the view we get regarding the individual banks. It is clearly shown on *Figure 3* which banks tended to 'overreport' and which institutions were more likely to 'underreport' the fixing in the period between 2014 and 2018.

Figure 3
Fixing dynamics of O/N BUBOR contributors between 2014 and 2018



Note: The Figure shows submissions without a tolerance band around the mean.

To detect suspected manipulation through the analysis of fixing dynamics, the long-run trend should be compared with an institution's behaviour in a selected period. When there is a marked difference between the short-term behaviour and the long-term trend, the period should be scrutinised with respect to manipulation. It is important to ensure that the shorter period reflects at least a one-month – or better still, quarterly – fixing practice, as a period shorter than this is likely to yield a marked difference. As is the case with the rest of the methods, this method in itself can only indicate a suspicion of manipulation. Considering that the result of the method is also influenced by other factors (e.g. an enduring change in liquidity position), it should therefore primarily be used as a double-checking method (when another method has already pointed to potential manipulation).

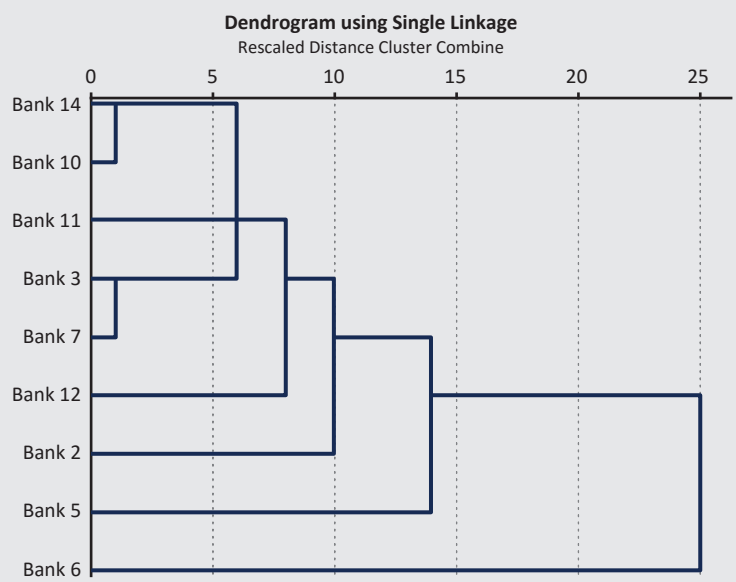
4.8. Cluster analysis

Concerted fixing submissions were examined by way of a cluster analysis, relying on two methods (nearest neighbour and Ward procedures). In examining such collusions, it is once again important to select the appropriate period. If the period selected is too long, the result will be less likely to capture any suspected collusions because other characteristics of the contributor will also be reflected indirectly (e.g. household/corporate profile). In other words, the cluster analysis should be focused on behaviour over a shorter horizon (less than 1 year but not less than a quarter[7]).

For the purposes of this study, O/N BUBOR submissions in 2018[8] were compared at each individual institution where a time series for the entire period of January 2018 – August 2018 was available.

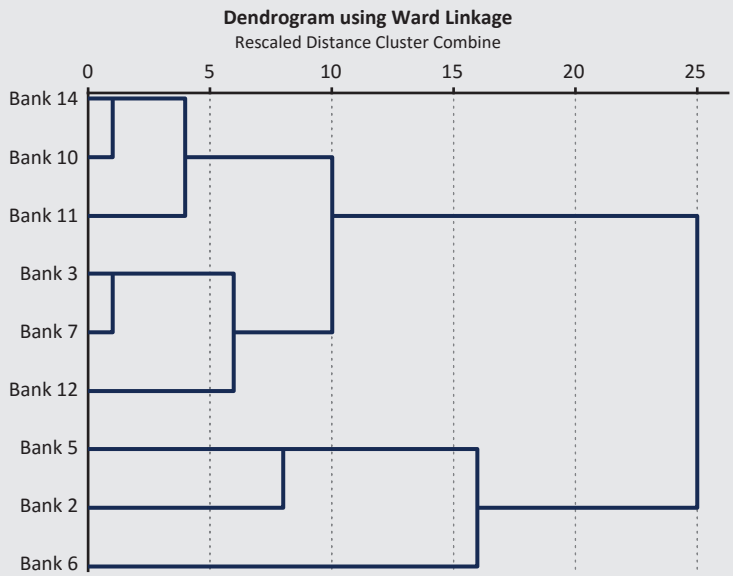
Collusion may be suspected if the submissions by two or more contributors are consistently the same when a method using various distance and similarity measures is applied. Simply, the method puts them into the same group, irrespective of the method applied. The resulting dendrograms are displayed on *Figure 4* and *Figure 5*.

Figure 4
Cluster analysis (nearest neighbour)
(Jan – Aug 2018)



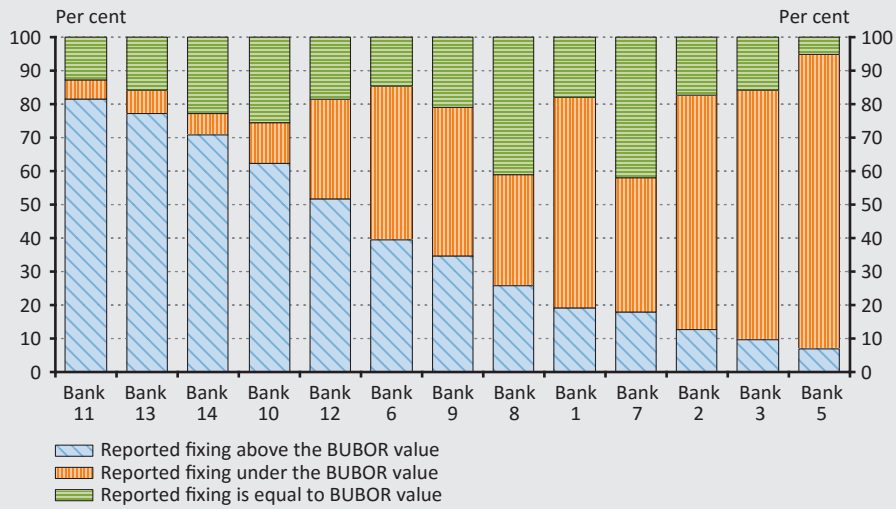
[7] Cluster analyses may only be conducted with a sufficient number of submissions.
[8] From 1 January 2018 to 15 August 2018

Figure 5
Cluster analysis (Ward)
(Jan – Aug 2018)



As the dendrograms indicate, the submissions of some institutions are identical according to both methods (Bank 10 and Bank 14, as well as Bank 3 and Bank 7); consequently, manipulation should be suspected in their case. Applying the fixing dynamics analysis for the same period – to double check – partly confirms the result of the cluster analysis, with Bank 10 and Bank 14 'overreporting' at a nearly identical rate (see *Figure 6*). In the case of Bank 7 and Bank 3, however, the correlation is not that clear: apparently, Bank 7 was far more likely to have fixing submissions consistent with the mean than Bank 3.

Figure 6
Fixing dynamics of O/N BUBOR contributors in 2018



Considering the low interest environment and excess liquidity that characterised the market throughout the review period, and the low standard deviation of the fixing submissions (partly due to the former factors), the suspected manipulation cannot be confirmed even in the case of Bank 10 and Bank 14. Based on the methodology applied by the central bank, the manipulation potential of the benchmark rate would not be significant in quantitative terms even in the case of collusion between two banks (*Table 5*).

Table 5
Manipulation potential under trimmed mean and low fixing volatility

Trimmed mean	Manipulation potential (basis points)
Underreporting manipulation (3 banks)	2.02
Underreporting manipulation (2 banks)	0.94
Underreporting manipulation (1 bank)	0.38
Overreporting manipulation (1 bank)	–0.63
Overreporting manipulation (2 banks)	–1.21
Overreporting manipulation (3 banks)	–2.06

Based on the above we may conclude that the cluster analysis of co-submissions may be a more efficient tool if the fixing submissions underlying the benchmark rate had a higher – rather than a lower – standard deviation. In any event, also in view of the manipulation potential pertaining to the review period, we found evidence – as mentioned before – that this method, like the others, is not suitable in itself to confirm suspected manipulation.

5. Conclusions

To reduce the manipulation risk of interbank rates used as financial benchmarks to a minimum level, it is indispensable to understand the historic processes that shaped the emergence and development of reference rates. In this regard, it was *Fliszár* (*2016*) who captured the main difference between the calculation of the scandal-ridden LIBOR and that of BUBOR. As pointed out by the author, before the eruption of the LIBOR scandal the data underlying the LIBOR calculation were based on the self-assessments of the reporting institutions and in theory, the submissions reflected the cost of funds of the institutions concerned. By contrast, in the case of BUBOR the data reflected the cost of funds at which banks would be willing to grant unsecured loans to each other. Put simply, one rate was based on self-rating, while the other rated the market. In this regard, the incentive for manipulation is far higher in the case of self-assessment, whereas in the other case, the rating of partner institutions' market or partner risk also functioned as a significant counter-incentive for manipulation.

It is also important to be aware of the extent to which a benchmark rate is exposed to a potential manipulation attempt. For BUBOR, this was examined for two different periods under 6 scenarios in each period. At a low level of fixing submission volatility, the results indicated that even with the collusion of 3 banks and applying the worst method (dynamic mean) the manipulation potential was far below 4 basis points. The corresponding value calculated with the best method (arithmetic mean) was 0.01 bps. With high fixing submission volatility, a manipulation potential of 28.47 bps was yielded by the worst method (dynamic median) assuming a collusion of 3 banks, while the best method (trimmed median) produced a corresponding value of as low as 9.64 bps. It is also important to stress that BUBOR is far more likely to be 'underreported' than 'overreported'. As regards the methods applied, the simple arithmetic mean performed the best under low fixing submission volatility, while under high submission volatility the trimmed median and trimmed mean methods were the best.

Considering that manipulations of the financial benchmark cannot be detected immediately (as they occur) under reasonable audit costs, priority should be given to methods which reduce the manipulation potential on the one hand, and increase

the likelihood of detecting manipulation on the other hand. *Table 6* presents the methods applied in this article and their possible areas of implementation with respect to the data available.

Table 6
Methods that may be used to prevent and detect fixing manipulations, by possible area of institutional implementation

Name of method	Administrator	Data provider (contributor)	Supervision
Mean, median, trimmed mean and trimmed median fixings	X		X
Dynamic extreme value analysis	X		X
Analysis of pricing of correlating products	X		X
Outlier analysis	X	X	X
Analysis of fixing dynamics	X	X	X
Analysis of trading days that impact asset pricing		X	X
Cluster analysis	X	X	X

The table does not include determining the benchmark rate based on payment system data. This is because operators of high-value payment systems may appear in several different roles (e.g. administrator, central bank, supervision, etc.).

The methods applied in constructing the benchmark rate reduce the manipulation potential, while the methods that can be implemented at the institutional and supervisory level increase the likelihood of detecting manipulations.

Overall, we can state that the low interest rate environment and the low standard deviation of the fixings combined with the applied methodology essentially reduced the manipulation potential to a near-zero level. This also means that when fixing submission volatility is low, it is justified and substantiated to reduce the resources deployed on supervising and auditing the process of producing reference rates.

Last but not least, it should be noted that introducing specific methods may prompt an adjustment on the part of the contributors, which may weaken or strengthen the efficiency of the method concerned.

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Analysis of Households' Investment Decisions Based on International Data*

Eszter Balogh – Zsuzsa Kékesi – Balázs Sisak

The paper attempts to pinpoint the economic, demographic and risk-taking factors that influence households' demand for risky financial assets, using the Household Finance and Consumption Survey (HFCS) database as the basis for the analysis. From the perspective of risky asset holding, supply is also important, and therefore clustering was used to identify several country groups based on capital market features. The study mainly focuses on the countries that are, similar to Hungary, less active based on their capital market features, but the characteristics of countries with a more active capital market are also presented for comparison. In line with the empirical literature, demand for risky assets is examined using econometric tools, isolating the effect of the significant factors. Accordingly, separate logit models were created for the demand factors in the different country groups under review, i.e. those with a less mature and those with a highly mature capital market. The results indicate that income, wealth, skills and risk-taking positively influence risky asset holding, while liquidity constraints and background risks have a negative influence; the findings confirm the preliminary expectations and can be deemed robust.

Journal of Economic Literature (JEL) codes: D14, D31, E21

Keywords: income, savings, financial assets, household

1. Introduction

According to widespread empirical evidence, households' holdings contain a very low share of risky assets, for example equities, well below the theoretical optimum.[1] The theory of portfolio selection would warrant a much higher ratio of equities than what is suggested by the data. The lower ratio of equities compared to the theoretical level is characteristic of many countries, even developed ones: despite the higher returns from the risk premium, households underweight equities in their portfolios (*Zhan 2015*). A salient example for this that among households

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[1] In the paper, risky assets refer to financial instruments, and when real assets are meant, it is clearly indicated.

in the United States whose liquid instruments amount to at least USD 100,000, only half hold equities. Hungarian households' equity exposure is low even by international standards. In an international comparison, indirect equity wealth, held through financial institutions (insurers, pension funds, investment funds) is also low in Hungary, although in this respect the country lags a little less behind.

The micro-database of the Household Finance and Consumption Survey (*HFCS*) *facilitates an examination of the reasons behind the low exposure to risky assets indicated in macro data.*[2] The household-level data collection performed across the euro-area countries in three waves so far was joined by Hungary on a voluntary basis[3] in the second wave (2014); the latest survey was conducted in 2017. The survey involved over six thousand households in Hungary in both waves of data collection, and the total sample size in the second wave was over 84,000 (for more information on the sample size by country and the reference year, see *Table 5* in the Appendix). In addition to questions on households' financial assets and liabilities, the survey also covers demographic characteristics and consumption habits, and on the whole, it is the most comprehensive data collection in the European Union.[4] The data used to identify factors influencing risky asset holding were taken from the database of the survey's second wave (hereinafter HFCS).

The study attempts to identify the factors that influence whether households hold risky financial assets, which we deem to include listed equities and mutual funds. The primary objective of the analysis is to establish households' demographic, income and wealth characteristics that may play a role in their demand for risky financial assets. At the same time, we believe that in any country, households' demand is strongly influenced by the supply characteristics of risky financial assets, for example the cost of acquiring the necessary information or the typical form of corporate financing. The logistic regression involves several countries to achieve the necessary sample size and thus robust results, and this merging was performed based on supply-side features. When controlling for the characteristics of the supply side, the depth of the capital market was taken into account, which was quantified using the stock market characteristics available in the World Bank Global Financial Development database. In the end, two country groups were created based on the above: those with an active capital market and those with a less active one.[5] Overall, Hungary was grouped with countries where these supply-side characteristics are

[2] Access to the HFCS database can be gained as described on the relevant webpage of the European Central Bank (ECB) (https://www.ecb.europa.eu/pub/economic-research/research-networks/html/researcher_hfcn.en.html), after describing the research objective.

[3] In addition to Hungary, Poland also performs the survey on a voluntary basis.

[4] Nevertheless, it must be pointed out that a common problem that arises in the case of micro-level statistics is accessing the highest and lowest earners. The real issue with the wealthiest is under-reporting of income. To tackle this, most countries participating in the HFCS design the survey to ensure that wealthy households are oversampled, but the effectiveness of this varies by the different approaches (*ECB 2018*).

[5] The countries with an active capital market included the Netherlands, France, Germany and Finland, while those with a less active capital market were Lithuania, Greece, Hungary, Poland, Estonia, Portugal, Austria, Slovenia and Cyprus. The two country groups include approximately 21,000–23,000 households (*ECB 2016b*).

similar, and therefore the results of the regression for the country group containing Hungary also hold true for Hungarian households.

The second section of the paper first describes the theoretical background and then presents the studies on the factors determining risky asset holding as well as the analytical framework. Section 3 demonstrates the process of creating the country groups based on clustering, which seeks to capture supply-side factors. Finally, Section 4 discusses the model and the estimates.

2. Theoretical background and analytical framework

The theoretical framework of households' risky asset holding is based on the research on households' saving decisions on the one hand, and on the portfolio theory recommending diversification in investment decisions on the other. While household saving levels have long interested researchers, portfolio selection only later garnered considerable attention. The foundations of modern portfolio theory were laid by American economist *Harry M. Markowitz* (*1952*) in 1952, with his study "Portfolio Selection" published in The Journal of Finance. One of the most important findings of the theory is that investors seek to maximise returns and diversify during investment decisions, i.e. invest their liquid assets in several securities, to reduce the perceived risks. Initially, the results of the portfolio theory did not attract much attention, because its significance was not seen at that time. In their studies, *Sharpe* (*1964*) and *Lintner* (*1965*) used Markowitz's findings to create the capital asset pricing model (CAPM), which describes the equilibrium relationship between securities' risk and their expected return. The CAPM model confirmed that the results of portfolio theory can be applied in practice as well.

However, according to empirical evidence, investors do not diversify their portfolios in line with the theory, possibly due to information barriers and bounded rationality. Researchers also attempted to take into account practical experiences in theory. According to *Kahneman and Tversky* (*1979*), one potential explanation for inappropriate diversification is that investors perceive asymmetric risks. Prospect theory says that individuals are likely to overweight losses relative to gains. At the theory level, an attempt was made to handle this by using different elasticities on underperforming markets for example (*Bawa – Lindenberg 1977*) or by using the volatility of the underperforming market instead of the expected volatility (*Harlow 1991*). Empirical evidence also showed that investors assign much greater weight to recent events. The myopic loss aversion (MLA) theory by *Benatzi and Thaler* (*1995*) merges loss aversion with another concept of behavioural economics, mental accounting described by *Kahneman and Tversky* (*1984*). According to *King and Leape* (*1998*), households' portfolio selection decisions cannot be explained by the traditional portfolio selection model, because households do not diversify. This is partly because their consumption and investment decisions may become intermixed and managing a more diversified portfolio is more expensive.

Age may influence not only the amount of households' savings but also their composition. According to the life-cycle hypothesis, older households should increase their savings and hold less risky assets (*Cocco et al. 2005*). This is confirmed by *Bodie et al.* (*1992*), who explain that in contrast to older households, younger investors have greater labour market flexibility, and therefore they can better diversify the arising shocks. However, *King and Leape* (*1987*) found that age positively influences the probability of risky asset holding, even adjusting for the wealth effect. This is attributed to higher financial awareness, which presumably increases with age. *Paxson* (*1990*) also confirms that older households hold more stocks and argues that younger households often face a liquidity constraint, so they primarily prefer liquid assets that are considered relatively safe. According to some studies, risky asset holdings increase early in the life cycle and then decline after a while.

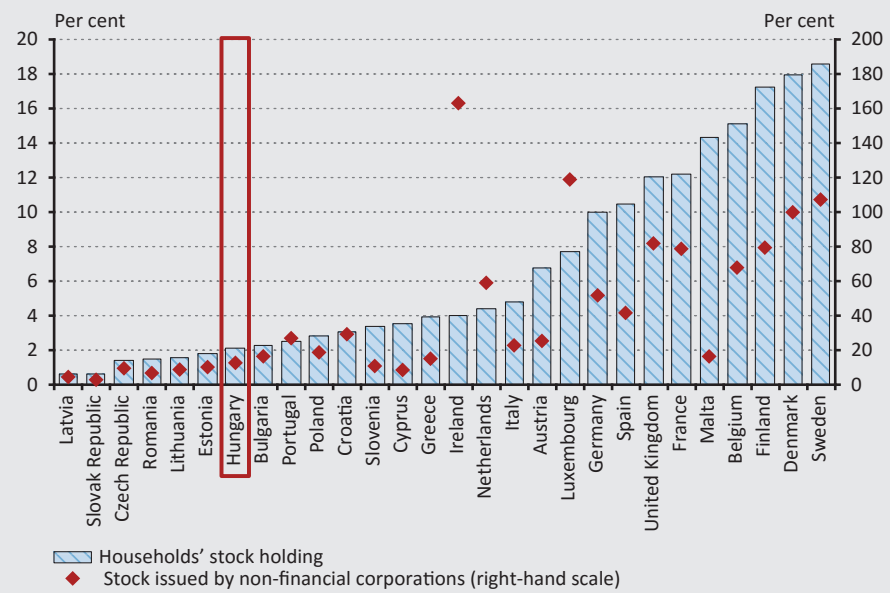
Although the theory of portfolio selection makes normative statements about households' portfolio allocation decisions, empirical research on people's decisions is still a relatively new area. The theory of portfolio selection increasingly turned towards empirical evidence as questionnaire-based surveys became widespread. The liberalisation and modernisation of the financial sector has also affected households' asset allocation: the emergence of new instruments has dramatically transformed financial markets. Researchers started focusing on micro-databases and exploring the factors that influence households' asset allocation. Most studies endeavoured to explain the share of listed equities, because according to empirical evidence, due to high risk aversion, households hold only a very low amount of equities, which cannot be explained with the standard theory of portfolio selection. In the literature, this is referred to as the «equity risk puzzle» (*Gollier 2001*).

The empirical literature most often examines households' wealth held in listed equities, which falls well short of the level expected by the theory. International empirical evidence suggests that even though a large number of households could afford to invest in equities, many of them refrain from doing so. In the European countries under review, on average only 27 per cent of the households that have a bank deposit of at least EUR 50,000 hold stocks. Within this group, the proportion of stockowners is the highest among Finnish households, at over 50 per cent, while in Greece the same figure is merely 4 per cent. Accordingly, *many households do not venture onto the equity market*. In an international comparison, Western European countries typically have a higher share of stockholding households, whereas Eastern Europe, including Hungary, has a lower share. Based on international data for 2014, the two Baltic states, Estonia and Latvia, are also in the low-share group, just like Greece, which took a pounding in a sovereign debt crisis. According to the 2014 HFCS data, 1.3 per cent of Hungarian households held listed equities in their portfolios.

2.1. The role of the supply side

A strong correlation can be identified between households' direct listed equities holding and the equity financing of non-financial corporations (*Figure 1*). Households can provide the funds necessary for companies partly through financing bank loans, and partly in a more direct fashion, by purchasing corporate equities. In the more mature European economies, the value of the latter is usually over or close to 10 per cent of GDP. By contrast, in Hungary, the value of equities held by households merely amounts to 2 per cent of GDP (it should be noted that if households' stock holdings were measured relative to financial assets, the result would be similar as relative to GDP). It should also be taken into account that in more advanced countries the non-financial corporation sector may have equity funds of over 100 per cent of GDP, while in Hungary the corresponding figure is just 20 per cent of GDP. Therefore, even though the literature mainly focuses on the effect of the demand for equities, along with households' demand-side factors, the corporate sector's supply-side funding structure must also change to allow the amount of household financing to increase, whether through direct or indirect financing.

Figure 1
Value of households' listed equities and non-financial corporations' equity financing
(relative to GDP, 2017)

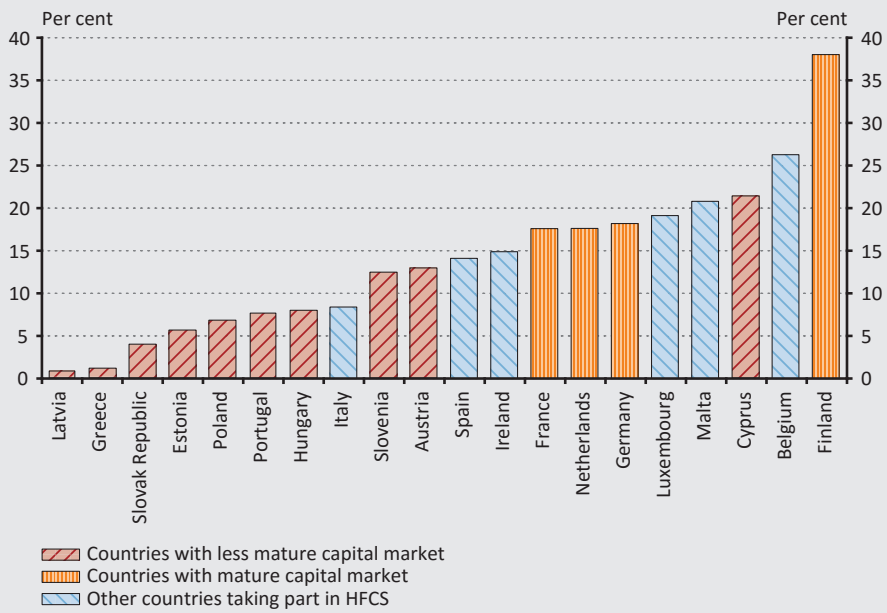


Source: Eurostat – European Sector accounts[6]

[6] https://ec.europa.eu/eurostat/web/sector-accounts/overview (Downloaded: 20 May 2018)

Among the demand-side factors of risky financial assets, the study also takes into consideration the role of the supply side, and therefore, the logistic regression examines two country groups: those with an active capital market and those with a less active one (*Figure 2*). European countries were clustered to present the results of the HFCS survey, while the depth of the capital market was measured based on the stock market characteristics available in the World Bank Global Financial Development database (for more on the methodology of creating the groups, see *Section 3*). Of the four country groups created during clustering, two were involved in the analysis, and the first group includes the countries with a less active capital market, for example Hungary. Four countries were classified into the active capital market group. The group of countries with a less active capital market comprises those with lower risky asset holdings, while in the other group, at least 8–10 per cent of households have risky financial assets.

Figure 2
Share of households holding risky financial assets (equities or mutual funds)
(2014)



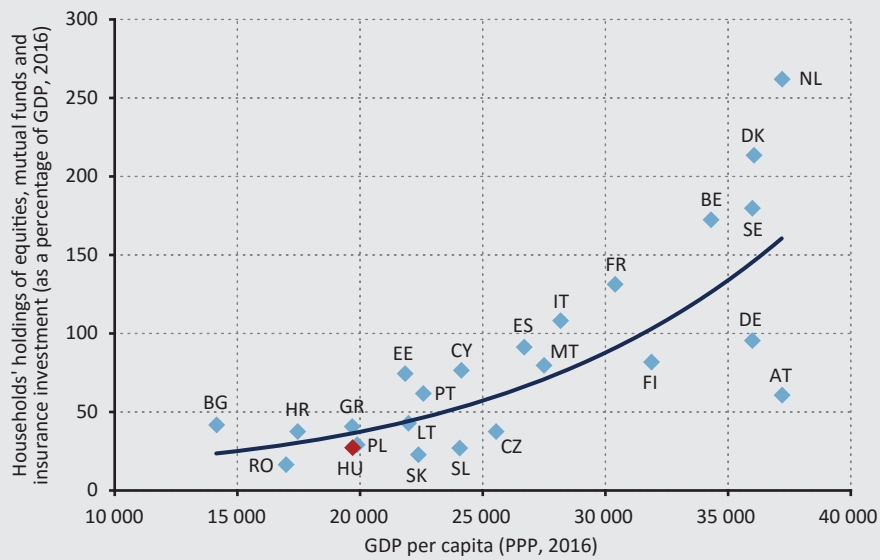
Source: HFCS[7]

[7] https://www.ecb.europa.eu/pub/economic-research/research-networks/html/researcher_hfcn.en.html

2.2. Factors influencing demand for risky assets

According to empirical studies, households' insurance, investment fund, pension fund and equity wealth – in other words the share of all risky financial assets – is strongly correlated to per capita income (*Figure 3*). In European countries, the wealth held in more sophisticated forms of investment typically grows faster than per capita income, so the correlation is not linear. All in all, in higher-income countries, households hold an increasing share of their wealth in riskier assets. This correlation based on macro data is examined in more detail using the available database. We have a detailed breakdown of households' financial assets from the HFCS survey: households were asked to report whether they held bank deposits, bonds, managed accounts, equities and mutual funds, and if so, how many. Bank deposits and bonds are typically not risky assets, while only an insignificant number of households have managed accounts. In addition, pension savings form a separate category, but the survey does not provide information on riskiness, i.e. the portfolio where households hold their pension savings. Therefore, based on the available data, it was decided that the risky financial assets under review should include equities and mutual funds, and the descriptive statistics below also refer to the holders of these assets.

Figure 3
Relationship between the equity, mutual fund and insurance wealth of the household sector of European countries and GDP per capita
(2016)

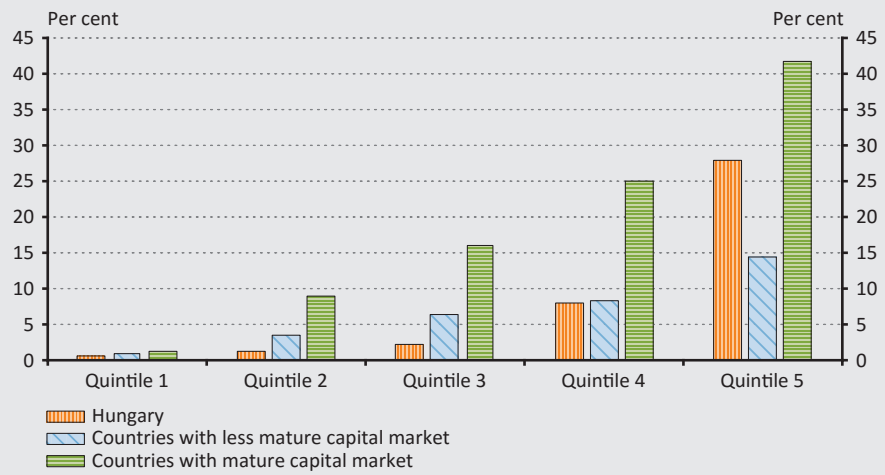


Source: Eurostat – European Sector accounts, National Accounts[8]

[8] https://ec.europa.eu/eurostat/web/sector-accounts/overview (Downloaded: 20 May 2018) and https://ec.europa.eu/eurostat/web/national-accounts/overview (Downloaded: 13 April 2018)

The HFCS survey confirms that, not unrelated to the unequal distribution of financial assets, the proportion of risky asset holdings strongly depends on households' gross wealth and income (*Figure 4*). Based on the micro-database, the proportion of households holding risky assets is the highest in the top quintile. Wealth and income fundamentally determine whether households enter the equity investor market. Low-income households (first two quintiles, based on gross wealth) hold risky assets in very low numbers. As we approach the higher earners, the proportion of risky asset holding grows increasingly, i.e. the correlation is not linear. This correlation holds true at the country level as well: in Hungary, risky asset holding rises from a lower level and more steeply than in European countries. The distribution of risky financial assets by income quintiles shows a similar picture, albeit a lower overall inequality, and therefore the effect of this is also examined in the model-based approach.

Figure 4
Proportion of risky financial asset holders in the gross (real and financial) wealth quintiles



Source: HFCS[9]

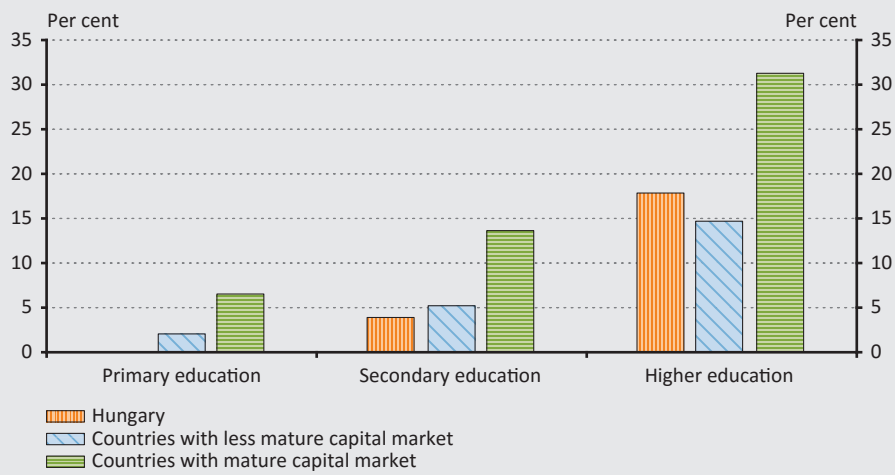
Several studies have pointed out the role of education in holding risky assets. The educational attainment of the head of household (reference person)[10] is important from the perspective of stockholding because the more educated access relevant information easier, thereby reducing their entry costs, and therefore education may have a positive effect on owning risky assets. *Haliassos and Bertaut* (*1995*) found

[9] https://www.ecb.europa.eu/pub/economic-research/research-networks/html/researcher_hfcn.en.html
[10] The head of household means the person with the highest financial awareness who filled out the HFCS questionnaire.

that in all income groups, stockholding was more widespread among households with higher education. In her extended CAPM model, *Bertaut* (*1998*) assumes that investing in equities depends on households' financial awareness, and thus ultimately on education.

According HFCS data, the education of the head of household strongly determines whether a household holds risky assets (*Figure 5*). This correlation is clearly reflected in the data. In the countries with an active capital market, households' stockholding increases with the education of the head of household. While the proportion of those holding risky assets is close to 30 per cent for college or university graduate households, in the case of secondary school qualifications, less than one-fifth of households hold equities or mutual funds. The share of those with any risky asset is much lower than this in the countries with a less active capital market, although higher education raises the proportion here as well. It should be noted, though, that according to the HFCS survey, Hungarians with a basic education essentially do not invest directly in equities or investment funds.

Figure 5
Relationship between educational attainment and risky asset holding



Source: HFCS[11]

Risky asset holding is influenced not only by education, but also by the profession of the head of household. People like to invest in the company they work for, because

[11] https://www.ecb.europa.eu/pub/economic-research/research-networks/html/researcher_hfcn.en.html

they know how it operates. This is referred to in the literature as the "equity home bias" (*Lewis 1999*), since it increases households' risks even though they do not perceive this. From a diversification perspective, it is less appropriate for households to invest in their own workplace, as that results in a positive correlation between earned income and the returns from the portfolio held by households. Nevertheless, *Carroll* (*2001*) also confirmed that the households that own stocks typically invest in one type, often that of their own workplace.

Women are typically more conservative investors, while marriage is positively correlated with stockholding. According to the international empirical literature, the gender of the head of household fundamentally determines whether the given household holds equities. Female heads of household are less likely to invest in equities than males. For example, *Barber and Odean* (*2001*) found that men are more confident about their financial knowledge and hold riskier portfolios. Furthermore, in a marriage (multiple-earner households), holding risky assets is also more frequent. This is attributable to the fact that income from two different sources mitigates households' risks (*Agnew et al. 2003*). *Barber and Odean* (*2001*) also argue that married couples make their investment decisions together, thereby weakening the effect of the difference between the genders.

Among external factors, the studies mostly focus on transaction and information costs, as they can negatively impact households' risky asset holding, especially among the poor. Haliassos (*2005*) claims that over the medium term, the greatest challenge faced by the financial sector is managing households' entry to or exit from the risky asset market rather than the fact that households already holding risky assets reweight their portfolios.

Moreover, borrowing constraints also significantly hamper households' risky asset holding and reduce the value of households' risky asset portfolio (*Guiso et al. 2001*). The existence of borrowing constraints is typically measured by the responses to some survey rather than the lack of savings. Households having low liquid savings may have a similar effect. This is because as income and gross wealth increases, the probability of liquidity constraints falls (*Boldizsár et al. 2016*), which may also impact risky asset holding.

Besides households' gross wealth, their other characteristics, for example their attitude towards risk, also influence portfolio allocation decisions. In theory, higher risk aversion should go hand in hand with greater diversification, which would mean lower risk in a household's portfolio with a given expected return. However, empirical evidence suggests otherwise, because the more risk-averse a household considers itself, the less risky assets it holds. This may suggest that most households do not fully comprehend the risk-reducing effect of diversification (*Barberis – Huang*

2001), or that households refuse to run risks even despite the expected returns. Households' investment decisions may be influenced not only by their attitude towards risk, but also by the background risks perceived by them (income risk, housing risk) (*Guiso – Paiella 2008; Cocco 2004; Heaton – Lucas 2000; Zhan 2015; Dong – Jiang 2016; Fratantoni 1998; Wältermann 2011*).

One common feature of the studies on households' portfolio allocation is that they consider earned income exogenous, which generates background investment risk,[12] *thereby also influencing asset accumulation and portfolio composition* (*Haliassos 2005*). In other words, the job of the head of household and the risks perceived related to the household's income play a major role in households' financial decisions. Although according to some studies earned income is risky, it is not correlated with the return on equity, and therefore equities should be preferred over less risky assets while maximising returns. However, empirical evidence does not support this, as even a low probability of losing earned income reduces stockholding (*Cocco et al. 2005*). Most studies have found that households with lower income risk are more willing to run additional risks. *Agnew et al.* (*2003*) argue that a secure job mitigates income risks, and therefore increasing risk exposure would be optimal. However, several papers have shown that the form of employment, whether people work as employees or as entrepreneurs, also counts. *King and Leape* (*1998*) and *Alessie et al.* (*2004*) found that sole proprietors are more likely to hold equities. *Bertaut and Starr-McCluer* (*2002*) on the other hand showed that being an employee correlates positively with stockholding, while being self-employed has a negative correlation.

Households are also held back from investing in risky financial assets by housing risk, especially in the case of young households. First, young households typically have fewer liquid assets due to the housing investments made by this generation, and they cannot afford the costs related to participating on the stock market. Second, their property is a major asset in the household's wealth, and therefore the fluctuation of property prices has a significant impact on their wealth. Moreover, the changes in property prices and interest rates also affect the amount of loans that can be taken out by the household (*Cocco 2004*). So housing risk typically affects young households.

[12] These variables cannot be measured accurately, and therefore they were quantified based on the available data as described in *Section 4.1*, and they were only used in the model presented later.

3. The supply side – Classifying countries by clustering

To explore the role of the supply side, the features of the stock markets in the countries participating in the HFCS were used as a basis. According to the literature, households' stockholding is influenced by the supply side; in other words, by the features of the stock market of the given country, for example the number of companies present on the stock market, their capitalisation, the level and quality of infrastructure or the cost of accessing the necessary information, and thus our analysis also takes this aspect into account. Therefore in the regression examining households' risky financial asset holding, the countries most similar from supply aspects should be merged. The depth of the capital market was measured based on the stock market characteristics available in the World Bank Global Financial Development database. However, it should be borne in mind that differentiating the supply side based on these indicators is not all-encompassing as regards the risky financial assets included in the logistic regression. The HFCS survey is used to analyse households' equities and mutual fund holding, while the clustering of countries by capital market depth is performed based on three stock market indicators (see *Table 6 in the Appendix*). This simplification is necessary primarily due to the limitations of the available data, however, the idea is justified because households typically hold more stocks in the countries where they also have more investment fund wealth. Moreover, *Guiso et al.* (*2003*) notes that investment funds played a central role in spreading the "equity culture" in Western Europe in the 1990s. Accordingly, the effect of capital market depth on households' risky asset holding was taken into account based on the following capital market indicators: stock market capitalisation (value of listed stocks), the market value of the stocks traded on the market in the reference period (value of transactions) and the turnover ratio, which measures how often stocks change hands.[13] Analysis of the data shows a large standard deviation across countries with respect to all three indicators: it is around 30 in all cases, while values range from a couple of per cent to over 100 per cent in some cases[14] (*Table 1*). With countries' stock markets showing such great variation, the hypothesis that the supply side needs to be controlled by examining the stockholding of the households in several countries seems confirmed.

[13] From the indicators, the values included were for the year when the HFCS survey was carried out in the individual countries, with only five exceptions. For Estonia, Finland, Lithuania and Slovakia only data from one year earlier were available, and in the case of Italy, the data for the turnover ratio was also used from one year earlier (*ECB 2016a*).

[14] Because all indicators are expressed as a percentage, relative standard deviation does not need to be calculated, since the standard deviation values can be directly compared.

Table 1
Descriptive statistics of the stock market indicators of the countries participating in the second wave of the HFCS

Statistics	Stock market capitalisation	Value of traded stocks	Turnover ratio
Minimum	4.9	0.1	0.2
Average	41.9	20.8	39.3
Maximum	109.7	86.3	138.0
First quartile	14.1	0.7	6.9
Median	34.7	9.2	32.9
Third quartile	65.1	36.7	58.3
Inter-quartile range	51.0	36.0	51.5
Standard deviation	30.1	26.0	37.9

Source: Calculated based on the World Bank – Global Financial Development Database[15]

Countries with a similar stock market size and turnover were grouped together using clustering, which is one of the most widespread methods for classifying the observations of a sample or population. Clustering comes in many shapes and forms, and this study used agglomerative hierarchical clustering, which has the advantage over the other popular method, *k*-means clustering that no hypothesis is needed as regards the number of groups.[16] Based on the other economic characteristics of the countries under review and due to the considerations regarding the sample size of the micro-analysis, in the end four groups were created using clustering (*Table 2*).

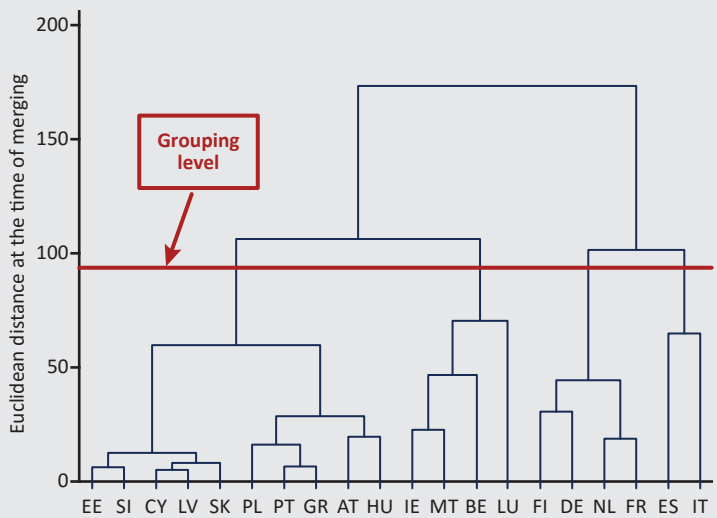
Table 2
Country groups produced by clustering

I	II	III	IV
Austria	Belgium	Finland	Italy
Cyprus	Ireland	France	Spain
Estonia	Luxembourg	Germany	
Greece	Malta	Netherlands	
Hungary			
Lithuania			
Poland			
Portugal			
Slovakia			
Slovenia			

[15] http://databank.worldbank.org/data/source/global-financial-development (Downloaded: 4 June 2018)
[16] Hierarchical clustering is a process that initially regards all observations as a separate cluster and merges nearby groups step by step based on the chosen distance calculation and merging process. When uninterrupted, this produces a cluster that contains all the observations. The whole chain was taken into account in the merging process of hierarchical clustering (farthest first – merging the two nearest groups where the distance between their farthest elements is the shortest), while Euclidean distance was used for calculating the distance. For more details, see: *Kovács* (*2014*).

Of the four groups that resulted from clustering, one can be identified as the country group with a less deep capital market, while another cluster includes the countries with a deeper capital market based on all indicators (*Figure 6*). To understand the outcome of the classification, the dendrogram of the clustering, which shows the sequence of the classification of the countries, and the original data should be taken into account. This clearly sets apart Cluster III, which includes countries with a mature stock market based on all three indicators. The same holds true for Cluster IV comprising Spain and Italy, but since the economic situation of these two countries differs markedly from the previous group, the two were not merged. Cluster II includes countries where stock market capitalisation is relatively high, but the other two indicators fall short of Clusters III and IV. In Cluster II countries, there is a sizeable stock market, but the activity, captured by the other two indicators, is more muted than in the countries with a similar capitalisation-to-GDP ratio. Cluster I contains the most countries, ten in all, which have the least mature stock markets relative to the other three groups, and this is where Hungary belongs as well. Besides the Eastern European HFCS countries, the Baltic states, two Mediterranean countries (Greece and Cyprus) and a sole Western European country, Austria, which lags far behind Cluster III countries in all the indicators, were also included here. Since this study aims to provide relevant results from a Hungarian perspective, the micro-analysis of risky asset holding focuses on Cluster I, which contains Hungary.

Figure 6
Dendrogram of the clustering



4. Modelling risky financial asset holding

The descriptive analysis presented in Section 2 showed how households' stockholding develops from a given aspect, however, this method cannot handle the effect of interactions. It is easy to see that for example demographic situation and income are closely correlated, and therefore their effect should be examined simultaneously if the aim is to show whether the isolated effects of the different factors are significant from the perspective of stockholding and mutual fund holding, in other words risky financial assets. Therefore, this section uses the model-based approach and attempts to estimate how the factors analysed in the descriptive section affect households' risky asset holding as defined above, with respect to the partial effects.

4.1. Model specification

In order to identify the factors influencing households' risky asset holding, logistic regression is used, a major prerequisite of which is the exact establishment of the questions to be answered during the analysis. *First, if households' stockholding is sought to be analysed, besides indirect holdings, direct ones should be taken into account as well.* A major portion of households' equity wealth comprises indirect holdings (through investment funds, pension funds and insurers), however, direct equity investment through the financial architecture is also low in Hungary. Indirect stockholding is partly a result of the institutional system set up through economic policy measures, but it cannot be clearly isolated from the factors influencing direct stockholding. According to the experience of Western European countries, pension funds play a major role in popularising stockholding: in the countries where pension funds' total asset holdings are large, households are more likely to own equities. However, the direction of the relationship is not straightforward, and on account of endogeneity, indirect and direct stockholding should be examined together and simultaneously, perhaps even merging all risky assets. However, the available database does not contain information on all risky assets, so only stockholding and investments in investment funds can be examined.[17] The model's binary dependent variable takes the value 1 if households have any risky assets, so they hold equities or mutual funds.

Second, overcoming the entry barrier is key in risky asset holding: the primary issue to be examined is whether households hold risky assets at all. In portfolio allocation decisions, households' features may be important, but they play a bigger role in whether households hold any equities at all rather than in the size of the risky portfolio when risky assets are held. For example, *Haliassos* (*2005*) pointed out that household characteristics (demographics and other features) strongly influence

[17] According to the data from the questionnaire-based survey used here, one-third of those holding mutual funds invest in equity funds, while the share of those investing in risk-free money market funds is negligible.

whether households hold risky assets. However, a less close relationship was found between the proportion of risky assets and household characteristics (a similar result was reported by *Guiso et al. 2003*). Therefore, it is worth examining how and to what extent certain household characteristics influence, hinder or stimulate, entry into this market.

Third, risky asset holding is influenced not only by the demand side but also by the features of the capital market that cannot be measured accurately. In contrast to the results of the studies presented above, *Christelis et al.* (*2010*) showed that the differences in risky asset holding often do not arise from household characteristics. Instead, the differences in the economic environment explain risky asset holding and the amount invested in such assets. Therefore, the analysis involved the two country groups created during clustering and already used in the descriptive section, the group of countries with a mature and large capital market based on the indicators, and those with a less mature capital market (lower stock market capitalisation and activity), with Hungary belonging to the latter. Although the study primarily aims to examine Hungarian households' portfolio allocation decisions, including countries with similar stock market characteristics was considered necessary to ensure the appropriate sample size. During the analysis, the model analysing risky asset holding was run for both country groups so that the significance of each factor and the extent of their impact can be compared on two markets that offer different risky assets.

In modelling risky asset holding, the effect of households' demographic, income and wealth position as well as the impact of background risks were explored. The modelling sought to establish whether a negative effect of background risks on stockholding can be identified, and whether there was any major difference between the extent of the effects in the two country groups. With the help of the literature, three background risks were identified, as in the paper by *Zhan* (*2015*): income risk, housing risk and entrepreneurial risk. Since these variables cannot be measured accurately, they were quantified using the information available in the database as described below.

- *Income risk*: high exposure to the labour market and the typical information asymmetry represent an uncertain factor in household income. This is especially true if the household does not gain income from any other source, for example from pension, letting property, or financial investments. Therefore, only those households which earn income solely as employees are considered to be exposed to this risk. In this respect, this study deviates from the approach employed by *Zhan* (*2015*), who used empirical evidence and considered the households working in sectors characterised by high unemployment as exposed to this background risk.[18]

[18] We believe that based only on the sector of employment it is hard to say how much households are exposed to unemployment risk, and *Zhan* (*2015*) also failed to produce significant results in this respect.

- *Housing risk*: as seen in the theoretical summary, property ownership may severely constrain disposable liquid income, and the risk arising from being more exposed to the property market may curb the risk faced on other markets, for example financial markets. Housing risk rises as the share of properties within total wealth increases. Therefore, this ratio was represented as a percentage in the model.
- *Entrepreneurial risk*: according to a study by *Heaton and Lucas* (*2000*), households where entrepreneurial income plays a bigger role within total income are less likely to invest in risky financial assets. To quantify this background risk, the method used by *Zhan* (*2015*) was employed: entrepreneurial income was taken as a ratio of total income.

In addition, the effect of households' demographic, income and wealth position and other characteristics on risky asset holding is also analysed. Among the demographic characteristics, the effect of the size of the household, marital status and the age of the head of household (reference person) was evaluated. Female heads of household are a separate variable, because the data and relevant literature confirm that they are less risk-seeking in terms of financial investments. Nevertheless, higher education and financial education were taken into account, since more educated people are more likely to hold risky assets, and the information transaction costs of those working in the financial sector are lower in the case of money market products. Households' self-assessed investment attitude, i.e. the extent to which they see themselves as risk-seeking investors, was a separate variable. In addition, the effect of whether households experienced liquidity constraints was also examined. They were considered liquidity-constrained if their available liquid assets did not exceed two months' gross income.

4.2. Results of the model

Based on the results of the logistic regression, several factors influence households' risky asset holding, but there are differences across the country groups with different levels of activity on the stock market (*Table 3*). Based on the analysis, the main difference between the two groups under review is that in the countries with a deeper capital market (II), the effect of demographic factors is significant in several cases, while in the other group (I) the wealth position and education are the major factors. This is consistent with the observation that in the countries with a less active capital market and, with a few exceptions,[19] a less advanced economy, risky asset holding is almost exclusively typical of wealthier households.

[19] For example, Austria is clearly part of Western Europe as regards is economic development, but based on the extent of its stock market, it belongs to the less active group. This outlier feature can be seen in *Figure 1*, which shows that based on per capita GDP, Austrian households should hold more risky assets.

Income and the wealth position are major and significant factors in both country groups, but wealth increases risky asset holding more in the countries with a deeper capital market. A 10 per cent rise in households' income lifts the probability of risky asset holding by 0.31 per cent on average, while in the second group this figure is roughly 0.8 per cent. Wealth exerts a greater impact, and it raises the probability of risky asset holding substantially more in the countries with a deeper capital market, which confirms the widespread nature of these assets. The regression includes the dummy variables of the wealth quintiles for the countries, and the median, i.e. the third, quintile serves as the reference group. In both country groups, households hold more risky assets in the higher quintiles, although there are also differences:

- In the group that includes Hungary, belonging to the first and second wealth quintile reduces the probability of holding by 6 and 3 per cent, respectively, but the marginal effect of the fourth quintile does not differ significantly from the third. Moreover, belonging to the top wealth group boosts the likelihood of risky asset holding by 5 per cent on average.
- In the other country group, the probability also increases with the wealth quintiles, but overall the marginal effect is greater, in absolute terms, in all quintiles. Belonging to the first quintile means a 12.4 per cent lower probability of holding, the same figure is –6 per cent in the second quintile, while it is 6.3 and 15.5 per cent in the fourth and fifth quintiles, respectively (relative to the third).

Table 3
Results of logistic regression

	Average marginal effects (AMEs)	
	Less active capital market (I)	**More active capital market (II)**
Total household income (log)	0.031*** (*0.109*)	0.078*** (*0.146*)
Gross wealth *(third quintile)*		
First quintile	−0.056** (*0.062*)	−0.124*** (*0.044*)
Second quintile	−0.029*** (*0.120*)	−0.06*** (*0.091*)
Fourth quintile	0.003 (*0.173*)	0.063*** (*0.207*)
Fifth quintile	0.049*** (*0.284*)	0.155*** (*0.367*)
Graduate	0.049*** (*0.208*)	0.056*** (*0.128*)
Working in the financial sector	0.055*** (*0.506*)	0.096*** (*0.403*)
Risk-taking in investments *(do not take risks)*		
Average	0.08*** (*0.880*)	0.137*** (*1.250*)
Above–average	0.134*** (*0.881*)	0.238*** (*1.030*)
Exceptional	0.088** (*0.301*)	0.156* (*0.220*)
Number of children	−0.006 (*0.065*)	−0.017** (*0.037*)
Female head of household	−0.018** (*0.072*)	−0.033*** (*0.060*)
Liquidity constraint	−0.021*** (*0.069*)	−0.058*** (*0.053*)
Age	0.000 (*0.004*)	0.000 (*0.003*)
Labour market exposure	−0.023* (*0.128*)	−0.123*** (*0.090*)
Entrepreneurial income	−0.0005*** (*0.001*)	−0.0013*** (*0.002*)
Ownership of residential property	−0.031** (*0.093*)	−0.047** (*0.092*)
Sample size	23,430	21,200

*Note: The reference group is the third quintile in the case of the wealth quintiles and "do not take risks" in the case of risk-taking attitude. The figures in brackets under the average marginal effects denote the robust standard errors. *p<0.05; **p<0.01; ***p<0.001*

Two conclusions can be drawn from the above. First, in the countries with a deeper capital market the rise in the share of the holders by quintiles is more gradual, which – together with the relevant descriptive statistics – suggests that in the case of the households with relatively lower wealth, holding equities and mutual funds is more typical than in the other country group. Second, in the countries with a smaller capital market, the top wealth quintile is strikingly distant from the others. *Table 4* shows that in the higher wealth quintiles, the proportion of risky asset holders steadily grows. While in the countries with a deeper capital market this ratio increases gradually, a bigger jump can be seen at the fifth quintile in the other country group. This is especially true in Hungary: while the proportion of holders in the fourth quintile is 13 times that of the first, it is almost 46 times that in the fifth. And the lack of gradual increases is also evident since there is no major difference between the second and third quintiles in Hungary, and between the third and fourth quintiles in the other countries with a less active capital market, whereas the more active group exhibits such differences. This is consistent with the fact that in the case of the first country group, the effect of the fourth quintile relative to the median is not significant in the regression. This allows us to conclude that in these countries, risky asset holding is more concentrated and is mainly typical of the wealthiest households.

Table 4
Multiple of the proportion of risky asset holders in the wealth quintiles relative to the first wealth quintile

Wealth quintile	Hungary	Less active countries	Active countries
I	1	1	1
II	2.0	3.4	7.9
III	3.9	6.1	14.2
IV	13.0	7.7	22.4
V	45.9	13.4	37.1

Besides wealth and income, another important factor is the existence of liquidity constraints. The model examined the effect of households' liquid assets, here meaning assets on a bank account, in a demand deposit or fixed-term deposit, which amount to less than two months' gross income. According to the regression, this situation reduces the probability of risky asset holding by almost 6 per cent in the countries with a more mature stock market, and by 2.1 per cent in the other country group. This suggests that those who cannot save in liquid form, on account of precautionary motives, are less likely to consider equities and investment funds as possible forms of saving.

Education and employment in the financial sector have a highly positive and significant effect on the probability of risky asset holding. Based on the logistic regression, higher education, which, according to empirical evidence and the theories, reduces the transaction costs of obtaining information necessary for financial investments, boosts the likelihood of risky asset holding by 5.6 and 4.9 per cent in the countries with an active capital market and those with a less active one, respectively. Employment in the financial sector, which also facilitates access to the relevant information, raises households' risky asset holding by a similar extent (by 9.6 and 5.5 per cent).

Among demographic characteristics, the number of children and the gender of the head of household influence risky asset holding the most. Child-rearing ties down a huge amount of financial assets in a household, which presumably reduces the probability of holding equities and mutual funds. This negative effect can be seen in both country groups under review (0.6 per cent and 1.7 per cent drop), but it is not significant in the countries with a less active capital market. By contrast, female heads of household exert a significantly negative impact on the probability of risky asset holding in both groups: the probability of holding falls by 1.8 and 3.3 per cent in the first and second country group, respectively. In addition, the effect of marital status and age was also examined, but no significant correlation was established. While in the countries with a less mature stock market age also did not play a considerable role in descriptive statistics, in the other country group it seemed that risky asset holding increases with age, but this was not confirmed by the model analysing partial effects. All in all, demographic characteristics play a lesser role in the countries with a less active capital market, and based on the model only the gender of the head of household influences holding. This tallies with the earlier finding that in these countries wealth position and education are the dominant factors in risky asset holding.

The model confirms the hypothesis that background risks are partly responsible for households' risky asset holding falling short of the theoretical optimum. All three background risk indicators under review significantly reduce the probability of holding equities and mutual funds in both country groups, and the only major difference in their impact can be observed in labour market exposure. If a household is completely dependent on earned income, it reduces the probability of risky asset holding by an average of 2.3 and 12.3 per cent in the first and second country group, respectively. This huge difference is probably because risky assets are more widespread in Group II: in the countries with a less active capital market, even those who otherwise have income from other sources do not hold substantially more equities, so the difference is not that marked. By contrast, in the countries with a deeper capital market, which are also more advanced economically, there are probably fewer people who live solely from earned income and mostly belong to the lower income quintiles. The background risk arising from owning residential property and the crowding-out effect can also be seen from the model: these

households are significantly less likely to hold risky assets (the effect is –3.1 and –4.7 per cent in Group I and II, respectively). Entrepreneurial income, which, according to empirical evidence, is more volatile than other types of income, also has a negative impact on stockholding. If the ratio of entrepreneurial income rises by 1 percentage point within total household income, the probability of risky asset holding drops by 0.05 per cent in the group containing Hungary and by 0.13 per cent in the other one. Nonetheless, it should be noted that the model showed a relatively low marginal effect for all background risk indicators, which is probably attributable to the heterogeneous nature of the group under review, for example those living exclusively from compensation of employees (especially in the countries with lower capital market activity).

Even after controlling for households' wealth, income and demographic characteristics, the investment attitude of the head of household plays a significant role. Households that consider themselves risk-averse served as the reference group, and respondents could choose from three further options: average, above-average and exceptionally risk-taking. While the extent of the effects in the two country groups under review varies, a similar pattern can be observed: in the first group, the probability of risky asset holding increases by 8 per cent for average risk-takers, and by 13.4 per cent for above-average risk-takers. Interestingly, however, in both groups, belonging to the top category raises the likelihood of stockholding by less than being above-average. This contradiction may be because only a smaller share of households hold equities due to their exceptional riskiness (and the corresponding exceptional expected returns). From this perspective, venture capital investments, for example targeting start-ups, offer a better investment alternative.

5. Conclusions

This study examines households' risky financial asset holding and the factors determining it. Within households' wealth, the proportion of riskier assets correlates strongly with economic development. At the same time, several papers have pointed out that even in advanced countries, the share of stockholding households is low, since households do not diversify their portfolios in line with the theory. The analysis of the topic was facilitated by a questionnaire-based survey on wealth, containing households' unique characteristics, and also involving Hungarian households (Household Finance and Consumption Survey, HFCS).

The paper sought to establish the factors that influence whether households hold risky financial assets (equities or mutual funds). In addition to analysing demand factors, differentiation was performed by capital market depth, separating the countries with an active capital market from those with a less active one. The logistic regression supplementing the descriptive analysis presented in the first half of the study allowed us to determine the partial effect of a given factor on stockholding.

The main messages of the analysis are as follows:

- A strong correlation can be identified between households' listed stock holding and the equity financing of corporations. In the countries with higher per capita GDP, the corporate sector may have equity funds in excess of total GDP, while in Hungary the corresponding figure is just 20 per cent of GDP.
- Risky asset holding depends strongly on the wealth and income of households. The countries involved in the analysis were classified into several groups based on the role played by the stock market in financing. In the country group with an active stock market, even the households with lower wealth (income) hold significant amounts of risky assets, while in the other group also including Hungary, this is much less typical (which is presumably related to lower average income).
- In the mainly Western European countries with a more active capital market, far more households hold equities directly than indirectly, while in the countries with a less mature capital market, indirect stockholding is more widespread.
- The existence of liquidity constraints is also an important factor: those who cannot save in liquid form, on account of precautionary motives, are less likely to consider equities and mutual funds as possible forms of saving. By contrast, the results suggest that lending does not influence risky asset holding.
- Education and employment in certain sectors of the economy (for example in finance) also have a highly positive effect on the probability of risky asset holding. Since the results of the model give us partial effects, this finding is independent from income, and thus measures aimed at improving financial literacy are expected to also positively influence households' risky financial asset holding.
- Demographic characteristics (number of children, marital status, age) play a lesser role in risky asset holding, and this is especially true of the countries with a less active capital market. This tallies with the finding that in these countries wealth position and income are the dominant factors.
- Large labour market and property market exposure and a higher proportion of entrepreneurial income, which is considered more volatile than wages, have a negative effect on risky financial asset holding. According to the literature, these risks are difficult or impossible to quantify, but individuals need to take them into account during their investment decisions, and therefore overall they can reduce the share of households' risky financial assets.
- Besides the above, households' risky asset holding may also be strongly influenced by self-assessed investment attitude, how much households consider themselves risk-taking. Risk-averse households are significantly less likely to hold risky assets in both the countries with an active capital market and those with a less active one.

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Appendix

Table 5
Main characteristics of the second wave of the HFCS

Country	Sample size	Year of data collection
Belgium	2,238	2014
Germany	4,461	2014
Estonia	2,220	2013
Ireland	5,419	2013
Greece	3,003	2014
Spain	6,106	2011
France	12,035	2014
Italy	8,156	2014
Cyprus	1,289	2014
Latvia	1,202	2014
Luxembourg	1,601	2014
Hungary	6,207	2014
Malta	999	2013
Netherlands	1,284	2013
Austria	2,997	2014
Poland	3,455	2013
Portugal	6,207	2013
Slovenia	2,553	2014
Slovakia	2,135	2014
Finland	11,030	2013

Source: ECB (2016a)

Table 6
Stock market indicators used for clustering

Number of cluster	Country	Stock market capitalisation (% of GDP)	Value of traded stocks (% of GDP)	Turnover ratio (%)
I	Austria	24.5	6.3	26.8
	Cyprus	13.3	0.2	1.8
	Estonia	8.5	0.9	9.4
	Greece	29.1	12.1	48.1
	Poland	37.0	12.9	37.4
	Lithuania	9.2	0.5	4.4
	Hungary	12.1	6.3	42.1
	Portugal	32.4	14.6	53.2
	Slovakia	4.9	0.1	2.3
	Slovenia	14.8	1.2	10.0
II	Belgium	70.9	21.0	28.5
	Ireland	59.3	5.2	10.5
	Luxembourg	109.7	0.2	0.2
	Malta	39.0	0.6	1.7
III	Finland	57.2	56.6	86.1
	France	77.3	40.1	53.2
	Netherlands	86.7	52.8	63.4
	Germany	47.4	33.3	69.1
IV	Italy	28.0	65.8	138.0
	Spain	75.9	86.3	99.9

Source: World Bank – Global Financial Development Database[20]

[20] http://databank.worldbank.org/data/source/global-financial-development (Downloaded: 4 June 2018)

The Impact of Adverse Selection on Stock Exchange Specialists' Price Quotation Strategy*

Kira Muratov-Szabó – Kata Váradi

This paper focuses on the activity of the specialists – one of the key participants in stock exchange trading. We attempt to model the price quotations of specialists in a modelling framework where some of the parties involved in the transactions may be informed, while others are uninformed "liquidity traders". It is in this adverse selection modelling framework that, relying on the technique of Monte Carlo simulation, we seek an answer to the following research questions: how does adverse selection impact the price quotation of specialists; to what extent are prices and logreturns influenced by uncertainty; to what degree of accuracy can specialists determine the proportion of informed traders and liquidity traders from trading volumes? Our model confirmed that as soon as uncertainty subsided in the simulated market, the number of transactions, wealth and the stock portfolio started to grow, while price fluctuations began to decline and the standard deviation and the distribution of logreturns edged closer and closer to a normal distribution, which points to improving market efficiency.

Journal of Economic Literature (JEL) codes: G12, G14, G17

Keywords: specialist, price quotation, adverse selection

1. Introduction

In this study, we explore the price quotation strategy of stock exchange specialists. Specialists are market makers in stock exchange trading with exclusive rights to quote bid and ask prices in a given product. The study is based, on the one hand, on a paper by *Kornis* (*2017*) that focused on the behaviour and presumed strategies of specialists in quote-driven markets, which we supplemented with the inclusion of quoted volume. On the other hand, the article by *Caglio* and *Kavajecz* (*2006*) also serves as a basis for our study, as the authors demonstrate that specialists can use quoted volumes strategically to mitigate the risk of adverse selection. The concept of adverse selection is presented in this study as a scenario where some

* 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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of the market participants placing orders are informed about the expected price movement of the product, while others are uninformed and act as liquidity traders. However, when posting the prices the specialist has no way of knowing whether the actor placing the order is informed or not; consequently, he does not know which specific price should be quoted. Overall, our study connects these two research papers, and the new model we construct is intended to seek an answer to the following research questions:

- How does adverse selection impact the specialist's price quotation?
- How do prices and logreturns change at various uncertainty levels?
- How precisely can specialists update their belief regarding the proportion of informed traders based on transaction volume?

Drawing partly from the work of *Caglio* and *Kavajecz* (*2006*) and partly from *Kornis (2017)*, our model includes numerous new assumptions and new methods. The former study primarily provided a theoretical background, while the latter inspired ideas in the area of practical execution. In order to simulate the model, we created a programme[1] in Excel in the Visual Basic for Applications programming language.

After the introduction, in the second section of the study we provide an overview of the relevant international literature. The third section presents the model proposed by *Caglio* and *Kavajecz* (*2006*) supplemented with our own additions and methods. We attempt to explore possible ways of introducing the problem of adverse selection into the model and examine who exactly acts as informed traders, who are liquidity traders, and how can specialists identify them in order to maximise their profits. In the fourth section, we briefly describe the simulation process as a preparation for the fifth section, which is dedicated to the statistical analysis of the results yielded by the simulation as a reward for our practical work. In Section 5 we also present our figures and our conclusions. The study is concluded with a summary in which we offer concise answers to the questions posed in the introduction.

2. Literature review

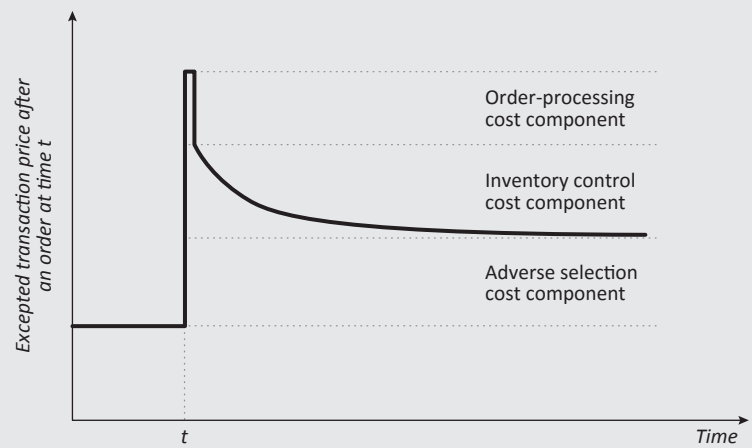
Although the approaches taken may be different, a substantial part of the research on financial markets ultimately seeks an answer to the same question: in what way can market prices be predicted in order to serve as a basis for a profitable trading strategy? The literature on market microstructure has shed new light on this area in recent decades: instead of concentrating on actual price movements to draw

[1] The codes of the programme's main components (subroutines and functions) are presented in the Appendices.

conclusions about expected price developments, this field of study attempts to determine how specific market mechanisms affect the price discovery process. Market microstructure research examines who market participants are, what level of information they have and what type of products are being traded (e.g. underlying instruments or derivatives); in other words, it tries to investigate market efficiency and price formation based on the elements of market microstructure (*O'Hara 1995*).

One central concept in market microstructure is market liquidity. Market liquidity is understood as the speed at which a given product can be sold or purchased in a given volume with the smallest possible price effect. This issue is generally approached both by practitioners and scientific research by way of the bid-ask spread, a measure of liquidity's transaction cost expressing the difference between the best bid price and ask price. Based on *Foucault et al.* (*2013*), a basic premise of market microstructure is that the bid-ask spread is composed of 1) adverse selection, 2) inventory control and 3) order-processing costs (*Figure 1*) as indeed, specialists face these costs in trading and pass on these costs to market participants when quoting prices.

Figure 1
Components of transaction costs



Source: Foucault et al. (2013), p. 121.

1. Adverse selection cost: Since informed traders purchase when the quoted price is too low and sell when the quoted price is too high based on market information, specialists are exposed to adverse selection costs.

2. Inventory control cost: On continuous markets buy and sell orders are not received at one and the same time, which leads to a temporary disparity between the offers. In such cases, specialists step in committing their own inventory in order to restore equilibrium between supply and demand, while their net position remains zero over time. This role, however, exposes specialists to inventory control risk as the value of their inventory may change at any time, for example as a result of new information or intelligence affecting the given asset. For this reason, specialists charge inventory control costs.

3. Order-processing cost: Specialists charge order-processing costs for trading commissions, for the clearing and settlement fees, paperwork, time spent on the phone and such.

On the whole, these costs are ultimately charged to the rest of the market participants in the form of transaction costs, which is the bid-ask spread itself (*Foucault et al. 2013*).

The problem of transaction costs was first formalised by *Demsetz* (*1968*). Harold Demsetz treated the bid-ask spread as a cost assumed by the trader for immediacy. *Bagehot* (*1971*) asserted that there are (at least) two kinds of traders who confront specialists: informed traders and liquidity-motivated traders. Informed traders possess non-public information that allows them to have a better estimate of the future price of a security than liquidity traders or specialists themselves. Since transactors trading on special information always have the option of not trading with the specialists, the specialists will never gain from them; they can only lose. By contrast, transactions with liquidity-motivated traders can be profitable, as these market participants are willing to pay a "fee" for gaining access to immediacy.

These two thoughts are synthesised by *Copeland* and *Galai* (*1983*) who modelled the bid-ask spread as a "trade-off", which compensates specialists for the expected losses to informed traders with the expected gains from liquidity traders. The research by *Glosten* and *Milgrom* (*1985*) was founded on this concept. The authors used a formal model to demonstrate that the spread increases in response to adverse selection. They assume that specialists are risk-neutral, competitive and make zero expected profits. In addition, specialists are assumed to have unlimited inventories of both money and securities. From their research *Kornis* (*2017*) drew the following five key assumptions:

- The bid and ask prices straddle the price that would prevail if all traders had the exact same information as the specialists.

- The prices at which transactions actually occur form a martingale.[2]

[2] For more detail about martingale processes, see: *Doob* (*1971*)

- There is a boundary on the size of the spread that can arise from adverse selection.
- The price expectations of the specialists and informed traders tend to converge.
- Generally, ask prices increase and bid prices decrease if the insiders' information becomes better, or the insiders become more numerous relative to liquidity traders, or when the elasticity of the expected supply and demand of a liquidity trader increases.

All of the literature discussed so far focused on the size of the bid-ask spread. As *Harris* (*1990a*) pointed out, however, the spread is only one dimension of market liquidity. *Harris* (*1990a*) defined liquidity as follows: "A liquid market is one in which every agent can buy and sell at any time a large quantity rapidly at low cost. Liquidity is a trader's willingness to take the opposite side of a trade that is initiated by someone else when the cost is low enough." In other words, in addition to the bid-ask spread, turnover can also be a measure of liquidity. A consistent summary of liquidity measures was provided, for the first time, by *von Wyss* (*2004*).

On the NYSE (New York Stock Exchange) the full offer of a specialist includes both the best bid and the best ask prices, as well as the volume of shares available at the best price, in other words, the depth. If the specialist perceives an increased probability of insider information among certain traders, he can respond by widening the bid-ask spread. Alternatively, he can protect himself by offering a lower trading volume at each quoted price (*Lee et al. 1993*).

It was a paper by *Kyle* (*1985*) that first defined liquidity by using the concepts of tightness, depth, breadth (static dimensions) and market resiliency (dynamic dimension). The (also dynamic) dimension of immediacy can be linked to *Harris* (*1990b*), while diversity was first identified as a new, separate dimension by *Kutas* and *Végh* (*2005*). In view of the multidimensional nature of market liquidity, it is highly surprising that much of the literature focuses on the spread alone. Numerous price quotation models examined in the context of adverse selection disregard depth with the proviso that all transactions (and hence the quotes) should be conducted in the same volume. Examples include the models presented in *Copeland* and *Galai* (*1983*)*, Glosten* and *Milgrom* (*1985*) and *Easley* and *O'Hara* (*1992*). The models that permit trading in different volumes – such as those proposed by *Kyle (1985)* and *Rock* (*1989*) – typically assume that the specialist's quotes are full quotes. In these models information on both the price and the volume is needed to support an implicit evaluation of the liquidity of the price quotation.

Lee et al. (*1993*) demonstrated that specialists can actively manage the risk of information asymmetry by adjusting both spreads and depths. Their result underscores the importance of the quantity dimension ignored by previous models and emphasises the fact that both spread and depth are needed to induce changes

in liquidity unambiguously. In other words, a widening (narrowing) of the spread, combined with a decrease (increase) in depth, is sufficient to induce a decrease (increase) in liquidity.

Similarly, *Kavajecz* (*1999*) investigated the reduction of adverse selection risk, and he did so from the angle of quoted depth. Four important conclusions may be drawn from his findings:

- If a quote changes, the specialist will (also) change the quoted volume in 90 per cent of the cases; in fact, the quote will only change in terms of volume in 50 per cent of the cases, with no shift in the price whatsoever. Consequently, the specialist actively manages his own inventory even if no price change occurs.
- If informed traders are in an overwhelming majority on the market, the specialist's quotation is likely to reflect the top of the order book instead of his own inventory. This is how he ensures that an incoming limit order will be matched with the best limit orders contained in the order book rather than being filled from his own inventory.
- Quoted volumes are consistent with the size of the specialist's own stock portfolio; consequently, determining the volume also plays a role in his strategy.
- In response to the announcement of new information, both the specialist and the traders decrease the volume of their orders.

Carrying this thought forward, the stylised theoretical framework in the article of *Dupont* (*2000*) shows that a risk-neutral, monopolistic specialist narrows quoted depth in proportion to the widening of the spread when he reacts to an increase in adverse selection; in other words, equilibrium depth is proportionally more sensitive than the spread to changes in the degree of adverse selection. The elasticity of substitution between depth and spread – in consideration of the quality of information possessed by the better informed trader – depends on market conditions which, in turn, are determined by the information asymmetry, the asset's volatility and the strength of demand for liquidity. This elasticity converges to infinity if market conditions become either extremely favourable (depth increases to infinity while the spread remains positive) or extremely unfavourable (depth approaches zero, while the spread remains finite). Whether the informed trader is risk-neutral or risk-averse does not essentially affect the results.

Kavajecz and *Odders-White* (*2001*) examined how specialists update their price schedules in a simultaneous equations model. They found that changes in the best prices and depths on the order book had a significant impact on the posted price schedule, while the effects of transactions and order activity were secondary. Moreover, they pointed out that specialists revise quoted prices and quoted volumes

differently. For example, quoted depths are revised in response to transactions of any size, whereas the quoted prices are revised only when transaction sizes exceed the quoted depth. However, they found no evidence that specialists revise the price schedule in response to changes in their inventory.

Caglio and *Kavajecz* (*2006*) were the first to examine whether adjusting liquidity's quantitative dimension, i.e. depth, gives rise to a specification error in the spread decomposition model. The aim is to understand whether changes in the bid-ask spread alone are capable of defining the size of the adverse selection. In other words: is the extent of the change in depth redundant information in decomposition procedures?

The authors constructed a simple sequential trade model, which offers a distinct, analytical solution to the specialist's optimisation problem, i.e. how to choose prices and depths in order to maximise his profits. The model measures the changes induced at various levels of informed trading in the adverse selection component of the spread. The authors demonstrated that specialists can use quoted volume strategically to address adverse selection risk and the risk of change in the trading environment. The result is consistent with the previously mentioned finding (*Kavajecz 1999*) that a change in the quote will prompt the specialist – in roughly 50 per cent of the cases – to change the quoted volume, but not the price. The authors simulated the model based on this theoretical framework, examining two scenarios. In one scenario the specialist is not constrained by restrictions in terms of price quotation, while in the other scenario quoted volumes are constrained by the maximum limit on liquidity trading. Applying a simulated sequence, they compared the estimates of three decomposition models for the two scenarios. They found that spread decompositions failed to capture the full extent of adverse selection risk when the specialist could define depth without constraint. The solution is for researchers to use adverse selection measures that account for depth as well as spread to mitigate this problem.

3. The model

The basis of the model is the paper written by *Caglio* and *Kavajecz* (*2006*), which we supplemented with a number of new elements and methods:

1. Consistent with the assumption of *Caglio* and *Kavajecz (2006)*:

   a. we assume that the distributions, such as the distribution of the return on the asset under review, are normal.

   b. we select the parameter values (such as quantitative data).

2. Our own, new assumptions for the specialist's passive quotes are the following:

   a. based on the current size of the bid-ask spread, the specialist needs to improve his quote depending on whether he has exceeded a pre-defined limit or not.

3. We connect the model with *Kornis* (*2017*) and run a simulation based on the result.

Consistent with *Caglio* and *Kavajecz* (*2006*), the analytical framework is the following: Consider a sequential trade model where the return on a risky asset is expressed by a stochastic variable of Θ. As the authors did not define the distribution of the asset's returns, we assume Θ to have normal distribution, an expected value of 100 and a standard deviation of 5. At a probability of μ, the ultimate value of the security is Θ_1, and at a probability of 1–μ it is Θ_2, where $\Theta_1 < \Theta_2$. We conducted the simulation for five different μ values: 0.49[3]; 0.4; 0.3; 0.2 and 0.1.

Traders are uniformly distributed over the [0, 1] interval, with λ part of the traders being fully informed about the security's return and 1–λ part of them not possessing any information about the ultimate value of the risky asset, where $0 < \lambda < 1$. We took 0.2 to be the value of λ for the simulation.

Apart from traders, there is one actor on the market: the risk-neutral, profit maximiser specialist who posts the quote of the risky asset for his own purposes while also observing market rules. His task is to announce a bid price and size and an ask price and size set. No transaction takes place at prices and sizes worse than the announced set. In addition, the specialist has an expectation about λ, and he updates this belief after each trade, which is marked by λ_s.

3.1. Events of a period

Caglio and *Kavajecz* (*2006*) defined a period as follows. First, the two different return potentials of the risky asset change. Next, the specialist determines the quoted bid and ask prices (marked by *b* and *a*, respectively, where $b < a$ in equilibrium) along with the corresponding bid and ask volumes (marked by β and α, respectively). While doing so, the specialist considers the probability of trading with the different traders, the volumes they are willing to purchase of the given financial product, the potential returns on the given product and the product's expected value. Among the population of market participants, a randomly selected person decides whether he wants to trade or not. If the trader decides to trade, he selects a certain volume, which is either smaller than or equal to the relevant depth. After the transaction has been completed, the specialist updates his belief about the proportion of informed traders and revises its quoted offer. After he has defined his new offer, another trading round takes place, and this process is repeated again and again throughout a specific period.

[3] We must use 0.49 instead of 0.5 in order to avoid dividing by 0 later on, such as in the case of Equation 4.

Caglio and *Kavajecz* (*2006*) assumed that each trader has only one trading opportunity. Since an informed trader has perfect information about the ultimate value of the risky asset, theoretically he can have infinite demand if the specialist has mispriced the asset. Only the specialist's quoted volumes can put a limit on this demand; therefore, the key assumption of the model is that informed traders will choose maximum depth. Consequently, the jth informed trader will place his order as follows:

$$q_j^i = \begin{cases} -\beta, & \text{ha } b > \theta^* \\ |\alpha|, & \text{ha } a < \theta^* \end{cases} \tag{1}$$

where Θ^* is the real value of the risky asset and q stands for the volume. It should be noted that, since the specialist buys (sells) at the bid (ask) prices, the bid depth is positive and the ask depth is negative, i.e. $\beta_j > 0$ and $\alpha_j < 0$.

Since uninformed traders are not driven by information, they can be viewed as a group of people with various, exogenously determined motivations and inclinations towards trading. The kth trader is written as a set of (e_k, r_k), which represents the trader's endowment and his reservation price. The positive (negative) values of e_k mean that the trader wishes to sell (buy) a certain quantity of the risky asset. Moreover, a high (low) value of r_k indicates that the trader overvalues (undervalues) the asset. Therefore, each uninformed trader places an order in accordance with the following strategy:

$$q_k^u = \begin{cases} -\min[\beta, e_k], & \text{if } e_k > 0 \text{ and } b > r_k \\ +\min[|\alpha|, |e_k|], & \text{if } e_k < 0 \text{ and } a < r_k \\ 0, & \text{otherwise} \end{cases} \tag{2}$$

Accordingly, an uninformed trader will buy (sell) if his reservation price is higher (lower) than the quoted ask (bid) price and the traded volume is the same as the ask (bid) depth or lower. For the sake of clarity, the volumes to be bought/sold by traders are uniformly distributed over a pre-fixed t_1 and t_2 set, and the reservation prices are also uniformly distributed between Θ_1 and Θ_2; accordingly:

$$e_k \sim U[t_1, t_2] \quad r_k \sim U[\theta_1, \theta_2] \tag{3}$$

Since they were not given, we took the interval of the fixed t_1 and t_2 set as [–100, 100], and the r_k-s fall between two possible returns on the risky asset that are generated by the model from a normal distribution as described above. Moreover, suppose that both the e_k-s and the r_k-s are independent of each other.

Taking the two different trading strategies together, *Caglio* and *Kavajecz* (*2006*) calculated the way in which the specialist maximises the expected value of his profits as follows:

$$
\begin{aligned}
E\left[\pi(b,\beta,a,\alpha)\right] &= \mu\lambda\beta(\theta_1-b)+(1-\mu)\lambda\alpha(\theta_2-a) \\
&+(1-\lambda)\left(\frac{t_2-\beta}{t_2-t_1}\right)\left(\frac{b-\theta_1}{\theta_2-\theta_1}\right)\beta\left\{\mu(\theta_1-b)+(1-\mu)(\theta_2-b)\right\} \\
&+(1-\lambda)\left(\frac{\beta}{t_2-t_1}\right)\left(\frac{b-\theta_1}{\theta_2-\theta_1}\right)\left(\frac{1}{2}\beta\right)\left\{\mu(\theta_1-b)+(1-\mu)(\theta_2-b)\right\} \\
&+(1-\lambda)\left(\frac{\alpha-t_1}{t_2-t_1}\right)\left(\frac{\theta_2-a}{\theta_2-\theta_1}\right)\alpha\left\{(\theta_1-a)+(1-\mu)(\theta_2-a)\right\} \\
&+(1-\lambda)\left(\frac{-\alpha}{t_2-t_1}\right)\left(\frac{\theta_2-a}{\theta_2-\theta_1}\right)\left(\frac{1}{2}\alpha\right)\left\{\mu(\theta_1-a)+(1-\mu)(\theta_2-a)\right\}
\end{aligned}
\tag{4}
$$

The first line of the right-hand side of the equation indicates expected losses from transactions with informed traders, while the rest of the lines show the expected value of profitable or non-profitable trades with uninformed traders. This optimisation makes implicit assumptions about the relationship between the variables chosen by the specialist. These assumptions can be summarised in the following two constraints:

1) Quoted depth is equal to or lower than maximum liquidity trading.

$$t_1 \le \alpha < 0 < \beta \le t_2 \tag{5}$$

2) Quoted prices must fall between the two final returns:

$$\theta_1 < b < a < \theta_2 \tag{6}$$

3.2. The active quotation method

Caglio and *Kavajecz* (*2006*) defined the equilibrium values of the model as follows:

PROPOSITION 1: *If μ meets the following conditions:*

$$\left(\frac{\lambda-\lambda\left(\frac{t_2}{t_1}\right)}{1-\lambda\left(\frac{t_2}{t_1}\right)}\right) < \mu < \left(\frac{1-\lambda}{1-\lambda\left(\frac{t_1}{t_2}\right)}\right) \tag{7}$$

then the unique equilibrium of the single-period model is:

$$b_u^* = \frac{1}{4}\left(3E_\mu[\theta] + \theta_1\right) - \frac{1}{4}(1-\mu)(\theta_2 - \theta_1)\sqrt{1 + \left(\frac{8}{t_2}\right)\left(\frac{\lambda}{1-\lambda}\right)\left(\frac{\mu}{1-\mu}\right)(t_2 - t_1)} \quad (8)$$

$$\beta_u^* = \frac{3}{2}t_2 - \frac{1}{2}t_2\sqrt{1 + \left(\frac{8}{t_2}\right)\left(\frac{\lambda}{1-\lambda}\right)\left(\frac{\mu}{1-\mu}\right)(t_2 - t_1)} \quad (9)$$

$$a_u^* = \frac{1}{4}\left(3E_\mu[\theta] + \theta_2\right) + \frac{1}{4}\mu(\theta_2 - \theta_1)\sqrt{1 - \left(\frac{8}{t_1}\right)\left(\frac{\lambda}{1-\lambda}\right)\left(\frac{1-\mu}{\mu}\right)(t_2 - t_1)} \quad (10)$$

$$\alpha_u^* = \frac{3}{2}t_1 - \frac{1}{2}t_1\sqrt{1 - \left(\frac{8}{t_1}\right)\left(\frac{\lambda}{1-\lambda}\right)\left(\frac{1-\mu}{\mu}\right)(t_2 - t_1)} \quad (11)$$

The restriction on μ is equivalent to demanding that the specialists keep both sides of the market open. Left-hand side inequality provides the ask side of the market $a_u^* < \Theta_2$ and $\alpha_u^* < 0$ and right-hand side inequality the bid side $b_u^* > \Theta_1$ and $\beta_u^* > 0$.

The restrictions on variables (μ, λ, t_1, t_2) can be interpreted in two ways:

1) In the first interpretation, the restriction ensures sufficient uncertainty about the final return on the asset; in other words, μ should not be too close either to zero or 1 in order to prevent the specialist from giving up the profits expected from one side of the market by closing off that side.

2) The second interpretation asserts that the restriction ensures the presence of a sufficient number of uninformed traders in the population in order for the specialist's expected position to be profitable; in other words, λ must be close to zero.

In the special case where there are no informed traders (i.e. $\lambda = 0$), the square roots disappear, and the quote simplifies to ($0 < \mu < 1$):

$$b_u^* = \frac{1}{2}\left(E_\mu[\theta] + \theta_1\right) \quad (12)$$

$$\beta_u^* = t_2 \quad (13)$$

$$a_u^* = \frac{1}{2}\left(E_\mu[\theta] + \theta_2\right) \quad (14)$$

$$\alpha_u^* = t_1 \quad (15)$$

Consequently, the prices are merely mean values between the expected value and the ultimate values, while depths allow traders to trade with the desired volumes.

3.3. The passive quotation method

If μ fails to fulfil Proposition (1), meaning that there is no sufficient uncertainty around the payoff of the financial product and/or the specialist believes that there are too many informed traders, the equilibrium method of *Caglio* and *Kavajecz* (*2006*) will not work. Therefore – in view of the fact that the specialist's quote is likely to reflect the top of the order book if he thinks that there is a relatively large presence of informed traders on the market (*Kavajecz 1999*) – we assumed that the quote would evolve as follows: in such cases the specialist is concerned that he is likely to be confronted with a trader to whom he can only lose. Presumably then, he will try to move together with the market and refrain from announcing offers that deviate too much from the best prices.

Our assumptions for modelling are the following:

1) If the bid-ask spread is not greater than the pre-defined maximum spread (a parameter that can be set during the exercise), then the specialist will once again quote the best bid price and size and the best ask price and size sets listed in the order book.

2) If the bid-ask spread is greater than the prescribed maximum, the specialist is required to improve his quote. In such cases he will quote the next best price for an order of 150 shares on both sides, which will be entered into the order book, but only a part of it will actually remain in the book; namely, the quantity that was not matched during the transaction concluded with the trader that arrived at the given time.

3.4. Revision of the expectation about λ

In this sequential model, the specialist revises his λ expectations at the end of each trading round and announces a new quote for the next round. To understand the specialist's learning process it is important to see that when an incoming order is smaller than the quoted ask or bid depth (α or β), the specialist knows that the investor placing the order is uninformed because a liquidity trader would definitely want to buy less than the depth not knowing which way should he shift the price as he has no information about what the correct price should be. By contrast, if the incoming order is α or β, the specialist has no way of knowing whether the person placing the order is a large liquidity trader or an informed trader. An informed trader may take the full volume because he knows that he can shift the price towards the correct price. However, if an investor takes the depth in full, that is no guarantee in itself that he is uninformed.

Therefore, according to *Caglio* and *Kavajecz* (*2006*), the specialist interprets orders that are equal to the depth in accordance with the Bayes rule. The authors assumed that the proportion of informed traders follows a binomial distribution in the trader

population, with a λ parameter over the [0, 1] interval. In fact, the specialist has a preliminary expectation about λ, which was assumed to be uniformly distributed. Then, when the specialist observes an order with a volume of α or β, the ex-post probability of λ is the following:

$$P(\lambda|\alpha)=\frac{(1-\mu)(\lambda)}{(1-\mu)(\lambda)+\left(\frac{\alpha-t_1}{t_2-t_1}\right)\left(\frac{\theta_2-a}{\theta_2-\theta_1}\right)(1-\lambda)} \tag{16}$$

$$P(\lambda|\beta)=\frac{(\mu)(\lambda)}{(\mu)(\lambda)+\left(\frac{t_2-\beta}{t_2-t_1}\right)\left(\frac{b-\theta_1}{\theta_2-\theta_1}\right)(1-\lambda)} \tag{17}$$

Each individual trade carries information; it is an indication of the composition of the population. The aggregation of these signals defines the specialist's belief about the distribution of informed traders on the market. Based on *Caglio* and *Kavajecz* (*2006*), as more and more trading periods follow one another, the specialist's belief about the probability of being confronted by an informed trader should exponentially converge to the real value of λ.

Proposition 2: *If a trader's arrival at the market is a binomial stochastic variable with an unknown* λ *parameter and the ex-ante distribution is uniform over the* [*0, 1*] *interval, then with k full depth trades out of N trades the ex-post expected λ value will be:*

$$E\left(\lambda|k\ full\ trades\ out\ of\ N\ trades\right)=\frac{k+1}{N+2} \tag{18}$$

4. The simulation

The programme embodying the model was developed in Excel VBA and we ran the test with the Monte Carlo simulation. The programme consists of numerous components. On the one hand, it is composed of various functions, which react promptly to any changes in the input parameters and adjust the value of the functions; on the other hand, it comprises numerous subroutines that re-run the calculations only on repeated command. The sequence of calls plays an important role in this exercise. The programme is extremely flexible: parameters can be set easily, and accordingly numerous different cases can be simulated at the click of a button or two.

4.1. The quotation

Connecting the two kinds of quotation methods discussed in Sections 3.2 and 3.3, the function named "Specialist"[4] plays a key role in the simulation. Its outputs are quoted bid price and size and quoted ask price and size (*Table 1*). If μ fulfils

[4] See *Appendix 1*

Proposition (1), the specialist will use the "active" method to quote based on the equilibrium values of *Caglio* and *Kavajecz* (*2006*). If, however, μ does not meet the criteria, the quotation will be done with the "passive method" depending on the value of the spread at the given moment. During the simulation, these two quotation styles change continuously in response to the specialist's revisions of his beliefs as the only variable parameters are the λ_s, values included in the condition and the μ values linked to the different cases.

Table 1
The specialist's quotation

The specialist's quotation			
Buy		Sell	
Volume	Price	Volume	Price
12	99	–7	100

4.2. The management of orders

The second most important component is the "Order" subroutine.[5] The entire programme is built on running the subroutine n times. One of the basic assumptions of the simulation is that the specialist's quotes make up the limit orders that will be included in the order book, whereas traders' offers are market orders which, matched with the limit orders continuously knock the latter out of the book.

It is important, however, to understand the process of how orders are added to the book. If the specialist applies the active quotation method, the quoted orders will be included in the order book. If he needs to resort to the passive method, orders will only be added if they improve the quote; in other words, if the spread was higher than that permitted by the parameter we set. Otherwise, he will only announce the best orders from the book once again, in which case the orders will not be repeatedly added to the book, because this would set off a duplicating chain reaction and the order volumes would soar to infinity.

For the sake of transparency, instead of bid and ask prices we used a common price column with values ranging between 79 and 121. Upon generating the initial order book, the expected value of ask prices is 105 with a standard deviation of 7, the expected value of bid prices is 95 with a standard deviation of 5, and the volumes of the orders themselves are taken from a normal distribution with an expected value of 50 and a standard deviation of 15. (*Table 2* shows an excerpt from the initial limit order book).

[5] See *Appendix 2*

Table 2
Consolidated order book

Order book		
Buy	**Price**	**Sell**
	105	63
	104	55
	103	58
	102	174
72	101	
91	100	
78	99	
123	98	

4.3. The logs

We used two different logs for recording the observations. One of them is the order log.[6] The relevant subroutine copies all new incoming orders other than 0 into this log; i.e. this log collects all cases where the arriving trader accepted the specialist's quotation. The log contains the volume of all orders that have a meaningful sign, prices, the buy or sell direction and the fact whether the programme classified the given trader as informed or uninformed. Another subroutine is at work in the last column, which displays the specialist's belief about whether the given trader was informed or not (*Table 3*).

Table 3
Order log

Diary of orders					
Sequence number	**Volume**	**Price**	**Direction**	**Trader**	**Spec's belief**
1	–84	98	Sell	Uninf	
2	–48	96	Sell	Uninf	1
3	–51	98	Sell	Inf	1
4	7	100	Buy	Uninf	1

For understandable reasons, the specialist is not always correct in guessing the trader's type (as shown by *Table 3*) as indeed, the specialist can only see whether the given person traded the full depth or not. If yes, the specialist will deem the trader informed (signalled by 1) even though it is also possible that the trader was

[6] See *Appendix 4*

uninformed but by chance, his demanded volume coincided with the quoted depth. The sum of the numbers contained in this "Spec's belief" column gives the *k* value for Proposition (2); i.e. the number of full-depth trades, while the last sequence number of the log at a given moment gives the *N* value, which denotes the number of all trades completed that far.

The second log is the transaction log,[7] the first five columns of which are generated by another subroutine integrated into the "Order" subroutine. The next four columns are computed by Excel as shown in *Table 4*.

The transaction log is used for the purposes of inspecting the results.

1. The commission fee column simply contains the order value (volume·price) multiplied by 1.5 per cent; the value of the latter parameter can be set as required. Wealth is received as the product of current money and price.

2. For the calculation of money and stock, the direction of the transaction should be taken into account. In the case of a sell order, after the t[th] transaction money is computed as follows:

$$money_t = money_{t-1} + price_t \cdot volume_t + commission\ fee_t \tag{19}$$

   In the case of a buy order, the calculation will be:

$$money_t = money_{t-1} - price_t \cdot volume_t + commission\ fee_t \tag{20}$$

3. For stocks, the calculation is the opposite: if it was a sell order, the stock portfolio decreases after the t[th] transaction:

$$stock_t = stock_{t-1} - volume_t \tag{21}$$

   Conversely, in the case of a buy order, the portfolio increases:

$$stock_t = stock_{t-1} + volume_t \tag{22}$$

Table 4
Transaction log

Sequence number	Type	Volume	Price	Spread	Commission fee	Money	Stock	Wealth
1	Buy	84	98	3	123.5	501,699	993	599,013
2	Buy	48	96	4	69.1	497,161	1,041	597,097
3	Buy	51	98	4	75.0	492,238	1,092	599,254
4	Sell	7	100	2	10.5	492,948	1,085	601,448

[7] See *Appendix 5*

5. Evaluation of the results

5.1. Comprehensive statistics

Firstly, we would like to present a statistical table designed to evaluate the simulation as a whole and containing the mean values received for selected μ values. We computed these values with the Monte Carlo method, using the transaction log described in Section 4.3.

Table 5
Statistics

Averages / μ	0.49	0.4	0.3	0.2	0.1
Wealth growth	1,350	9,067	15,414	43,669	81,741
Δ Stocks	27	3,631	6,448	9,741	26,998
Commission fee	793	7,924	12,473	18,532	43,591
Transactions	10	34	39	45	48
Minimum price	95	94	93	94	95
Maximum price	104	105	104	103	103
$\lambda_i^{s,v}$	0.30	0.25	0.20	0.15	0.11
Revaluation	556	1,144	2,940	25,137	38,150

For each individual case, we ran 20 rounds of the programme where one round means 100 periods, i.e. 100 arriving traders. During the simulation a round takes place as follows:

1) The contents of the order and transaction logs are deleted.

2) The programme generates a new initial order book.

3) The "Order" subroutine runs 100 times (the parameter can be set as needed). The subroutine calls a trader in each period. The new order is added to the order log, the subroutine books the transaction in the transaction log, and the order book is updated. Obviously, not all traders say yes to the specialist's offer as it is quite possible that their reservation price is lower/higher than the quoted ask/bid price. In such cases no transaction takes place; the programme continues to run and the next participant arrives. Meanwhile, the specialist's quote and the possible final returns on the risky asset change continuously.

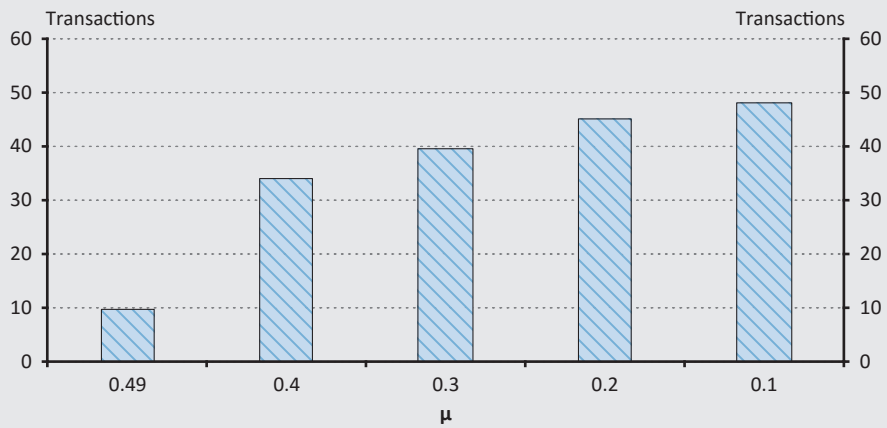
4) The results are calculated based on the transaction log.

After having run 20 rounds, the programme computes the mean of the results received at the end of each round, which is included in *Table 5*.

The means of minimum and maximum prices do not show a significant difference; apparently, changes in μ did not influence these values unambiguously. Price fluctuations, however, had a greater impact, as will be discussed in *Section 5.2*.

Table 5 also shows the average number of transactions of the 100 periods; in other words, the number of traders who accepted the quote of the specialist. *Figure 2* shows an impressive growth rate in line with a declining μ.

Figure 2
Changes in the number of transactions

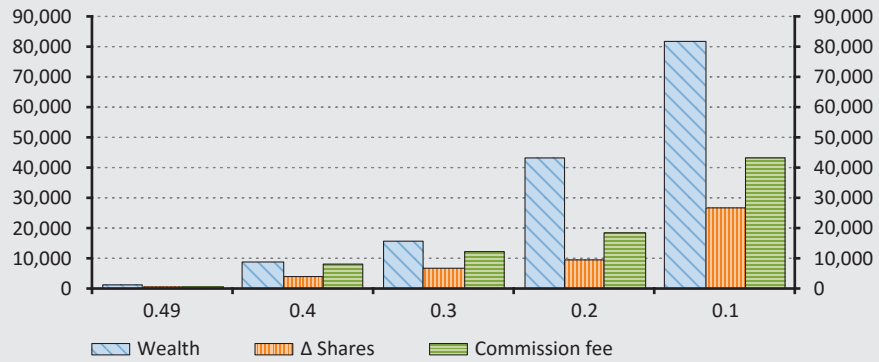


The smaller the μ, the smaller the uncertainty about the final payoff of the risky asset and simultaneously, the specialist's expectations about the percentage of informed traders also decrease exponentially ($\lambda_i^{s,v}$ indicates the mean value of the specialist's beliefs calculated from the values at the end of the simulation rounds), even though λ was set to 0.2 throughout the exercise. *Table 5* shows that the model behaved best when μ=0.3; that is when it deduced the real value of the specialist's lambda most accurately on average.

Accordingly, the number of transactions grows in line with the decline in uncertainty for the following reason: the specialist is more likely to know the possible price of the financial product as orders are more likely to come from informed traders, and thus the market price can converge to the fair price with more accuracy during the course of the transactions.

At the beginning of the simulation, the initial earnings of the specialist comprised 500,000 units of money, 1,000 shares, and the commission fee was set at 1.5 per cent. The greater number of transactions combined with the greater certainty about the product's return may account for the exponential increase in wealth, stocks and commission fees. Revaluation shows how wealth changed once the amount of commission fees was deducted. *Table 3* indicates this increment clearly.

Figure 3
Changes in wealth, stocks and the commission fee



5.2. Changes in prices

In order to examine the changes in prices and based on the results, changes in logreturns, we ran the code for each μ as many times as to receive nearly 400 observations for all five cases. We calculated their maximum and minimum values and, from the difference of these two, the range and the standard deviation.

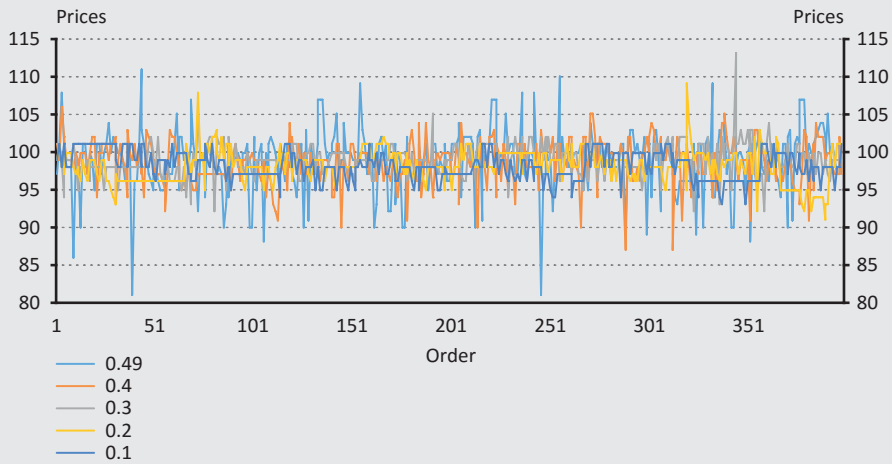
Table 6
Minimum and maximum values and range and standard deviation of prices

Price	0.49	0.4	0.3	0.2	0.1
min	81	87	92	91	93
max	111	106	113	109	101
range	30	19	21	18	8
standard deviation	3.95	2.85	2.09	2.20	1.86

Although *Table 5* shows that for each μ, the average minimum price is between 93 and 95 and the average maximum price is between 103 and 105 calculated from the values received at the end of the individual rounds, and μ did not appear to exert a clear impact on the prices, *Table 6* reveals that μ did have an influence on the prices. This is best demonstrated by the standard deviations of the individual cases. The smaller the uncertainty, the smaller the standard deviation of the prices (with a larger sample size this would be illustrated even more precisely, and the result of 0.3 would fit between 0.4 and 0.2 even better), which is consistent with the findings presented in Section 5.1.

Figure 4 clearly shows that the smaller the μ value, the smaller the price fluctuation.

Figure 4
Changes in prices



5.3. Changes in logreturns

According to the Efficient Market Hypothesis (EMH), market prices fully reflect public information; in other words, all available information is already incorporated into prices and therefore, prices are reliable (*Fama 1970*). Consequently, prices are shaped only by new information, from which it follows that the daily logreturns are independent and normally distributed (*Száz 2009*). Therefore, in the next section of our study we examine the extent to which this consequence holds true for the distribution of the logreturns received after the simulation.

We received logreturns from the prices by taking the natural logarithm of the chain indices. Their minimum and maximum values, means and standard deviations are summarised in *Table 7*.

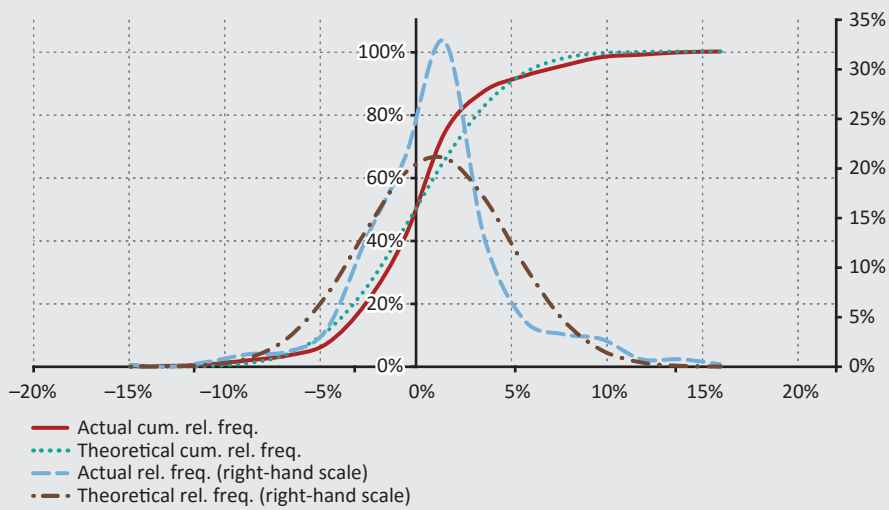
Table 7
Minimum and maximum values and mean and standard deviation of logreturns

Logreturn	0.49	0.4	0.3	0.2	0.1
min	–22.07%	–14.92%	–11.23%	–10.32%	–6.19%
max	18.03%	15.91%	10.24%	13.75%	6.19%
mean	0.00%	–0.01%	–0.01%	0.01%	0.01%
standard deviation	5.38%	3.81%	2.58%	2.14%	1.70%

We used these values for drawing up the frequency table, taking each individual case separately. Firstly, by using the minimum and maximum values, we prepared an absolute frequency table with 16 class intervals. From this, we calculated actual relative frequencies and then, actual cumulated relative frequencies. After this, we used a built-in Excel function to calculate the values that should be received from a normal distribution with this mean and standard deviation. The numbers received were the values of the cumulative distribution function of the normal distribution, which correspond to the theoretical cumulated relative frequency. Working our way backwards, from this we received the theoretical relative frequencies, and after multiplying these values by the number of observations we received the theoretical absolute frequencies.

The best result was received when μ=0.4 (*Figure 5*): this is when the distribution of logreturns most closely approximated the normal distribution, although even then, the probability density function was far more peaked than the normal bell curve. The cumulative distribution functions are fit to the primary axis and the probability density functions to the secondary.

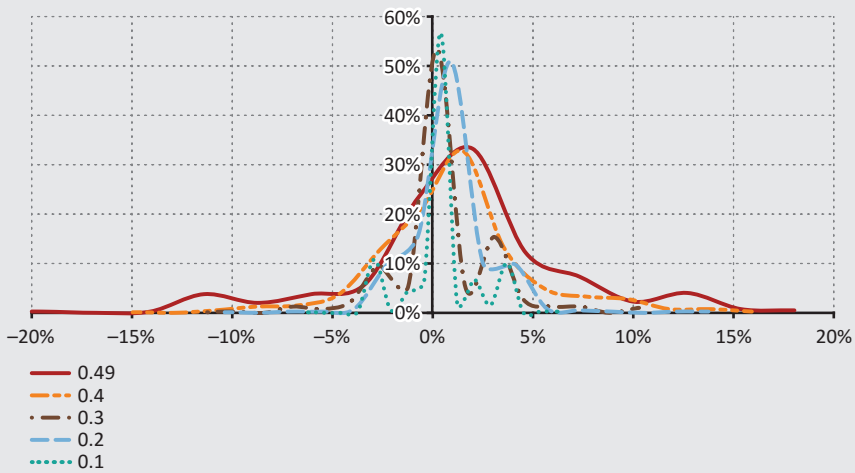
Figure 5
Distribution of logreturns if μ=0.4



In *Figure 6*, we show the distribution of the logreturns received for each of the five μ-s together. This pattern meets our expectations as it shows that the smaller the μ – i.e. the smaller the uncertainty about the ultimate value of the risky product – the more biased the probability density function of the actual logreturns relative to that of the normal return. Accordingly, the more information the specialist has about the asset's payoff, the more impaired the EMH; namely, that all information

available is incorporated into prices and thus, the distribution of the logreturns fits the normal curve less and less. A larger sample size would probably result in an even more spectacular demonstration of the continuous upward bias.

Figure 6
Distribution of logreturns for each μ value under review



The case where μ=0.49 is apparently more biased compared to the case featuring the 0.4 value. This is probably because in that case μ seldom meets the criteria defined with the inequality included in Proposition (1) and therefore, the programme applies the passive quotation type instead of the active equilibrium model proposed by *Caglio – Kavajecz.*

6. Summary

The purpose of our study was to write a simulation programme that may allow us to examine the impact of adverse selection on the specialist's price quotation, the extent to which various levels of uncertainty influence prices and logreturns, and the accuracy to which the specialist can determine the proportion of informed traders on the market based on the transactions.

Based on the simulation, the specialist's belief about the ratio of informed traders was the most accurate where μ=0.3 on average.

The results showed unambiguously that the number of transactions grows in line with the decline in uncertainty, as the specialist becomes more likely to predict the potential price of the financial product. Parallel to this, both the specialist's earnings and stock portfolio increase progressively.

At the same time, price fluctuation and the standard deviation of logreturns decline continuously, and the consequence of the efficient market theory, namely, that the standard deviation of logreturns follows a normal distribution, becomes more and more biased as the condition that prices reflect public information becomes impaired.

Table 8 sums up these results. Analogously, when the process is reversed: an increase in uncertainty will trigger an opposite change in the other areas.

Table 8
Impact of changes in uncertainty

Uncertainty (μ)	decreases
Number of transactions	increases
Wealth	increases
Stocks	increases
Price fluctuation	decreases
Standard deviation of logreturns	decreases
Fit of logreturns to normal distribution	decreases

The results were consistent with our expectations and of course, their precision and clarity would probably improve further with a bigger sample size and repeated runs of the programme.

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Appendices

The appendices of our paper present the most important subroutines and functions written for the simulation.

Appendix 1: Function of the specialist's quotation I

As mentioned before, the function combines two methods. If μ fulfils condition (1) – which consists of two inequalities – then the equilibrium values will be consistent with *Caglio* and *Kavajecz* (*2006*). If the inequality is not fulfilled, then the programme jumps to the next commands. The same command is run even when it is not only the second half of the inequality that is unfulfilled, but also the first part of it. At the end of the function, a built-in function rounds up the generated bid and ask prices and volumes to the nearest whole number.

```
Function specialist(mu, v1, v2, lambdaS, t1, t2, spmax, spmost)

Dim Ev, v21, t21
ReDim assumption(1 To 2)
ReDim bidask(1 To 4)

Ev = mu * v1 + (1 - mu) * v2 'expected value of the asset
v21 = v2 - v1
t21 = t2 - t1
assumption(1) = (lambdaS - lambdaS * t2 / t1) / (1 - lambdaS * t2 / t1)
assumption(2) = (1 - lambdaS) / (1 - lambdaS * t2 / t1)

If assumption(1) < mu Then 'condition (1) is fulfilled
  If mu < assumption(2) Then 'condition (2) is also fulfilled
    'bid size
    beta = 3 / 2 * t2 - 1 / 2 * t2 * (1 + (8 / t2) * (lambdaS / (1 - lambdaS)) * (mu /
(1 - mu)) * t21) ^ 0.5
    'bid price
    b = 1 / 4 * (3 * Ev + v1) - 1 / 4 * (1 - mu) * v21 * (1 + (8 / t2) * (lambdaS / (1 -
lambdaS)) * (mu / (1 - mu)) * t21) ^ 0.5
    'ask size
    alpha = 3 / 2 * t1 - 1 / 2 * t1 * (1 - (8 / t1) * (lambdaS / (1 - lambdaS)) * ((1 -
mu) / mu) * t21) ^ 0.5
    'ask price
    a = 1 / 4 * (3 * Ev + v2) + 1 / 4 * mu * v21 * (1 - (8 / t1) * (lambdaS / (1 -
lambdaS)) * ((1 - mu) / mu) * t21) ^ 0.5
  Else 'but condition 2 is not fulfilled
```

```
      If spmost <= spmax Then
      'if the spread is good
        For i = 3 To 45
          If Cells(i, 12) > 0 Then
            beta = Cells(i, 12)
            b = Cells(i, 13)
            GoTo 51
          End If
        Next i
51
        For i = 45 To 3 Step -1
          If Cells(i, 14) > 0 Then
            alpha = -Cells(i, 14)
            a = Cells(i, 13)
            GoTo 53
          End If
        Next i
      Else
      'if the spread is higher than permitted
        For i = 3 To 45
          If Cells(i, 12) > 0 Then
            beta = 150
            b = Cells(i, 13) + 1
            GoTo 52
          End If
        Next i
52
        For i = 45 To 3 Step -1
          If Cells(i, 14) > 0 Then
            alpha = -150
            a = Cells(i, 13) - 1
            GoTo 53
          End If
        Next i
53
      End If
    End If
Else 'even condition 1 is unfulfilled
    If spmost <= spmax Then
    'if the spread is good
      For i = 3 To 45
        If Cells(i, 12) > 0 Then
```

```
            beta = Cells(i, 12)
            b = Cells(i, 13)
            GoTo 54
          End If
        Next i
54
        For i = 45 To 3 Step -1
          If Cells(i, 14) > 0 Then
            alpha = -Cells(i, 14)
            a = Cells(i, 13)
            GoTo 56
          End If
        Next i
      Else
      'if the spread is higher than permitted
        For i = 3 To 45
          If Cells(i, 12) > 0 Then
            beta = 150
            b = Cells(i, 13) + 1
            GoTo 55
          End If
        Next i
55
        For i = 45 To 3 Step -1
          If Cells(i, 14) > 0 Then
            alpha = -150
            a = Cells(i, 13) - 1
            GoTo 56
          End If
        Next i
56
      End If
End If

bidask(1) = Application.Round(beta, 0)
bidask(2) = Application.Round(b, 0)
bidask(3) = Application.Round(alpha, 0)
bidask(4) = Application.Round(a, 0)
specialist = bidask

End Function
```

Appendix 2: The order subroutine

This subroutine is the most complex of all. It calls numerous other routines which update the specialist's beliefs, change the value of the risky asset, book the orders, or are required simply for technical reasons.

2.1 Beginning of the subroutine

```
Sub order()

updating_belief 'the specialist's belief about lambda changes as a result of the previous order
risky_asset 'the value of the risky asset changes

'Parameter selection
mu = Cells(5, 1)
v1 = Cells(3, 1)
v2 = Cells(3, 2)
vi = Cells(3, 3)
t1 = Cells(3, 6)
t2 = Cells(3, 7)
beta = Cells(10, 1)
b = Cells(10, 2)
alpha = Cells(10, 3)
a = Cells(10, 4)
lambdaS = Cells(10, 6)

Dim e, r, Ev, v21, t21
Ev = mu * v1 + (1 - mu) * v2 'expected value of the asset
v21 = v2 - v1
t21 = t2 - t1
```

2.2 Inclusion of the specialist's orders in the order book

```
'SPECIALIST:
'HYPOTHESIS: the specialist's orders are limit orders
ReDim assumption(1 To 2)
assumption(1) = (lambdaS - lambdaS * t2 / t1) / (1 - lambdaS * t2 / t1)
assumption(2) = (1 - lambdaS) / (1 - lambdaS * t2 / t1)
Cells(4, 3) = assumption(1)
Cells(5, 3) = assumption(2)
spmax = Cells(3, 10)
spmost = Cells(3, 11)
```

```
If assumption(1) < mu Then 'condition (1) is fulfilled
   If mu < assumption(2) Then 'condition (2) is also fulfilled
   'new quote, which is added to the book
      For i = 3 To 45
         If Cells(i, 13) = Cells(10, 2) Then
            Cells(i, 12) = Cells(i, 12) + Cells(10, 1) 'the specialist's bid volume
         End If
         If Cells(i, 13) = Cells(10, 4) Then
            Cells(i, 14) = Cells(i, 14) + Abs(Cells(10, 3)) 'the specialist's ask volume
         End If
      Next i
   Else
      If spmost > spmax Then
      'if the spread is higher than permitted, then
      'the new order improves the quote and is also added to the book
         For i = 3 To 45
            If Cells(i, 13) = Cells(10, 2) Then
               Cells(i, 12) = Cells(i, 12) + Cells(10, 1) 'the specialist's bid volume
            End If
            If Cells(i, 13) = Cells(10, 4) Then
               Cells(i, 14) = Cells(i, 14) + Abs(Cells(10, 3)) 'the specialist's ask volume
            End If
         Next i
      End If
   End If
Else
   If spmost > spmax Then
   'if the spread is higher than permitted, then
   'the new order improves the quote and is also added to the book
      For i = 3 To 45
         If Cells(i, 13) = Cells(10, 2) Then
            Cells(i, 12) = Cells(i, 12) + Cells(10, 1) 'the specialist's bid volume
         End If
         If Cells(i, 13) = Cells(10, 4) Then
            Cells(i, 14) = Cells(i, 14) + Abs(Cells(10, 3)) 'the specialist's ask volume
         End If
      Next i
   End If
End If
```

2.3 Generation of informed traders

```
'TRADERS:
'trader generation
p = Rnd()
If p > 0.8 Then
   Cells(14, 4) = "Inf" 'informed
Else
   Cells(14, 4) = "Uninf" 'uninformed
End If

'informed trader
If Cells(14, 4) = "Inf" Then
   If b > vi Then
      Cells(14, 1) = -beta 'volume
      Cells(14, 2) = b 'price
   Else
      If a < vi Then
         Cells(14, 1) = Abs(alpha)
         Cells(14, 2) = a
      End If
   End If
End If
```

2.4 Generation of liquidity traders

```
'uninformed trader
If Cells(14, 4) = "Uninf" Then

   e = Application.WorksheetFunction.RandBetween(t1, t2)
   r = Application.WorksheetFunction.RandBetween(v1, v2)
   Cells(3, 8) = e
   Cells(3, 9) = r

   If e > 0 Then 'he wants to sell
      If b > r Then 'his min ask price is higher than the spec's bid price
         Cells(14, 1) = -Application.WorksheetFunction.Min(beta, e)
         Cells(14, 2) = b
      Else
         Cells(14, 1) = 0
      End If
   End If
   If e < 0 Then 'he wants to buy
      If a < r Then 'his max bid price is higher than the spec's ask price
```

```
        Cells(14, 1) = Application.WorksheetFunction.Min(Abs(alpha), Abs(e))
        Cells(14, 2) = a
      Else
        Cells(14, 1) = 0
      End If
    End If

End If
```

2.5 Ask order

```
diary_of_orders 'orders are added to a log

'parameters of the new order are saved in new variables
ordervol = Abs(Cells(14, 1)) 'abs value is needed because if ask order, vol. is negative
orderprice = Cells(14, 2)
ordertype = Cells(14, 3)

'HYPOTHESIS: traders' orders are market orders
If ordertype = "Sell" Then 'market price ask
a1 = ordervol
k = 0
  For i = 3 To 45
    k = i + 1
    If Cells(i, 13) = orderprice Then
      If Cells(i, 12) >= a1 Then
      'if there are more in the book than the order (remainder)
        Cells(i, 12) = Cells(i, 12) - a1 'TRANSACTION
        Cells(14, 6) = a1 'volume of last transaction
        Cells(14, 7) = Cells(i, 13) 'price of last transaction
        diary
        a1 = 0
      Else
      'if there is less in the book, the order is divided further
        a1 = a1 - Cells(i, 12)
        Cells(14, 6) = Cells(i, 12) 'volume of last transaction
        Cells(14, 7) = Cells(i, 13) 'price of last transaction
        diary
        Cells(i, 12) = 0 'TRANSACTION
        GoTo 21
      End If
    End If
    Cells(6, 10) = a1
  Next i
```

```
  21  Do Until a1 = 0
  For j = k To 45
    If Cells(j, 12) > 0 Then
      If Cells(j, 12) >= a1 Then
      'if there are more in the book than the order (remainder)
        Cells(j, 12) = Cells(j, 12) - a1 'TRANSACTION
        Cells(14, 6) = a1 'volume of last transaction
        Cells(14, 7) = Cells(j, 13) 'price of last transaction
        diary
        a1 = 0
        GoTo 22
      Else
      'if there is less in the book, the order is divided further
        a1 = a1 - Cells(j, 12)
        Cells(14, 6) = Cells(j, 12) 'volume of last transaction
        Cells(14, 7) = Cells(j, 13) 'price of last transaction
        diary
        Cells(j, 12) = 0 'TRANSACTION
      End If
    End If
  Next j
22  Loop
End If
```

2.6 Bid order

```
If ordertype = "Buy" Then 'market price bid
a2 = ordervol
h = 0
  For i = 45 To 3 Step -1
    h = i - 1
    If Cells(i, 13) = orderprice Then
      If Cells(i, 14) >= a2 Then
      'if there are more in the book than the order (remainder)
        Cells(i, 14) = Cells(i, 14) - a2 'TRANSACTION
        Cells(14, 6) = a2 'volume of last transaction
        Cells(14, 7) = Cells(i, 13) 'price of last transaction
        diary
        a2 = 0
      Else
      'if there is less in the book, the order is divided further
        a2 = a2 - Cells(i, 14)
        Cells(14, 6) = Cells(i, 14) 'volume of last transaction
```

```
            Cells(14, 7) = Cells(i, 13) 'price of last transaction
            diary
            Cells(i, 14) = 0 'TRANSACTION
            GoTo 23
          End If
        End If
        Cells(6, 11) = a2
    Next i

23  Do Until a2 = 0
    For j = h To 3 Step -1
      If Cells(j, 14) > 0 Then
        If Cells(j, 14) >= a2 Then
        'if there are more in the book than the order (remainder)
          Cells(j, 14) = Cells(j, 14) - a2 'TRANSACTION
          Cells(14, 6) = a2 'volume of last transaction
          Cells(14, 7) = Cells(j, 13) 'price of last transaction
          diary
          a2 = 0
          GoTo 24
        Else
        'if there is less in the book, the order is divided further
          a2 = a2 - Cells(j, 14)
          Cells(14, 6) = Cells(j, 14) 'volume of last transaction
          Cells(14, 7) = Cells(j, 13) 'price of last transaction
          diary
          Cells(j, 14) = 0 'TRANSACTION
        End If
      End If
    Next j
24  Loop
End If

netting 'netting in the order book

End Sub
```

Appendix 3: Updating the specialist's belief

First, the "Order" sub calls the "updating belief" subroutine. It computes the *k* and *N* values from the order log, then it computes the specialist's belief about the ratio of informed traders on the basis of the formula of Proposition (2).

```
Sub updating_belief()

beta = Cells(10, 1)
alpha = Cells(10, 3)
k = Cells(10, 7)
i = 23
Do Until Cells(i, 1) = 0
   i = i + 1
Loop

N = Cells(i - 1, 1) 'last sequence number
j = 22 + N
If Cells(j, 2) = alpha * (-1) Then
   Cells(j, 6) = 1
End If
If Cells(j, 2) = beta * (-1) Then
   Cells(j, 6) = 1
End If

lambdaS = (k + 1) / (N + 2)
Cells(10, 6) = lambdaS

Cells(10, 8) = N

End Sub
```

Appendix 4: Order log

The order log works as described in *Section 4.3*.

```
Sub diary_of_orders()
i = 23
Do Until Cells(i, 1) = 0
   i = i + 1
Loop
If Cells(14, 1) <> 0 Then
Cells(i, 1) = i - 22
Cells(i, 2) = Cells(14, 1)
Cells(i, 3) = Cells(14, 2)
Cells(i, 4) = Cells(14, 3)
Cells(i, 5) = Cells(14, 4)
End If
End Sub
```

Appendix 5: Transaction log

The transaction log works as described in *Section 4.3*.

```
Sub diary()

i = 2
Do Until Cells(i, 17) = 0 ‘check in which row should it enter the next transaction
i = i + 1
Loop ‘transaction is entered in the new i row

Cells(i, 17) = i - 1 ‘sequence number of last transaction
Cells(i, 19) = Cells(14, 6) ‘volume
Cells(i, 20) = Cells(14, 7) ‘price
Cells(i, 21) = Abs(Cells(10, 4) - Cells(10, 2)) ‘spread

‘the specialist stands on one side of each transaction
If Cells(14, 3) = "Buy" Then ‘if the incoming order was a bid order
   Cells(i, 18) = "Sell" ‘the specialist sold
End If
If Cells(14, 3) = "Sell" Then ‘if the incoming order was an ask order
   Cells(i, 18) = "Buy" ‘the specialist bought
End If

End Sub
```

Appendix 6: Changes in the value of the risky asset

It takes the two possible outcomes of the risky asset's ultimate value from the $N\sim(100,5)$ distribution. In the code, v1 corresponds to the variable denoted by Θ_1 in the model (the first possible outcome at a probability of μ), while v2 denotes Θ_2 (the second possible outcome at a probability of $1-\mu$), and w denotes Θ^* (the real ultimate return).

```
Sub risky_asset()

u1 = 5 * Application.NormSInv(Rnd()) + 100 'the first outcome
   v1 = Application.Round(u1, 0)
u2 = 5 * Application.NormSInv(Rnd()) + 100 'the second outcome
   v2 = Application.Round(u2, 0)
If v1 < v2 Then
   Cells(3, 1) = v1
   Cells(3, 2) = v2
Else
   Cells(3, 1) = v2
   Cells(3, 2) = v1
End If

w = Rnd()
mu = Cells(5, 1)
If w <= mu Then
   vi = v1
Else
   vi = v2
End If
Cells(3, 3) = vi 'real value

End Sub
```

Appendix 7: Calculation of the results

The "Results" subroutine works with the data contained in the transaction log at the end of each round. *Table 5* shows the results at the end of each round, as discussed in *Section 5.1*.

```
Sub results()
'check how long the series is
a = 2
Do Until Cells(a, 17) = 0
   a = a + 1
Loop
'Earnings increment
Cells(2, 28) = Cells(a - 1, 25) - Cells(2, 25)
'Change in stock portfolio
Cells(3, 28) = Cells(a - 1, 24) - Cells(2, 24)
'Commission amount
commission = 0
   For i = 2 To a - 1
      commission = commission + Cells(i, 22)
   Next i
Cells(4, 28) = commission
'Number of transactions
Cells(5, 28) = Cells(a - 1, 17)
'Minimum and maximum price
minprice = Cells(2, 20)
maxprice = Cells(2, 21)
For i = 2 To a - 1
If Cells(i, 20) < minprice Then minprice = Cells(i, 20)
If Cells(i, 20) > maxprice Then maxprice = Cells(i, 20)
Next i
Cells(6, 28) = minprice
Cells(7, 28) = maxprice
'Belief about lambda at the end of the period
Cells(8, 28) = Cells(10, 9)
End Sub
```

Optimising Nobel Prize Laureates*

Dietmar Meyer

The Nobel Prize, which has existed since 1901, is awarded to persons (and on rare occasion to institutions) who have achieved outstanding results in physics, chemistry, medicine, literature and the pursuit of peace. The history of the Nobel Prize in Economic Sciences – awarded for the first time in 1969 and officially known as the 'Sveriges Riksbank Prize in Economic Sciences in Memory of Alfred Nobel' – shows a slightly different picture, since in the first two decades it was awarded to still living "doyens" of this branch of science (Frisch, Tinbergen, Hicks, Myrdal, Hayek, Haavelmo, Coase – just to mention a few of them). In recent years, this prize serves primarily for the recognition of research results: In 1994, 2005, 2007, 2012 and 2014 the prize was awarded to scientists excelling in various game theories, in 1996 and 2001 to experts working in the field of asymmetric information, and in 2002 to experts researching the link between psychology and economic science. In 2010 and 2016, the Nobel Prize in Economic Sciences was awarded in the field of labour market analysis and contract theory, respectively. It appears as if the Committee awarding the prize first chose a generally topical subject matter and then award the Prize to experts who are successful and produce outstanding results in that field. 2018 was no exception. Although the laudation of the two laureates – William Nordhaus and Paul Romer – mentions their excellent scientific achievement, as they received the Prize "for their work analysing the impact of climate change on global economy, and related to the endogenous growth theory", a more detailed analysis shows that here again there is a very strong link between the two scientists in terms of content and methodology, since the problem of sustainability and the application of the optimisation procedures, mentioned in the title, also connects them.

Journal of Economic Literature (JEL) codes: B22, O40, O44

Keywords: endogenous growth theory, sustainability, climate change

1. Optimisation and control

Anybody who is just a little bit familiar with the history of economic science knows that optimisation appears in this discipline as early as with Adam Smith, at the time when formalised procedures were yet unknown. In the 19th century – particularly

* 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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since *Jevons* (1871) – the optimal consumption structure of households and the optimal factor utilisation of enterprises, etc. were already defined with the use of mathematical tools. However, these problems have always been examined statically, i.e. the optimal solution was determined under given and *constant* conditions. Dynamic elements appeared in the economic models relatively late.[1] In economic sciences, studies using the dynamic approach commenced in larger numbers only from the 1950s; however, these were still limited to the description of processes. The focus was on issues such as that of *Robert M. Solow* (1956), the laureate of the 1987 Nobel Prize of Economic Sciences, the goal of whose research was to find out how the growth of the revenue of an economy, which can be characterised by a given willingness to save – and in connection with this – to invest, can be modelled. In the language of mathematics: In fact, Solow and his followers set up a differential equation, which defines the temporal development of revenues or any of the variables determining that, under given parameters – constant growth rate of the population, stable saving rate and also a given depreciation rate – in an abstract way or generally, by the value of the given variable. Thus, the relation then targeted was an equation, which – assuming continuity – can be set up as follows:

$$\frac{dx(t)}{dt} = \dot{x}(t) = f\big(x(t)\big) \tag{1}$$

Naturally, with this the aforementioned economists were still very far from optimisation, since they assumed that the behaviour of the economic agents was given once and for all, instead of looking for a saving or investment behaviour – which although it varies, or rather can be varied in time, is still optimal – that in a specific period results in maximum revenue or consumption. Naturally, this condition is rather far from reality, since the propensity to save very much depends on the level of income. And yet such approaches are not surprising, since the necessary mathematical optimisation tools were not yet available at that time. The detailed elaboration of these was started in the 1950s by *Richard Bellmann* (*1954*), and it is mainly owing to *Lev Pontryagin et al.* (*1968*) that by deducing the maximum principle named after him, he published an optimisation procedure that could also be applied by economists. It was *Robert Dorfman* (*1969*) who called the attention of his colleagues to this opportunity. In Hungary, the significance of this method was first recognised by András Bródy.

Thus, economic scientists have only had a set of instruments suitable for resolving dynamic optimisation tasks since the early 1970s. In fact, this is based on the linking of two processes: one of these is the original process, consisting of state variables $x(t)$ while the other one is the $u(t)$ control process. This is determined by the controlling person or institution in such a way that it takes the extreme value of

[1] Of the early works, it is worth mentioning *Feldman* (*1967*, or the original paper: *1928*), and *Palomba* (*1939*).

an objective function depending on both $x(t)$ the process and the control process. If this occurs, then we selected the best control process of all, i.e. we applied optimal control.

Consider a simple example. A fish population, deemed fully homogenous for the sake of simplicity, has a natural increase. The rate of this obviously depends on the existing stock of fish. Thus, considering the birth and death rate of fish, the process of the natural increase of the fish population can be stated as

$$\frac{dh(t)}{dt} = \dot{h}(t) = f\big(h(t)\big) \tag{2}$$

where $h(t)$ is the stock of fish at the time t, $\dot{h}(t)$ is the change in the stock of fish also at the time t, while the $f(\ldots)$ function states the relation between them; in this example the state variable is the prevailing fish stock.

The control in this example is the fishery, i.e. $u(t)$ means the number of fish fished out at time t. With this, we influence the fish stock and thereby also the reproduction rate of the fish stock. Accordingly, the formula above needs to be supplemented:

$$\dot{h}(t) = F\big(h(t), u(t)\big) \tag{3}$$

If we strive for the maximum sustainable fish stock, we need to opt for a fishing strategy that on the one hand provides profit on fish consumption, and on the other hand does not jeopardise the fish population of the future. The $G\big(h(t), u(t)\big)$ function expresses the sustainability of the fish stock. In accordance with the foregoing, in fact we look for the maximum of $\int G\big(h(t), u(t)\big)dt$. If we can manage to determine the fishing strategy that produces this maximum, we find the optimal control for the purpose of the sustainability of the fish stock.

The work of both laureates of the 2018 Nobel Prize in Economic Sciences is characterised by the continuous application of the optimisation procedure presented above. But let us investigate this in more detail.[2]

2. William Nordhaus

William Nordhaus was born on 31 May 1941 in Albuquerque, New Mexico, the largest settlement in the state. He received his BA in 1963 and MA in 1967 from the renowned Yale University. He also defended his doctoral dissertation in 1967 at MIT, as a result of which he holds a Ph.D. His scientific career unfolded at Yale University, where he returned to after obtaining his doctorate. There he climbed

[2] In this work, the author follows Zsuzsa Bekker, who – sparing no trouble – edited an excellent book on the laureates of the Nobel Prize in Economic Sciences (*Bekker 2005*).

the teaching career ladder, and finally became professor in 1973. He still holds this position at present. Of his publications, probably the best known one is the textbook entitled Economics, written together with fellow Nobel Prize Laureate in Economic Sciences *Paul A. Samuelson*, published in several editions and languages, but even before this book he wrote studies that made his name known around the world. In one of his papers (*Nordhaus 1975a*), he dealt with the political business cycles, a topic well-known to all of us: it has been observed for decades that the value of certain economic variables moves in parallel with the election periods: in the year of parliamentary elections the income and/or budget deficit is high, while the unemployment rate becomes low.[3]

2.1. The political business cycle

An important element of Nordhaus' explanation for the cycles is the assumption that the government is not the usual "benevolent dictator" but rather a rational actor, just like all other actors. This is because the government is comprised of individuals, who are interested in remaining in office. This is referred to as an opportunist government, i.e. a machine with the goal of winning the next elections as well.

Nordhaus assumed of the *ith* voter that he makes the decision on the election date – strongly simplifying it[4] – only based on the current economic situation. He measures the latter by factors determining his own wealth – which, according to Nordhaus, includes the unemployment rate $u(t)$ and the inflation rate $\pi(t)$. Based on this, we can draw the $h_i\left(u(t),\pi(t)\right)$ "election function" of the ith voter applicable to the tth period, the value of which +1 if he votes for the government, and 0 if he votes against. By aggregating these individual election functions we obtain the nationwide election function:

$$h\left(u(t),\pi(t)\right)=\sum_{i=1}^{n}h_i\left(u(t),\pi(t)\right), \tag{4}$$

where n is the number of citizens eligible to vote. Since the nationwide election function contains only the number of votes for the governing parties, $\frac{1}{n}\sum_{i=1}^{n}h_i\left(u(t),\pi(t)\right)$ expresses the ratio of those voting for the government. The higher (lower) this ratio is, the greater (lesser) chance the governing parties have of winning the election.

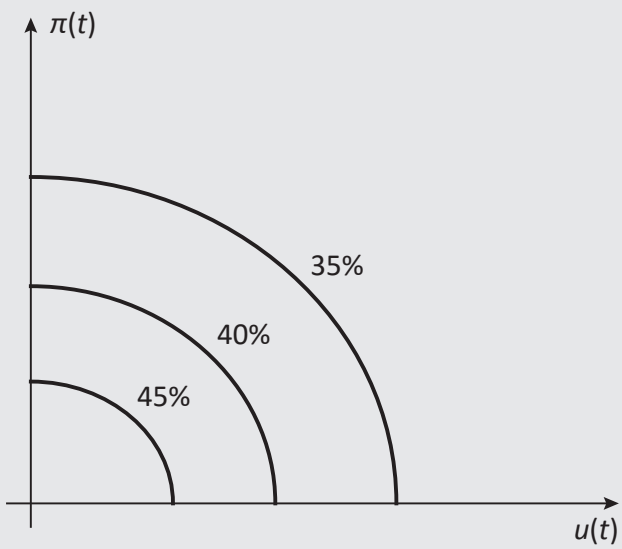
Obviously, an identical election result may be achieved by different $\left(u(t),\pi(t)\right)$ pairs. Accordingly, the indifference curve of the nationwide election can be drawn as the set of points providing an identical number of election votes. This curve

[3] This phenomenon existed in Hungary as well, except that here it was budget deficit – which until 2006 was always outstandingly high in the election years – that first follows the election period rather than the change in unemployment and inflation.

[4] Factors such as the voters' party loyalty, social approach, the positive or negative judgement of the organisations running for the election, etc. are ignored.

is left-skewed, since with an increasing unemployment rate an identical election result is feasible only with an inflation rate that is lower than before. Naturally, the different number of votes represents different curves, which obviously can have no common point. Since the higher unemployment rate and higher inflation rate result in decreasing wealth, which also reduces the number of votes, the curves which are further away from the origin represent a worse election result (see *Figure 1*).

Figure 1
Indifference curves of nationwide election



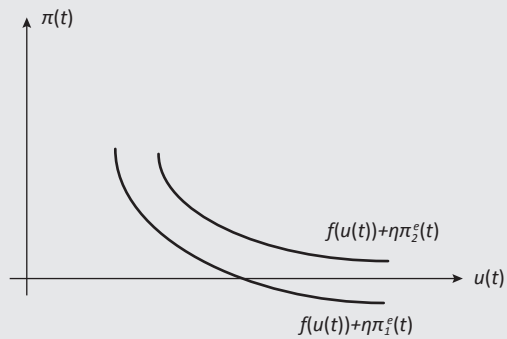
However, economic agents do not decide who to support with their votes solely on the basis of the unemployment rate and inflation rate prevailing on the election day: they also consider the period since the last election as a whole. If the date of the previous election was year 0 and the date of the current election is year t^*, the period in question is the interval $[0,t^*]$. The further away the date is, the less weight it has it in the current decision. Based on this, the number of votes that can be expected by the government is the weighted average of the votes belonging to each point of time of interval $[0,t^*]$, which – taking time as a continuous variable – leads to expression $\int_0^{t^*} h\big(u(t),\pi(t)\big)e^{\mu t}dt$. Thus, the government in office is interested in the maximisation of this.

The other side of the model is the restrictive condition, the *Phillips curve* – also relying on the unemployment rate and inflation rate – which, for the sake of a dynamic approach, Nordhaus supplemented with inflation expectations:

$$\pi(t) = f\big(u(t)\big) + \eta\pi^e(t)\,, \tag{5}$$

where $\pi^e(t)$ is the expected inflation rate, and $f'\big(u(t)\big) < 0$, and $0 < \eta < 1$. Equation (5) means that the higher the inflation expectations are, the higher the inflation rate will be with a constant unemployment rate, i.e. rising inflation expectations push the Phillips curve upwards (see *Figure 2*, where $\pi_2^e(t) > \pi_1^e(t)$).

Figure 2
Impact of inflation expectations on the Phillips curve



With this, the model contains three variables, $u(t)$, $\pi(t)$ and $\pi^e(t)$-t. The government is interested in pursuing an economic policy that earns the maximum number of votes, i.e. it needs to find the Phillips curve that affects the lowest lying election indifference curve. The optimal position thus determined also means that the combination of the unemployment rate and inflation rate is acceptable for the majority of voters (*Figure 3*).

Pursuant to the foregoing, the equation specifying inflation expectations is still missing from our model. In respect of this, Nordhaus assumes that it is produced in an adaptive manner, i.e.

$$\dot{\pi}^e(t) = \delta\big(\pi(t) - \pi^e(t)\big) \tag{6}$$

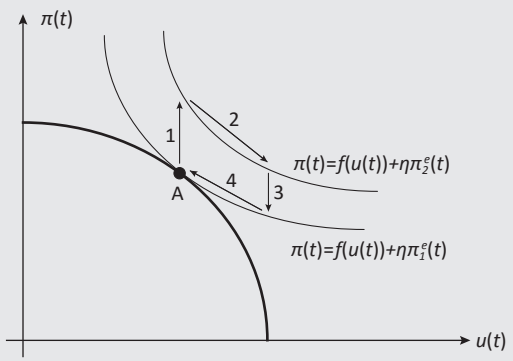
The duty of the government striving for re-election is now to maximise

$$\int_0^{t^*} h\big(u(t), \pi(t)\big) e^{\mu t} dt$$

under conditions (5) and (6).

In the model above, $\pi^e(t)$ is the state variable and $u(t)$ is the control variable. The problem can be formulated as follows: We look for the economic policy that results in an unemployment rate the development of which and the development of the related inflation expectations maximise the number of votes for the incumbent government. The mechanism for this is as follows: The government must ensure that the unemployment rate is low right before the election. According to the concept of the Phillips curve, this implies a high inflation rate (point A on *Figure 3*), which increases inflation expectations in the near future, and thus the Phillips curve shifts upwards (arrow 1). Naturally, in political terms this means a loss of votes. In its work, the government must make efforts to reduce inflation by proper financial strategy (arrow 2), as a result of which inflation expectations decline and the Phillips curve shifts downwards (arrow 3). However, the anti-inflation policy causes the unemployment rate to rise. If the government manages to reduce the latter once again before the next elections (arrow 4), it has a chance to win the elections repeatedly.

Figure 3
Mechanism of the optimal economic policy



In the Nordhaus model, unemployment and inflation rates fluctuate depending on the date of the elections. The more precisely the electoral law of a country stipulates the date of the elections (e.g. every five years, every seven years), the more regular cycle can be expected. Naturally, in the background there is the tacit assumption that the voters do not discover the trick, or – if they do anyway – they forget it by the next election...

2.2. Climate and economic growth

Nordhaus (*1975b, 1977*) also started to deal with climate issues almost simultaneously with the elaboration of the political business cycle. It was the potential control of the volume of carbon dioxide that raised his interest. He published two essays on this topic, in which he had not yet modelled, but rather wanted to present a picture of the situation based on empirical analyses. Naturally, this topic had been researched before as well, and even the first steps to curb the detrimental effects of carbon dioxide had been made, but – as noted by Nordhaus – these were mostly characterised by managing the problems locally, although it should be obvious that the world faces a global problem. Hence, it is very much possible that the carbon dioxide emission and the stronger presence of industrial heat may also generate climate changes in the future.

Nordhaus participated almost from the very beginning in the elaboration and application of the Integrated Assessment models. These are extremely complex models, which contain the models of the individual disciplines as parts, and the objective of their application is to analyse global questions, such as global warming or climate policy, as well as the causal connections, as comprehensively as possible, considering the technological, economic, political and social aspects. *Nordhaus* (*1992*) is also linked with the elaboration of DICE (Dynamic Integrated Climate-Economy) and RICE (Regional Integrated Climate-Economy), and the continuous fine tuning of these.

He also published numerous papers on the topic of economic growth and climate change. Carbon dioxide emissions increase due to the economic growth compulsion, and this causes changes in the climate. As a result of this, the economic and ecological conditions change, which leads to various climate policy measures. However, these curb economic growth. Thus, the question is: what can we do? *Nordhaus* (*1991*) and his followers looked for the answer relying on a growth model, which I present below in a very simplified form. In his model, Nordhaus considered three effects of climate change:

- Part of the otherwise realisable income cannot be generated due to climate change; arable land decreases due to floods, crops decrease due to droughts, the performance of employees decreases due to the lasting heat, etc.
- Capital goods are worn out to a larger degree; part of the real capital is damaged due to natural disasters (see Fukushima), but this also includes the increasingly frequent forest fires, which destroy a significant part of the wealth.
- A new cost factor appears: capital goods that were not necessary before must be deployed, e.g. due to the rise in the average temperature more air conditioners are needed both by industry and households, due to the drought more irrigation is necessary, etc.

The income that can be generated at the *t*th point of time before the occurrence of climate change is marked with $\hat{Y}(t)$. We define the generation of this with a Cobb–Douglas production function, i.e. $\hat{Y}(t)=AK(t)^{\alpha}L(t)^{1-\alpha}$; here *A* is the parameter representing technical progress, *K*(*t*) is the capital stock involved in production at the *t*th point in time, while *L*(*t*) is the number of people in employment at time *t*th. The α parameter is the production flexibility of the capital, while $1-\alpha$ is the production flexibility of labour; obviously $0<\alpha<1$. If as a result of climate change D_Y per cent of the potentially realisable income is not generated (first impact), then the actual income is only $(1-D_Y)\hat{Y}(t)$. However, if Λ per cent of this needs to be used for the recovery or mitigation of damages (third impact), the income[5] available for consumption and saving is only $Y(t)=(1-\Lambda)(1-D_Y)\hat{Y}(t)$, i.e.

$$Y(t)=(1-\Lambda)(1-D_Y)AK(t)^{\alpha}L(t)^{1-\alpha}. \tag{7}$$

Thus, the change in capital stock is the difference between the investment and the wear and tear of the capital stock, i.e. $\dot{K}(t)=dK(t)/dt=I(t)-\delta K(t)$. This relation now changes, because both the capital stock and the growth thereof decrease with the wear and tear stemming from climate change (second impact). If – as a result of climate change – the capital stock decreases by D_K per cent, the relation valid for the investment is now $(1-D_K)\dot{K}(t)=I(t)-(1-D_K)\delta K(t)$, i.e.

$$\dot{K}(t)=\frac{1}{1-D_K}I(t)-\delta K(t) \tag{8}$$

In the equilibrium assumed by Nordhaus, investment equals savings, and the latter forms part of the income, i.e. $I(t)=S(t)=sY(t)=s(1-D_Y)(1-\Lambda)Ak(t)^{\alpha}L(t)$. Some calculation returns the following (see *Appendix*) equation,

$$\dot{k}(t)=\frac{1}{1-D_K}s(1-D_Y)(1-\Lambda)Ak(t)^{\alpha}-(\delta+g_L)k(t), \tag{9}$$

the equilibrium resolution of which is

$$k^{\alpha}=\frac{(\delta+g_L)(1-D_K)}{s(1-D_Y)(1-\Lambda)A}k. \tag{10}$$

The left side of the equation practically contains a root function ($0<\alpha<1$), while the right side is a function linear in *k*, which passes through the origin, and the steepness of which is $\left[(\delta+g_L)(1-D_K)\right]/\left[s(1-D_Y)(1-\Lambda)A\right]$. These two curves are shown in *Figure 4*.

[5] Naturally, tax should be also taken into consideration, but we ignore it in this discussion.

Figure 4
Equilibrium in the climate model

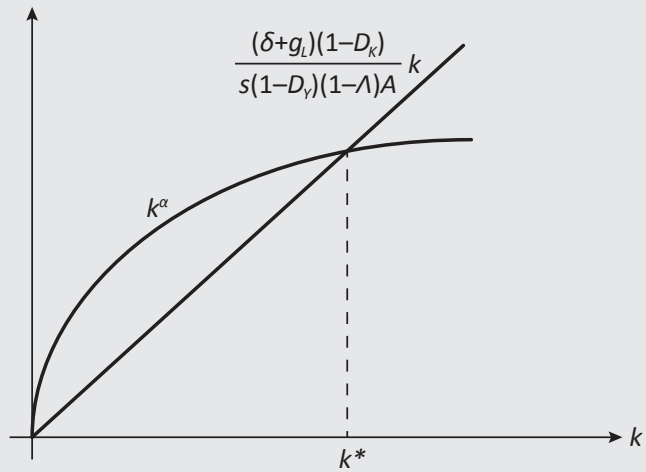


Figure 4 shows that

- if – as a result of climate change – the impact on income generation increases (D_K), the straight line will be steeper, i.e. the intersection will shift to the left, and thus the capital stock per capita decreases, thereby also decreasing the level of the equilibrium income;
- the situation is the same if the costs generated by climate change (Λ) increase: this also reduces the capital stock per capita;
- if climate change influences the capital stock negatively, the steepness of the straight line declines and the capital stock per capita increases.

The rather different impact of the first two and the third statements is attributable to the fact that in the first two cases either no supply is created at all or supply is damaged. However, in the third case the absence of capital generates demand, thereby stimulating production and income formation. Thus, it cannot be stated immediately and unambiguously that the economic impact of climate change is definitely negative; the question is much more complicated and complex than that.

The model presented reflects the work of Nordhaus in an overly simplified manner; Nordhaus made an attempt, through empirical analyses, to quantify the damages stemming from climate change and to also capture their development over time. His work legitimately makes him a leading climate economist in the field.

3. Paul Romer

Paul Michael Romer was born on 7 November 1955, in Denver, Colorado. His father, *Roy Romer*, was once Governor of Colorado. He earned a bachelor degree in mathematics in 1977 from the University of Chicago. He started to deal with economic science more deeply thereafter, first at MIT and then at Queens University, in Canada. He earned his Ph.D. from the University of Chicago in 1983. The first station in his career, between 1982 and 1988, was the University of Rochester, after which he served as professor at a number of famous universities – at the University of Chicago until 1990, at the University of California, Berkeley until 1996 and at Stanford University until 2010. At present, he is a Professor of Economics at the Stern School of Business, operating under New York University. He was chief economist of the World Bank between 2016 and 2018.

The mathematical background of *Romer* (*1986a*) can be felt mostly in his early publications. The paper, published three years after defending his dissertation, is a major mathematical contribution to mathematical economics and in a certain sense it is a starting point on the way leading to the elaboration of the endogenous growth theory.

One of the most frequent assumptions of economic science, even these days, is diminishing returns, i.e. the phenomenon according to which if we increase the production factor expenditure by one unit, output will increase, but an additional factor unit will only increase output to a lesser degree than the previous unit did. This can be supported by several examples; however, it should be noted that this criterion is extremely important in terms of modelling as well. This is because, in the language of mathematics, diminishing returns means that – staying in the above field, i.e. product manufacturing – the production function is concave, i.e. the marginal product curves belonging to it are left-skewed. Thus, it is certain that by increasing the factor expenditure, the factor price curve intersects the marginal product curve, and this intersection also determines the optimal factor utilisation. In other words, had the concavity condition been not met, the negative skewness of the marginal product curve would also not be ensured, and thus the definition of the intersection by the factor price curve, and thereby of the optimal factor utilisation, would be also at risk, or the “optimal” volume of factors would be infinite. In the aforementioned paper, Romer proved a thesis, which facilitates the usual optimisation in the case of non-concave functions as well.

Since human resource, knowledge or technological innovations are typically factors that produce non-concave functions, it is not surprising at all that *Romer* (*1986b*) published a paper back in 1986, where he applied his own results in the model that also takes technological changes into consideration.

3.1. The endogenous growth theory

The modern growth theory started with the work of *Robert M. Solow*, Laureate of the Nobel Prize in Economic Sciences (*1956*, *1957*). In his first paper, he elaborated an equilibrium and stable growth model, where investment in real capital was the driver of income growth. He chose a Cobb-Douglas relation as production function. Based on this – using the capital stock and employment time series of the USA for the period 1909–1949 – he prepared an estimate for the income values expected for the period. He compared this with the actually observed data and found that his own estimates explain only around 33 per cent of the real values. The conclusion he drew was clear: if it is not possible to describe the actual development of income only by capital and labour, there must be at least one more factor that influences production. He labelled this as "technical change" (*Solow 1957*).

In fact, he integrated this technical progress into his model by introducing a new parameter; thus, technical change simply "exists" – and hence it is an exogenous factor of economic growth. Naturally, it did not take long to come under fire; the "function of technical progress" of *Miklós Káldor* (*1957*) or the "learning by doing" concept of *Kenneth J. Arrow* (*1961*) are critiques and also attempts to manage the problem.

Romer (*1990*) also joined in the discussion on this topic. He also believes that technological change is the most important growth factor, but does not regard it as something given from outside or as a process determined by some macroeconomic regime; instead, he interprets technical progress as the result of the conscious, profit-oriented decision of micro actors, primarily enterprises, i.e. essentially some kind of product or at least a phenomenon similar to it. This means that in order to induce technological change, enterprises forego part of their consumption, and save and invest it in the same way as in the case of the other products. However, the product that carries the technological change – the idea – is a special product: it is neither private, nor public property. The utilisation of an idea does not disadvantage anybody; it can be often used without causing damages to other – i.e. there is no competition, and thus it cannot be private property. At the same time, they can prevent others by patents from applying the idea. They do so to be able to cover the – often very high – research or development costs, from the initial revenues earned on the monopolistic market created as result of the protection of the product. Others can be prevented from the use of the product, and thus it cannot be public property.

The fact that the use of the ideas may be restricted also meant that Romer overstepped the former neoclassical growth theory, since he had to break with the perfect markets approach, continuously emphasised by the advocates thereof. At this point, it is worth referring back to Romer's aforementioned optimisation

paper: on neoclassical perfect markets the marginal productivity theses are almost automatically valid, i.e. each factor of production obtains as much of the production result as it contributed to the generation thereof. Since the human resource or technical progress results in increasing yield, adhering to the marginal productivity theses would lead to the conclusion that this factor must receive an increasingly larger part of the final goods. And this would only be possible by spending less on the financing of the other factors, i.e. it would lead to the result that the marginal product of labour and capital would exceed the factor prices. And this is nonsense.

In his model, Romer differentiates three sectors:

a) the research sector, producing ideas – innovation;

b) the sector producing intermediate goods – essentially capital goods; which then

c) will be used in the sector manufacturing final goods for consumption.

In the *research sector,* part of the currently existing $H(t)$ knowledge (φ) is used, with defined efficiency (δ) for the "production" of additional knowledge:

$$\dot{H}(t) = \delta\varphi H(t). \tag{11}$$

The sector that produces final goods uses the following Cobb-Douglas technology:

$$Y(t) = \left[(1-\varphi)H(t)\right]^{\alpha} L^{\beta}(t) K^{1-\alpha-\beta}(t), \tag{12}$$

where $Y(t)$ is the final good, $(1-\varphi)H(t)$ is the human resource used during the production of the final goods, $L(t)$ is the labour input and $K(t)$ is the capital stock.

The capital stock is augmented from savings, i.e. from the unconsumed final goods, which – if we ignore the depreciation of the capital goods – means that

$$\dot{K}(t) = Y(t) - C(t) = \left[(1-\varphi)H(t)\right]^{\alpha} L^{\beta}(t) K^{1-\alpha-\beta}(t) - C(t). \tag{13}$$

Households strive to maximise their consumption, i.e.

$$\int_0^{\infty} C(t) e^{\gamma t}\, dt \rightarrow max!$$

The economic content of the problem can be formulated as follows: we look for the savings or investment strategy and human resource development strategy, based on which we obtain revenues that maximise consumption.

The statement of the problem shows that there is a very strong methodological parallel between the approaches of Nordhaus and Romer. Both of them optimise dynamic processes; Nordhaus optimises inflation expectations, while Romer optimises income developments. As anti-inflation policy was a tool for Nordhaus

to ensure the re-election of the government by the proper shaping of inflation expectations changing as a result thereof, similarly, the development of proper human resources is a tool for Romer to maximise households' consumption.

3.2. The Charter City concept

In 2009, Romer came up with an idea that has been disputed ever since. His solution for the global overpopulation and impoverishment observed in certain parts of the world is to establish new large cities in the territory of developing countries. In his view, overpopulation and impoverishment are caused by the fact that investment resources, undoubtedly available in the developed countries, are not used in the areas where they would be needed the most, because these countries are usually unstable in political terms. Potential investors do not invest in developing countries, because they deem the political risk to be too high. The question is: to what extent it is possible to reinvest the profit earned there, elsewhere. To what extent does the government guarantee the inviolability of ownership rights, and what does it mean when the government guarantees it in words? How corrupt is the administration of the respective country and what additional costs does this generate later on?

Romer believes that these are the issues that first of all should be settled reassuringly, because ensuring political stability and fixing the general legal and economic conditions over the long run would encourage the inflow of capital necessary for economic development and recovery would ensue almost automatically.

Romer envisages the implementation of this by the developing countries providing the territory for the establishment of artificial cities and the developed countries would elaborate the legal system applicable to these cities – the Charter – since in this case political stability and predicable economic and legal conditions would be guaranteed. The staff of the administration – including the justice system and the armed forces – would mostly include the experienced and tried-and-true representatives of the developed countries. There would no elections; the leaders of the cities would be elected by the population of the developed countries or appointed by the boards of these countries. Under such circumstances the problems that now deter investors would practically disappear.

The Charter Cities are the combination of the developed legislation and the low costs that characterise less developed regions. Under such circumstances, the less developed regions or countries would be able to enforce their comparative advantages better. This is why Romer proposed that these artificial metropolises initially be established mostly in the coastal areas, since it is much easier to manage trade there. Hong Kong, returned by the United Kingdom to China, but the operation of which is still controlled by the British in the new situation as well, is the favourite, often cited success story of Romer.

The formulation of Romer's concept was obviously governed by his own experiences in the USA. There, if a city (has not yet) adopted its own Charter, the functioning thereof is controlled by the constitution of the respective state. It is not uncommon in the United States for the cities to opt for this solution. For example, 121 of the 478 cities in California are governed solely by the laws and regulations issued by the State – including large cities such as San Francisco and Los Angeles. According to the legislation of Texas as well, all cities without a Charter organise their life in accordance with the constitution of the federal state.

However, there is a big difference between the examples from the USA and Romer's proposal. The basis of the success story of the United States, and even of Hong Kong, is that the population of those cities accept, or even become one with the superior government level. However, the situation is completely different when the representatives of the developed states "oppress" the less developed region and thus the opinions of those cannot be simply rejected. Due to this, Romer is accused of spreading neo-colonisation ideas.

4. Brief evaluation summary

This paper presented only a small part of the wide-ranging activity of the two award-winning economists. Nevertheless, outlining the selected research topics probably still supports the opinion of this paper's author, according to which in 2018 the Nobel Prize in Economic Sciences was awarded to two experts who take a very peculiar approach not only on the economic processes, but also on the social problems to be interpreted much more broadly and who – although their views may often be disputed – have enriched economic and social science with their work.

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Appendix

The equation below follows from relation (7)

$$Y(t)=(1-\Lambda)(1-D_Y)Ak(t)^{\alpha}L(t),$$

where $k(t)=K(t)/L(t)$, i.e. the capital stock per capita.

The change in the capital stock is

$$\dot{K}(t)=\frac{1}{1-D_K}s(1-D_Y)(1-\Lambda)Ak(t)^{\alpha}L(t)-\delta K(t),$$

or

$$\frac{\dot{K}(t)}{K(t)}=\frac{1}{1-D_K}s(1-D_Y)(1-\Lambda)Ak(t)^{\alpha}\frac{L(t)}{K(t)}-\delta=$$
$$=\frac{1}{1-D_K}s(1-D_Y)(1-\Lambda)Ak(t)^{\alpha-1}-\delta$$

Growth rate of the capital stock per capita

$$\frac{\dot{k}(t)}{k(t)}=\frac{\dot{K}(t)}{K(t)}-\frac{\dot{L}(t)}{L(t)},$$

from this – taking the growth in the number of people in employment as constant $\left(\dot{L}(t)/L(t)=g_L\right)$ – we obtain

$$\frac{\dot{k}(t)}{k(t)}=\frac{1}{1-D_K}s(1-D_Y)(1-\Lambda)Ak(t)^{\alpha-1}-\delta-g_L,$$

i.e.

$$\dot{k}(t)=\frac{1}{1-D_K}s(1-D_Y)(1-\Lambda)Ak(t)^{\alpha}-(\delta+g_L)k(t).$$

Nordhaus examined the stationary status, thus $\dot{k}(t)=0$. The discussed relation (10) follows from this.

Key to Understanding China, the Enigmatic Great Power*

Júlia Gutpintér

Yukon Huang:
Cracking the China Conundrum: Why Conventional Economic Wisdom Is Wrong
Hungarian translation: A Kína-talány megfejtése – Miért nem helytálló a konvencionális gazdasági bölcsesség?
PALLAS ATHÉNÉ PUBLISHING HOUSE, Budapest, 2018, p. 352
ISBN: 978-615-5884-03-0

Conventional knowledge on China is often misguided despite wide media attention and extensive academic research. This is the claim that the book entitled *"Cracking the China Conundrum"* starts from. It was originally published by Oxford University Press at the end of 2017, while the Hungarian edition was produced by the Pallas Athéné Publishing House. The author is Yukon Huang, senior fellow in the Asia Program at Carnegie Endowment for International Peace. During his career he has acquired extensive knowledge on both Western and Chinese perspectives. Through an in-depth review of specific aspects of China's economy, Huang examines why conventional economic wisdom cannot be applied to China, and why China's economic and political processes generate such extreme emotions and views. We can read at least as much about China's growing economic dominance as about its impending collapse. Its authoritarian regime is considered by at least as many people to be its Achilles heel as those who consider it the crucial factor in China's rise. It comes as no surprise that China attracts such huge attention. Its economic rise – achieved by following a different model from mainstream Western notions – has resulted in a fundamental shift in global power relations, and as a country accounting for one quarter of global production, its economic and political steps and changes have a profound impact on global trends. At the same time, it is less clear why there is such a great divergence of views. The author believes the reason behind the differences of opinion among experts and economists dealing with China are the lack of a common and adequate analytical framework. On the one hand, models describing socialist or transitional economies cannot be used in China; on the other hand, although the operation of its economy is closer to the functioning of a market economy, it cannot be fully aligned with the latter framework either.

* 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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Likewise, neither can the economic development models of developing countries be applied to it. The size and regional diversity of the country means it is difficult for the general public to draw the right conclusions too, since spatial factors influence economic processes in such a direction and to such an extent that macroeconomic indicators can only grasp to a limited degree. This often leads to generalisation and simplification, which together with emotional factors result in a complete misunderstanding and misinterpretation of China's economic processes.

In his book consisting of ten chapters and two appendices, the author seeks to clarify these misunderstandings and misinterpretations by analysing several aspects of China's economic and social system, often in an approach that goes against mainstream narratives. The selection of aspects is not entirely comprehensive. The author focuses on the aspects that influence the views on China to the greatest extent. In his opinion, the different global views of China are mainly shaped by three factors: its economic performance or role in the global economy, its changing activity in foreign and security policy, and the observers' political and ideological position. The author provides a deeper analysis in the book of the social, economic and political processes that determine these aspects. Due to space limitations, this review only highlights the most important processes.

Following a review of the various global perceptions of China and their changes over time, the author presents the reform period beginning in the 1980s as well as the mechanism for reforms, which is indispensable to understand the current problems. The author identifies two strong elements of the reforms initiated by Deng Xiaoping then developed during the term of Zhu Rongji, and the resulting economic transformation, i.e. the deliberate policy of regionally differentiated and concentrated development as well as the reliance on the banking system for policy purposes as the underlying causes for the current imbalances and problems of the economy.

In the following Chapter 4, the author examines these imbalances and refutes the (mistaken) beliefs surrounding them. It is a widespread notion that China's growth is unbalanced, both internally and externally. A sign of internal imbalance is that the share of consumption to GDP is unusually low, while the share of investment to GDP is exceptionally high. External imbalances stem from trade surpluses, but they have declined considerably since then, reaching 10 per cent in the mid-to-end 2000s, which hit the USA and Europe particularly hard, and fundamentally determined the view of China in this period. According to the author, the external imbalance is no longer an issue, since China's trade surplus amounted to just 1.3[1] per cent of GDP in 2017. The author emphasises, rather unusually, the role of urbanisation in

[1] *Source: World Bank*

the emergence of internal imbalances; he sees them as unavoidable by-products of a generally successful growth process, a reflection of fast urbanisation and regional production specialisation. He explains that the transfer of workers from labour-intensive, rural activities to capital-intensive urban activities increases the share of profits to GDP and results in higher levels of investment and growth in the economy. However, this process lowers consumption as a percentage of GDP, even if consumption grows in absolute terms.

Chapter 5 focuses on debt problems and property market issues which are considered to be weaknesses of China's economy. The author too believes they are serious, but he finds the related fears are excessive. What gives rise to the greatest concern – in the author's opinion – is the significant increase, even by global standards, in outstanding debt observed over the last 7–8 years, while in terms of debt-to-GDP ratio China still ranks in the middle. However, the biggest part of the change can be explained by the extension of credit financing and the growth of the private property market. Therefore, Huang argues, the surging debt levels do not pose a problem as long as the current level of real estate prices is sustainable.

In Chapter 6, the author reviews social and political problems and the related economic issues. One of the newest and – from a Western perspective – most astonishing findings of this chapter, and perhaps the book, relates to the role of corruption in China's economy. The author believes that corruption played a special role in China's economy, a role which is different from the widely accepted narrative based on the theories of institutional economics related to Acemoglu: corruption did not impede but encouraged growth, and has not slowed down with the economic development, but has increased instead. However, the current level of corruption is now proving to be a barrier to growth, and also leads to an increase in political instability. The vast majority of corruption results from the interplay of key actors that run the economy: the Party/government, state-owned enterprises and state banks. The author compares this network of relations to a Chinese dining table with a single pillar-like leg representing these three actors that supervise the distribution of resources in very close cooperation, and work towards the common goal, economic growth, which is represented by the table top. According to Huang, this model should be replaced by a Western-style dining table with separate legs to prevent the Party or the government from exerting influence on banks and enterprises. This shows that the success of attempts to fight corruption does not ultimately depend on impressive campaigns launched by Xi Jinping, but on whether the leadership allows the market to become the primary determinant of resource distribution.

Chapters 7 and 8 discuss the impacts of China's trade, capital investments and foreign policy for the global economy, with special regard to the USA and Europe. Chapter 9 presents China's changing role in the global balance of power. In 2013,

there was a clear shift in the passive foreign policy, a feature of China until then. The key thread of Deng Xiaoping's foreign policy was that China is not a great power, nor will it ever seek to be one, and that China's rise is peaceful, which does not threaten its neighbours, but benefits the whole world. However, Xi Jinping broke with this approach in order to restore China to its ancient prominence, and he announced an active, focused, strategic foreign policy to exploit the considerably increased resources of the country. The instruments to be used for achieving the foreign policy objectives encompass a broad spectrum: from "softer" instruments like the increase of export and outward direct investments, internationalisation of the renminbi and the implementation of infrastructure developments (e.g. Belt and Road Initiative) to "harder" ones like assertiveness in the South China Sea disputes. China's role in the global balance of power is determined by its "abnormal great power" status as defined by the author, which means precociousness: China is the first developing country to become a great power, but it reached this status before being mature in several respects; its population ages before becoming wealthy, and its economic potential is disproportionate to its negotiating power and manoeuvring capabilities in sensitive global issues, mainly due to its internal problems.

In Chapter 10, Huang reviews – perhaps less coherently than in previous chapters – the current situation and possible future change in the opinions on China, in view of economic and (geo)political prospects. He points out that in the last few years, due to falling growth rates, surging debt levels and the runaway property market, pessimistic voices have become louder than ever, forecasting a "hard landing". In contrast to them, he is in the camp of optimists: he believes there is no probability of any significant negative turn in growth, and he sees a fair chance of growth at a rate of 5–7 per cent in the next 5–10 years, which is still higher than that of most developed and many developing countries. Furthermore, if a more disciplined approach is adopted to fiscal and financial management, a hard landing could be avoided. This chapter also summarises the prospects for political liberalisation. Starting out from the examples of East Asian countries following a similar path, or more exactly from their income and urbanisation level during the transition, the author forecasts that political liberalisation will be induced in the second half of the next decade. This process will surely be different from Western and Asian models. It is likely that it will begin within the Party, as a result of intensifying pressures exerted by a widening middle class. From a geopolitical point of view, perceptions about China can increasingly be seen as negative. With its political and economic measures and assertive foreign policy, it not only demands its position in the changing world order but intends to play a leading role. Given the vastly different societal values and structures, this engenders fear and hostility in the West. However, it is important to emphasise that China's influence, for the time being, is not as strong as could be expected from its economic power, since its ability to deal with sensitive international issues and to exercise soft power is still limited.

This book will certainly give readers a better understanding of China, the enigmatic great power. However, rather than the creation and application of a new, rigorous analytical framework it is primarily the special perspective of the author and the detailed nature and depth of the content that help the reader explore China's economic, social and political processes and discover the reasons for the picture painted of China. The book is definitely useful for readers who know little about China, since they get an overall picture of the country's economic and (geo)political processes. The detailed analysis of the economic and political processes coupled with the author's unusual approach can also bring new information and perspectives to those who are familiar with the issues related to China.

The Future of the Financial Intermediary System in the Bank 4.0 World*

Tamás Kristóf

Brett King:
Bank 4.0 – Banking Everywhere, Never at a Bank
Marshall Cavendish International, Singapore, 2018, p. 384
ISBN: 978-1-119-50650-8

Brett King is a renowned futurist and highly reputed author of numerous publications that have attracted a high level of response from the professional field. In this work, he explores the future of banking in the context of a new paradigm shift in the financial intermediary system, in a world developing at an unprecedented speed. In this ground-breaking book, he reconsiders the future business model of banks and provides guidance on how to imagine and realise the vision and strategy that could ensure the future survival of banks in the face of the challenges posed by FinTech companies in a radically changing technological environment. To justify the predictions, the publication presents a wide range of case studies and analogies from which it turns out that the banking system is no exception from development trends in other sectors. The main finding of the publication is that – without a major strategic change – traditional financial institutions will not be able to survive in the future even if they are shielded under a protectionist umbrella, in a world where 200,000 smartphones are sold every hour, because they are simply not quick, flexible and agile enough to keep pace with FinTech firms.

The evolution of banking

According to *King*, the era of Bank 1.0 started with the activities of the Medici family and lasted until the 1980s. This period was characterised by branch-centred, physical contact and high level of friction and by having no or a low level of digitalisation. In the period of Bank 2.0 from 1980 to 2007, self-service banking arrived, which made it possible to access services outside opening hours, first through ATMs and then through the Internet. The era of Bank 3.0 started with the appearance of smartphones in 2007 and accelerated with the spread of mobile

* 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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payments and challenger banks which specialised in P2P and mobile payments through increasingly aggressive sales channels.

Bank 4.0 started in 2017. Bank 4.0 means ubiquitous real-time service which is embedded in the technology layer and eliminates physical contact with the bank. This digital, smart, multi-channel, compelling service anticipates consumer needs using artificial intelligence. Bank 4.0 is especially apparent through the drastic changes in customer behaviour and through the emergence of FinTech firms that provide financial services all over the world. In the Bank 4.0 world, a pioneering role in technologies is a crucial condition. Being good at banking alone is not enough: actually it is almost more of a disadvantage, because according to *King* the false sense of satisfaction is a barrier to quick adaptability. Banks will have to become invisible to their customers, while the services embedded in the technology layer will have to be continuously available.

It can be argued that the majority of banks are currently at the development level of Bank 1.0, 2.0 or 3.0. A Bank 4.0 institution is very rare, even at the global level, and for several banks there is no hope that they will ever reach such a development level. In the Bank 4.0 world, if a bank is not embedded into the technology layer around customers, it will fall victim to the changes. The bankers of the future will no longer be bankers but technocrats. Traditional banking products will disappear from the market, and their digitalisation will not be enough to ensure their survival.

The time will soon come when cameras in restaurants, places of entertainment, subways and airports can automatically assess customers' solvency and credit status. Customer identification will take place through facial recognition, and therefore we will not have to carry our mobile phones, cash, plastic cards and identity cards when we go out. Using face ID, our passports will be in the cloud linked to big data verifying creditworthiness. Correctness read from these data will be welcome everywhere, while unreliability will be refused.

King's predictions for the next ten years

After a thorough exploration of the development trends, challenges and alternatives for the future, the author outlines the following hard-to-dispute forecasts for the period 2025–2030:

- As early as 2025, leading technology companies (Alibaba, Amazon, Google, Tencent, Apple) and FinTech firms will be the biggest deposit collectors.
- By 2025, roughly 3 billion customers who have never set foot in a bank will enter the financial intermediary system.
- In 2025, more people will conduct transactions through a computer, smartphone, voice or augmented reality *daily* than they visit a bank branch at least annually.

- In 2025, more financial advice will be provided by AI-based algorithms and software solutions than are currently provided by advisors working in financial institutions worldwide.
- By 2025, one-fourth of day-to-day e-commerce and mobile commerce will be triggered by voice or a software agent, and voice-based smart assistants may expect 25–30 per cent higher income than competitors without voice recognition services.
- By 2025, the world's largest retail banks will generate the majority of their revenues through digital channels.
- By 2030, at least a dozen countries will go mostly cashless, including China's urban population, the Scandinavian countries, Singapore and Australia.
- By 2030, more than 30 per cent of current bank employees will lose their jobs as a result of artificial intelligence, although a small part of them will be replaced by data technicians, behavioural psychologists and technocrat gurus.

The key to survival in the Bank 4.0 world

King thinks that if a bank is steeped in tradition, has lots of bankers, an old core, a raft of regulations, and is reliant on branch traffic for revenue, it is likely too late to survive, because it will not be able to make the necessary transformation in time to become a bank embedded in the technology layer. Capital market analysts will soon simply question the sustainability of banking through a branch network, and the devaluation of traditional bank shares will commence shortly, as a visible sign of a slow decline.

King's conclusion may seem strange but true: FinTech firms alone will be unable to suppress banks, since the real winners of the fight for bank accounts will be voice, augmented reality and AI agents dominating the technology layer, platforms managing day-to-day commerce and instant messaging, and smart assistants. The bank account of the future will be an activated cloud-based repository which will respond through the technology layer anywhere where the customer wants to transact. This is not an application or a website, not even a bank branch. The ubiquitous "artificial intelligence-banker" will intermediate between the customer and the financial world. Advertisements will target the artificial intelligence-banker, not the customer. Financial intermediates will develop the technology through which they forward their services to the artificial intelligence-banker which will select the most suitable one.

Many traditional banks believe that regulators will not allow this to happen, but it is ridiculous. The regulators that are the first to awake (e.g. in Shanghai, Hong Kong,

Singapore, and London, and the MNB as well) are already launching a regulatory sandbox, implementing open banking, cooperating with FinTech firms and regulating crypto currencies, because they are aware that the financial services of the future are being created today, and they do not stand in the way of transformation. Regulators can improve the survival rates of today's banks by easing the regulations on personal customer identification and cloud platforms.

King summarises the key elements for survival in the Bank 4.0 world as follows:

- *Experiences, not products* – a complete reconsideration of the product paradigm is required to ensure the maximum usefulness of services for the customers through the technology layer, while having no physical contact with customers.
- *No more bankers* – instead of bankers, innovative talents must be employed who deeply understand technologies such as voice recognition, machine learning, blockchain, cloud integration, biometrics and customer experience design.
- *Data is the new driving force* – banking in the future will not be based on today's transactional or credit reference data, but on data that provides context for delivery of real-time banking services, since these data are the fuel for artificial intelligence.
- *Existing system is no excuse* – the existing system architecture should not be an excuse for not creating a unique experience for customers. This is when a new team is urgently needed to force the pace in creating the necessary middleware, cloud and FinTech solutions, and thus fill in the gaps. Agility paves the way towards Bank 4.0.
- *Artificial intelligence* – this is the key to a paradigm shift in real-time financial advice delivered through the technology layer.
- *Don't try this at home* – the key to agility is recognising that if banks replicate the solutions of FinTech firms, it adds a delay of several years and is far more expensive compared to if they license the appropriate technology from a professional external service provider. It is essential for banks to collaborate with FinTech firms through common cloud platforms and the application programming interface.
- *Open the kimono, don't block the blockchain* – by sharing data more effectively and securely, a model of auditable and permitted open banking can be set up, which is critical in a world where 80 per cent of customer relationships are dependent on the correct interpretation of data.

Finally, the author expresses his hope that everybody is ready for the coming era of Bank 4.0, because it will surely come, whether we are prepared for it or not.

In Good Times Prepare for Crisis*

Alexandra Pavelka

Ira W. Lieberman:
In Good Times Prepare for Crisis – From the Great Depression to Great Recession: Sovereign Debt Crises and Their Resolution
The Brookings Institution, 2018, p. 480
ISBN: 978-0-8157-3534-2

As an expert of the World Bank, Ira Lieberman has had ample experience with financial crises and their resolution. His knowledge of crisis management theory and the practical skills makes the book an interesting one, which not only shows the historical description of the facts, but presents the whole picture of the debtor-creditor relationship between countries. The author seeks to answer questions such as the following: What are the best techniques for sovereign debt crisis management? Why do debtor countries not pay debt servicing? How do creditors react? How effective is debt restructuring and are there general practices for it? One strength of the book is that the international relations of certain periods are highlighted and attention is drawn to the aspects of political economy.

The interwar period and the Great Depression

In the interwar period, lending increased in spite of the fact that the creditors accounted for huge losses due to the inflation and devaluation caused by the war. International lending increased on the heels of growth, faith in international trade, increasing influence in strategically important areas (e.g. England - India) and the creation of economic and political stability. However, the huge financial resources provided caused economic structural reforms to be postponed. A large part of the credits was spent on social benefits, reorganising the economy and restructuring existing loans, not on increasing future government revenues. Moreover, borrower countries did not introduce fiscal reforms, and so most of the credits were not sustainable.

At the time of the Great Depression, international lending decreased again. Since capital markets were not available for the countries, debt servicing decreased, stopped or was terminated (e.g. Russia). Banks faced a liquidity crisis, and there was

* 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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a need for the appearance of a lender of last resort in the international financial system. At the World Economic Conference in 1933 countries decided to handle each sovereign debt problem on a case-by case basis, relying on the lender and borrower counties' communication and agreement, as an answer to the problems that had developed.

Developing countries sovereign debt crises

Developing countries tried to become politically independent from the Great Powers, but economic independence was indispensable for achieving this goal. For this reason, they borrowed to develop their economy. At the same time, developed countries still lent to increase their influence. International relations led the formation of the credit market. It also occurred that debtors refused debt service on an ideological basis (e.g. Cuba, Vietnam).

In the 1960s, the inflow of capital brought stability to the developing countries, but they could not switch to a self-sustaining model as it turned out when the funds started to decrease. Not only their sovereign debt increased, their debt service was challenged by rising interest rates and a strengthening US dollar, and so they needed debt restructuring. Their banks were financed by short-term loans which showed more and more certain signs of a crisis. The crisis did not stop at the borders, as banks in developed countries also went bankrupt because of the widescale exposures in developing countries.

The increase in oil prices in the 1970s raised government expenditures in the exporting countries, but they soon became debtors again when – due to the fall in oil prices – their extra revenues decreased, credit and debt servicing rose. Thus, oil exporters were not able to prepare for a crisis in good economic times.

Although the problems arising from debtors not being able to service their debts were not handled during the restructuring of loans, it was obvious that there will be more rounds of restructuring programmes. The International Monetary Fund (IMF) played a key role in this process, but their programmes based on fiscal tightening did not prove to be effective. Later, in low income countries alternative solutions were implemented, such as linking debt servicing to the export revenue of certain products. During the ongoing restructuring programmes the practice changed, and they were able to restore trust and capital flow until new crises hit.

Liberalisation of the financial sector and crises in the emerging markets

Liberalisation of financial markets was important because private capital flowed from developed countries to emerging markets and transition economies. Structural reforms and privatisation helped to create jobs and economic growth. Investment funds frequently invested in the capital markets of emerging countries because of the higher

growth prospects. However, the inflow of capital made these countries vulnerable to external shocks. Moreover, the governments usually supported the capital inflow and promoted external financing. On top of that, many investments were short term and in foreign currency, and an adequate level of reserves were not built for these exposures, which further increased vulnerability. These high risks were not identified because financial market liberalisation and deregulation were not monitored.

There were several roots of the crises in emerging markets, but a banking crisis was one common feature in all. The Mexican banking crisis occurred because of devaluation, and it spread to nearby economies as well. The East-Asian crisis was caused by bubbles in the real estate market and the indebtedness in foreign currency, while in Turkey the high inflation, the undercapitalised bank system and devaluation of the currency were the culprits. In Argentina, banks found themselves in an unfavourable situation because of high exchange rate risk on the customer side and bad economic policy decisions. The fiscal deficit, decreased exports, and short-term external financing led to payment repudiation of the bondholders, and the debt was not settled for years. The case of Argentina perfectly represents one of the main messages of the book, which is that countries, in which interest payments threaten internal stability, have an interest in choosing bankruptcy.

International organisations took part in crisis management as lenders of last resort. Not only government bailouts participated in improving the economic situation, but the IMF, World Bank, G7 and the USA as well.

The 2008 crisis in the developed markets

Most crises were V shaped, followed by a boom, but after the 2007–2008 crisis there was no quick recovery, and the recession had an L-shaped form in developed countries. Unemployment increased, GDP decreased and credit increased. The USA and Japan transformed into debtor countries from creditors, and despite the fact that neither is threatened by a sovereign debt crisis as the author thinks, they have less room for crisis management.

The Japanese crisis was one of the first episodes of the crises in developed countries, as a credit-deflation spiral emerged. The private sector was indebted, which narrowed the fiscal opportunities. Stock and commodity prices decreased, which led to non-performing loans resulting in a banking crisis. Fiscal stimulus only created a larger deficit rather than any results, and the effect of the austerity policy escalated the financial crisis.

The epicentre of the 2008 crisis was the USA. The main factors which caused the crisis were: the housing price bubble, an increase in subprime loans, the indebtedness of the population, low interest rates, which encouraged leverage, banking deregulation which created financial conglomerates, and the underregulated shadow banking

system and its connection to the financial system of the world. These factors not only resulted in high leverage but also in undercapitalisation, and the risks in the system were identified neither by the financial and regulatory institutions nor by the credit rating agencies. As the subprime loan market started to fall apart, international financial institutions followed the way.

In the USA, they attempted to manage the problems and organise banking bailouts on a case-by case basis, but after the collapse of Lehman Brothers, which was followed by the spread of the crisis, it was necessary to find a systematic solution. The FED cut the interest rate to nearly 0 per cent, announced QE programmes, expanded its balance sheet, restored trust and became the lender of last resort to other central banks. As the trade balance and the budgetary position are both negative, the author thinks the USA is not prepared for the next crisis.

The crisis had an impact in Europe as well: the banking crisis evolved into an economic crisis, and in some cases a sovereign debt crisis appeared as well. The European Central Bank, the European Commission and the IMF served as lenders of last resort for countries dealing with problems. Greek sovereign debt nevertheless remained at a high level after the crisis, and according to the author, the current level is still unsustainable and threatens the stability of the euro area. The United Kingdom quickly recovered from the crisis because it had its own monetary policy and the Bank of England served as a lender of last resort to the UK economy. By contrast, the countries in the euro area were unable to pursue a self-supporting monetary policy which could help their economic growth. The author says the EU is not yet in the stage of a boom, when there is a time to prepare a for crisis.

All in all, one main conclusion of the book is that the sovereign debt crises are recurring, and thus it is possible to prepare for them. The problem is that several countries accumulate debt in good economic times which makes them vulnerable to shocks. The author thinks we are still vulnerable to a future crisis. However, he ignores the fact that in a recession, coming after a crisis, it can be a part of a natural process to increase the debt level as occurred in the last years, because austerity policies are not effective in these times. Of course, it is true that if we look in the future, the bubbles on housing and stock market can be signs of future crises and it is worth it to prepare for them. But the author does not make clear economic policy recommendations which leaves us with sense of lacking something, because he highlights main problems but does not bring up solutions. In spite of that, the book can be a valuable guide to those, who would like to understand the established debtor-creditor relationship between countries.

Report on the 2019 Lámfalussy Lectures Conference*

Ferenc Tóth

On 4 February 2019, the Lámfalussy Lectures Conference was organised for the sixth time. At this year's conference, the world's leading financial experts and academic researchers examined the issue of convergence.

In his welcoming speech, *György Matolcsy*, Governor of the Magyar Nemzeti Bank, first greeted *Yves Mersch*, winner of the Lámfalussy Award, Member of the Executive Board of the European Central Bank and former governor of the Central Bank of Luxembourg, as well as *Katalin Novák,* winner of the Popovics Award, Minister of State for Family and Youth Affairs at the Ministry of Human Capacities. In his lecture he outlined that the first stage of the euro convergence process lasting until 2008 had been successful. However, in the following period – lasting from the financial crisis to 2012 – convergence stalled and the structural problems of the euro came to the fore. Although the global financial crisis emerged in the United States, the crisis in the euro zone was deeper, longer-lasting and more painful than in the USA. In the third stage of the euro lasting from 2012 to date we see a slow recovery. *György Matolcsy* emphasised that it would be worthwhile to learn the following lessons from all this: 1) Longer and more dynamic boom periods are needed to achieve sustained convergence. 2) We need a fully-fledged euro and eurozone to prevent a possible future financial crisis. 3) We need appropriate crisis management mechanisms, quick and pragmatic crisis management based on experiences in the USA, as well as close cooperation between the government and the central bank. In respect of Hungary, he explained that although we are outside the eurozone, we are inside the European Union, and as Europeans we are entitled to have a vision on the future of the eurozone, since Hungary will join the eurozone in the decades to come. Finally, he outlined again that another financial crisis might happen in the future, when we will need quick and efficient crisis management. This will require efficient cooperation between governments and central banks so as to avoid budgetary restraints that may have severe impacts on society and long-term economic growth.

* 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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Ewald Nowotny, Governor of the Oesterreichische Nationalbank praised *Yves Mersch* in his speech, and in a historical context he provided a detailed presentation of his work and extensive experience, as well as his commitment to European and also to national affairs. *Nowotny* presented *Mersch* as a highly competent expert who is one the most deserving persons selected for the award, and whose thinking complies with the spirit represented by *Alexandre Lamfalussy*. *Mersch* is also a truly European thinker and an excellent role model. Reflecting on the conclusion of *György Matolcsy* that there were ups and downs in the last two decades, he said that without the ECB it would have been much more difficult for small countries in the European Monetary Union to tackle the crisis.

In his speech, *Yves Mersch*, Member of the Executive Board of the European Central Bank and former governor of the Banque centrale du Luxembourg, praised *Alexandre Lamfalussy*, whom he saw in different roles in the last 30 years of his life, and he always admired his outstanding precision and professional competence. The main topic of his speech was the changing role of central banks.

The design of the modern central bank dates back to the consensus around the disinflationary path of the 1980s that central banks should be independent and have a narrow mandate restricted to focusing on the fight against inflation. In Europe, there was a second layer of consensus on how to share tasks, and how to allocate what is done at a national and regional level. Although political considerations relating to shared sovereignty also supported the monetary institutional setup, economic and fiscal issues were left to coordination and some common rules. This created a breeding ground for critics. Problems were exacerbated by the failure of economic cooperation, and the European Commission changed too: from a technocratic body it turned into a political one. The biggest test was the great financial crisis which is still shaking the foundations of our societies today. Major changes took place in monetary policy implementation during the crisis in the context of instruments, communication and accountability. In terms of strategic thinking and interaction with various policy fields, the biggest change concerned financial stability and macroprudential policy. In 2010, *Alexandre Lamfalussy* called for central banks to not regard their macroprudential duty as being less important than maintaining price stability. In conclusion, *Mersch* argued that the best solution is to integrate financial stability concerns into monetary policy at the European level, including possible corrections with instruments at national levels.

Morning session: "The decade of convergence in the EU"

The moderator of the discussion forum was *György Szapáry*, Chief Advisor to the Governor of the Magyar Nemzeti Bank, who provided a brief introduction to the subject, saying that the share of Southeast Asian countries in world GDP was four times higher in 2017 than in 1990, and China's share is continuously increasing. Of the 28 Member States of the European Union, the eight Central and Eastern

European countries are experiencing slow but continuous convergence. Europe's share in world GDP is declining more rapidly than the share of the USA. Eleven of the world's top 20 high tech companies are American, nine are Chinese, and there are none from Europe. Innovation and technological development will be key competition factors in the future (in particular regarding artificial intelligence and robotics). Europe must improve its education system. The PISA surveys clearly reveal the outstanding performance of Asian countries.

Lúcio Vinhas de Souza, Head of the Economics Team at the European Political Strategy Centre (EPSC) of the European Commission, talked about reviving convergence. Although the EU remains a "convergence machine", and one can see increasing standards of living in Member States, we need to do more. Central European countries have achieved real convergence, but they are facing new challenges that they must meet to continue this process. Central European Member States are also performing relatively well in macroeconomic terms. Although non-euro-zone members could easily meet most of the accession criteria, he thinks that Central European Member States will remain among the least competitive economies of the EU. The quality of governance remains below the EU and eurozone average, and in fact is becoming a little poorer. Adequate institutional capacity is crucial. A favourable investment environment requires quick and efficient administrative procedures, reliable and accessible data, legal certainty and planning capacity. The efficient functioning of domestic markets is also dependent on factors like the rule of law, quality and efficiency of institutions. If these are not adequate, it may lead to an outflow of capital or a lack of domestic and foreign investments. For some Member States, labour costs exceed productivity growth, which results in a decline in relative competitiveness, and investments largely depend on the EU Cohesion Fund. From the perspective of sustainable convergence, financial stability is crucially important. This has particular significance for euroised financial systems in Central Europe. On the whole we may conclude that there is economic convergence in the region, but there is a need for adjustments in a number of areas. The EU will always be a partner for dialogue in this field.

William R. White, former chairman of the Economic and Development Review Committee at the Organisation for Economic Co-operation and Development (OECD) and former economic advisor to the BIS, lectured on the decade of catching up within the EU. As regards convergence in the pre-crisis period, he said it was difficult to measure convergence. Not only per capita GDP is important, but well-being, too. Convergence slowed down after the crisis, as did the process of legal and institutional reforms. It is important to maintain the achieved results. Strong institutions and confidence facilitate cooperation, avoiding disturbances. There needs to be more focus on crisis prevention management and resolution. Preventive measures must be taken to handle domestic problems. He highlighted the excessive

increase in private sector debt. Macroprudential policies are important, but there is no magic bullet. At the same time, the points of particular importance include long-term reforms in the budgetary framework, the support of domestic (local currency) capital markets and the continuation of the intensive legal and institutional reforms. Central and South Eastern European countries will not be able to avoid many external problems either (trade war, Brexit, weakening global economic growth) if they occur. In any case, it is worth preparing ourselves for tougher times, putting measures on improving crisis-management mechanisms in the forefront, and generally focusing on creating confidence and systemic resilience to remain capable of attracting investors and continuing with convergence.

*Christian Kopf***,** Managing Director at Union Investment Privatfonds GmbH, emphasised the importance of the European integration process and institutional system. Recalling the four freedoms embedded in the Treaty of Rome, he commented on their impacts on the economic convergence of Central Europe. On the free movement of people he remarked that in some cases this might have a negative consequence: young, highly qualified people leaving Central European countries. In terms of the labour shortage, Hungary has two options: a low growth path or inflows of foreign labour. He believes that the reason why Hungary was hit more severely by the crisis than the Czech Republic or Poland is partly because the yields of Hungarian government securities were higher. Another important factor was that due to the free movement of capital, Member States could not introduce limitations on capital flows during the financial crisis. The free movement of goods and services was one very positive element in the economic integration, particularly in terms of participating in supply chains.

Povilas Lastauskas, Director of Centre for Excellence in Finance and Economic Research at the Bank of Lithuania gave his personal opinion – 25 years after Maastricht – on the heterogeneity and convergence in the European Union. According to his calculations, 26 countries are approaching, albeit slowly, the same equilibrium level of real GDP per capita, and there is almost overall convergence in the EU. There are wide and persistent differences in terms of real labour productivity. Although there is some convergence at the macro level, there are more significant differences at the regional level where there is a lower degree of convergence. He finished his presentation by asking about the regional dimension, even if there is convergence at the macro level. Is it sufficient to track aggregate convergence?

Afternoon session: "The decade of convergence in Asia"

The afternoon session started with the keynote speech of *Kairat Kelimbetov*, Governor of the Astana International Finance Centre (AIFC), former governor of the National Bank of Kazakhstan on the subject of the cooperation between Europe and Asia. First he drew attention to the shift of power in the global economy, where

the economic and political centre has shifted and is expected to further shift from the Euro-Atlantic power centre to Asia. During recent decades the economies of Asia have undergone enormous change. According to some forecasts, China will become the world's largest economy by 2050, with India in second place, and the USA will only be third. The Asian market comprises 62 per cent of the world's population. In addition, substantial industrialisation and urbanisation processes have taken place in China and India. China is also a leader in terms of the future, being a global force in the digitalisation of the world economy (e.g. in e-commerce and FinTech). A number of Chinese companies have developed to such an extent that they are competing with Silicon Valley companies. In Davos, special attention was paid to the topic of U.S.-China competition, in particular in the field of artificial intelligence. The reason for the success of Asian countries lies partly in their approach to innovation, in their demographic trends, and partly in the prudent regulatory environment and institutions. We need to focus on how to facilitate the financial connection between the European and Asian markets. Central European and Central Asian economies may play a key role in creating this connection.

The moderator of the afternoon discussion forum, *Dániel Palotai*, Executive Director and Chief Economist of the Magyar Nemzeti Bank, highlighted in his introduction to the debate that the global world order has changed. The evolution of new economic centres and the rebirth of the ancient trading routes have created a multipolar world order, in which Asian countries are becoming more and more important. Furthermore he confirmed that Hungary acts as a bridge-builder between the East and West. For the future, he emphasized that by 2030 three of the four largest global economic powers might be in Asia. Turning to competitiveness, he said that there is a considerable competitiveness gap across regions. In 2018, based on World Economic Forum survey and the IMD World Competitiveness Center's research three or two of the ten most competitive economies in the world have been Asian economies, respectively, while the others are European and North American. Policies aimed at boosting competitiveness have served for them as a basis for convergence. This is a major lesson for Hungary too.

Denis Hew, Director of the Asia-Pacific Economic Cooperation (APEC) Policy Support Unit, examined the catching-up decade of the Asian-Pacific region from the perspective of the APEC. The APEC is an informal, non-binding, consensus-driven forum with 21 member countries. It works towards achieving free trade and making investments in the region. The APEC region's GDP growth has consistently exceeded the world average since the crisis, and the APEC members' share of world GDP and trade is continuously growing. However, a study demonstrated that due to geopolitical tensions, trade is no longer considered a reliable driving force of APEC's economic growth. The opportunities of the digital economy – particularly e-ecommerce – the development of green technology, an increase in green-field investments as well as implementing reforms that improve productivity in education,

health care and other social services, encouraging innovation, narrowing gaps in infrastructure and promoting women's participation in economic activities will likely be the engines of growth in the future. Current issues affecting future growth are as follows: demographic problems (aging population, distribution of resources to prepare for solving key economic issues like the lower labour supply and higher healthcare costs), issues relating to digitalisation and employment (medium-qualified jobs can be replaced with computers), and workplace polarisation (as most mid-skill routine jobs are being computerised, only non-routine and discretionary jobs are left at the low and high end of the skills spectrum). Furthermore, natural catastrophes and diseases may negatively affect future growth, since the need to provide temporary shelters and transitional livelihoods entails a significant budgetary cost. In his closing remarks, he said that APEC was developing a new vision for the future for the post-2020 period. It already takes into account the new trends and challenges: growing trade protectionism and tensions, tackling non-customs barriers and structural reforms, geopolitical risks, structural unemployment due to digital technologies and artificial intelligence, inadequate skills, issues relating to the middle income trap such as moving up the technological ladder, the environmental effects of fast industrialisation and urbanisation, anti-globalisation opinions and increasing inequality.

Khee Giap Tan, Co-Director of the Asia Competitiveness Institute of the National University of Singapore, Associate Professor at the Lee Kuan Yew School of Public Policy, and Chairman of the Singapore National Committee for Pacific Economic Cooperation (SINCPEC) talked about the East Asian economic development model, some elements of the One Belt, One Road Initiative, and the consequences of the US-China trade war. First, he provided a quick and updated overview of global economic development trends in respect of the US-China trade war, indicating that growth in the Asian-Pacific region is still expected to be higher than in developed economies, while the slump in the growth rate will remain marginal and decrease less than in developed economies. The second part presented the East Asian economic development model (EAED) for resolving bottlenecks. The experience and success of the robust EAED model show that overcoming the production bottlenecks through investments aimed at resolving production bottlenecks is a pre-condition for an economic recovery, and a useful tool for escaping the middle income trap. Effective leadership and good governance clearly have a prominent role in facilitating infrastructure investments. The third part was about the facilitation of regional and bilateral free trade agreements and the fact that OECD economies are still very important for the ASEAN states. In the fourth part, the lecturer addressed the importance of the ASEAN area in respect of the fragmentation of production in global value chains, and the transfer of production from China to ASEAN economies. Then he talked about the opportunities offered by China's One Belt, One Road Initiative for Hungary and Eastern Europe. As he said, Hungary can explore the

opportunities provided by the One Belt, One Road Initiative if the government does not leave it to the market but takes over the duties of this project. Finally, he presented Singapore as the infrastructure centre of Asia, focusing on the cross-border cooperation in infrastructure development, investments and finance.

In his lecture *Hyeonjung Choi*, Director of the Centre for Global Governance at the Asan Institute for Policy Studies and a research fellow at the Asan Institute for Policy Studies pointed out what we can learn from the East Asian catch-up economies. Since the end of the 1980s these economies have continuously achieved higher growth rates than the world average, and to an increasing extent. He presented the features of the East Asian catch-up countries: the dominance of state bureaucracy and economic policy, the control of the domestic market, the "revolving door policy" of business and industry associations, the focus on selected key industries, the central role of finance, and the export-led strategy. He then went on to list the favourable external conditions for convergence: the Cold War era provided a kind of security umbrella, financial and technological support when a wide range of new market opportunities opened up for the allies. The existence of the American and liberal economies, the robust economic growth of the great powers in the 1960s to 80s, the target countries of the export-oriented economy, the accepted political intervention of authoritarian regimes in the economy, the onset of the era following the Cold War, and the twin deficits of major importers – all this stimulated growth.

His lecture continued with the challenges that catch-up economies face in the 21st century. The world market has become more mature, competitive and liberalised. In addition, free-trade rules and free market economies have also changed. The industry is undergoing a paradigm shift too. New enterprises with increasing profits are emerging, while the manufacturing industry is less profitable. "Sustainable development" has become the creed, including economic growth, environmental protection and social justice. He closed his presentation by drawing conclusions from predecessors' development: first he highlighted the important role of the government: it is necessary to create a future-oriented growth vision, well-defined national competitiveness, and well-structured, long-term objectives and industrial policies. Secondly, there has to be consensus on national economic development: it is necessary to have a well-supported political system and leadership, as well as a fair distribution of the national wealth. Thirdly, it is necessary to support the enterprises that generate increasing profits, as well emerging sectors. Fourthly, the liberal international order and markets must be utilised. Finally, environmental degradation must be avoided, and sustainability must be a priority.

Andrew Sheng, Distinguished Fellow of the Asia Global Institute at the University of Hong Kong and former Chairman of the Hong Kong Securities and Futures Commission viewed Asia from the perspective of a global system. At the beginning of his speech he paid tribute to *Alexandre Lamfalussy*. He considers Hungarian

economists to be the best economists in the world, and as he sees it, the best ones work at the central bank. He believes that megatrends signal a paradigm shift, a move away from the neoliberal order, but the transition will be very chaotic. From a macroeconomic aspect, geopolitical risks will exceed financial risks. He mentioned six disrupting megatrend factors: the shift from a unipolar towards a multipolar world; the geographical shift from West to East; the shift in gender roles (women are getting richer and earning more and more); the shift of generations (the young facing a future without jobs); climate change (shortage of water, food and energy); and the technological shift which entails jobs and creative disruption. Even one single factor is extremely complicated. Moreover, each factor interacts with the others, and thus may result in very complex outcomes. This poses enormous challenges for politics, as well as for business models, since the policy of "America first" does not create a level playing field. The next topic touched upon the emerging opportunities and threats, and the issue that the strengthening of the US dollar, the trade war, and the whole neoliberal thinking endangers sustainable prosperity. If the US dollar strengthens, emerging economies suffer from enormous liquidity pressures. The trade war constitutes a setback – not only for trade itself. Another big question is who will implement the 5G technology. Finally, referring to the Hungarian economist, Karl Polanyi, he said that it had become clear that market self-regulation did not work and this might erode human society and destroy nature.

In his closing words*, György Matolcsy* thanked participants for their very high quality and exciting presentations and inspiring thoughts, and expressed his hopes that the collective thinking on the new paradigms that determine future development would continue within the framework of the Lámfalussy Lectures Conference.

Report on the Conference on Famous Hungarian Economists of the 20th Century at Pázmány Péter Catholic University*

Katalin Botos

On the occasion of the "Day of Science", the Farkas Heller Institute of Economy of the Pázmány Péter Catholic University organises an annual conference on important theoretical and economic policy topics in the area of economics. On 14 November 2018, the theme of the conference was the work of famous Hungarian economists of the 20th century, with the participation of the academics of the Farkas Heller Institute of Economy of the Pázmány Péter Catholic University (PPCU, FHIE) and the Corvinus University of Budapest, along with Katalin Botos, founder of the Heller Institute and professor emeritus of the University of Szeged.

Péter Ákos Bod (university professor at BCE, Department of Economic Policy) gave a lecture on Lord Péter Tamás Bauer entitled "Individual choice – economic freedom". *Aladár Madarász* (associate professor at BCE, History of Economic Thought Department) presented the work of Miklós Káldor with the title "Value and distribution". *Ákos Szalai* (university professor, PPCU, FHIE) talked about János Harsányi, Nobel laureate for game theory.

Katalin Botos, who is also a professor at the Doctoral School of History, PPCU described the life and work of Farkas Heller and Ákos Navratil, establishing a parallel between them. Farkas Heller was the best-known Hungarian economist internationally at the time. His books were study materials, among others in Brazil and Australia, even in the 1960s. Ákos Navratil was a professor at the Pázmány Péter Catholic University. Heller was a representative of mathematical economics, while Navratil gravitated towards the historical school and represented the institutionalist approach. However, they respected each other, and worked together in the Council of the Hungarian Economic Research Institute founded by István Varga. Varga was the subject of the lecture given by *Violetta Mányó-Váróczy,* adjunct professor at PPCU, FHIE. István Varga's theoretical and economic policy work is outstanding, both as the creator of the Hungarian "currency miracle" and as the chairman of the Economic Commission established in 1956. Of the other academics from the Farkas

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Heller Institute, associate professor *András Schlett* presented the work of Tibor Scitovsky. Scitovsky examined when economic policy decisions can be considered as welfare decisions. One of his best-known theses came to be known as the Scitovsky Paradox: by resolving the paradox, the utility of an economic policy measure can be judged independently from distribution conditions. Later, he increasingly focused on the vulnerable points of "rational science". Possession provides the basis for the positive sense of identity of modern human beings, and as a result happiness is reduced to utility. Therefore, money is no longer only a medium of exchange, but also serves to measure the value of people, and to prove the social utility of an individual. Another consequence of a money-centred mindset is that earning potential is more highly valued than skills and abilities which just give sense to life.

István Kőrösi, associate professor, presented the audience with the views of István Muzslay, who dealt with the economic teachings of the Catholic Church, while *Klára Katona*, associate professor and current head of the Institute, lectured on the views of the late Sándor Lámfalussy.

Three of the persons presented passed away in the 21st century, lived abroad, and were held in great respect. Nevertheless, economists in the 20th century experienced very different fates depending on whether they remained in Hungary or continued their careers abroad.

It is almost three decades now that the Hungarian Academy of Sciences – before the political transformation – remedied the seriously unfair treatment it meted out in 1949 (under pressure from the political power). In 1989, civilian social scientists who had been deprived of their academic ranks were returned their ranks posthumously. Although this was only a principle-based, retrospective restitution to these economists who died in poverty, often in misery, it was a highly significant step towards restoring the reputation of the Academy. The whole profession celebrated this event with a conference, and after the political transformation in 1990, a volume containing the portraits of these scientists, edited by Antal Mátyás, was published.

To be fair, these scientist also suffered under the other dictatorship, national socialism. Not only were they sidelined, they were also imprisoned or even killed (see the sad fate of Frigyes Fellner; even the letter of safe conduct issued by the governor was not enough to stop the Germans from deporting him to Mauthausen). With the onset of fascism, many Hungarian scientists fled their homes and went to a safer Western country. It was established that "He who wants to be a poet in Hungary is a fool..." or more precisely, any scholar who remained in the country. Then, 1956 also forced out many valuable experts from Hungarian society (e.g. Béla Balassa left the country at that time). Hungarians who went abroad made their carriers. Many made it as far as professor or head of department or chairman

of economic association in America, and enjoyed a great deal of international recognition. Their names – Káldor, Lámfalussy, Tibor Scitovsky, and Balassa – are linked to a number of economic and even financial concepts and their works have been integrated into modern economics. Three became lords in England: Miklós Káldor, Tamás Balogh and Péter Bauer.

Most of them played a role in shaping the economic policy, either in Hungary or abroad (some of them, however, were definitely theoretical scientists). It is no wonder that at the conference of the Farkas Heller Institute of Economy of the Pázmány Péter Catholic University, the scientists in question were grouped as follows: the great creators of individual freedom, economic policy, economy and morality. Obviously, this is only a selection from the list of great scientists, and many relevant persons were left out. However, this excerpt was certainly useful in demonstrating, on the one hand, the differences between the fates of emigrants and that of those who remained and, on the other hand, something else that we consider very important: that they followed different ideological directions of economics. Some of them fought tirelessly against the opposing ideology or scientific approach. Káldor combated monetarism throughout his life. Lord Bauer, however, was knighted as an adviser to Mrs Thatcher's administration. Balogh and Káldor "the terrible twins" – as contemporary critics named them – were recommended to the Queen by the Labour Government... Another lesson is that our great economists in the period between the two World Wars, such as Farkas Heller and Ákos Navratil were able to collaborate "for the good of the country", even though they followed different economic approaches. István Varga's career is a shining example of how our great personalities put their communities before anything else, leaving aside ideological considerations and personal issues. The Heller Institute set an example by the careful selection of scholars to be presented: leading figures of traditional mathematical economics were included, as were economists explicitly representing institutional or behavioural economics. Károly Polányi was not presented in the lecture, however, interestingly enough he was a religious, left-wing community economist who considered the role of the state to be important (it should be noted, however, that he too was an uncompromising advocate of democracy; he firmly rejected dictatorship and was proud of 1956). Among the scientists commemorated at the conference, there were economists relying on the German Historical School, as well as scholars studying the teachings of the Catholic Church. This latter is especially important, I think, since the question of *subsidiarity* is or should be a major priority in international literature and in Hungary's economy policy.

The lecture that *Klára Katona* presented on the late Sándor Lámfalussy, known as an eminent financial expert and "the father of the euro", was particularly topical. It was important to highlight that Lámfalussy rightly saw how much the birth of the

euro was motivated by politics, and what problems that created. He recognised the risks in the financial system, as well as how they emerged in the world during his life. I would add that Lámfalussy had such a clear criticism of international finance, and in good time, which only few were capable of. He criticised uncontrolled liberalisation and full convertibility. He recommended to return to the system of limited convertibility created by the Bretton Woods agreement. He is no longer alone in this; many eminent financial experts have a similar opinion.

The conference highlighted our real values, strengthening our national identity, and also pointed out the fact economics is not a collection of old, confining dogmas, but a living, changing, diverse science. Another important message, delivered by one of the closing lecturers, is that science exists for the people. It must help create conditions in which members of society can be *happy people*.

Selected materials from the conference will be available later this year through publisher Pázmány Press.

INSTRUCTION FOR AUTHORS

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.
- 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.
- At the bottom of the title page a footnote is to be given. The footnote contains every necessary information related to the paper (acknowledgement, relevant information etc.). This is followed by the name of the institution and position the author works at, e-mail address in Hungarian and English.
- Journal of Economic Literature (JEL) classification numbers 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 are 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 separated by comma. When citing, the exact page be indicated.
- Tables and figures are to be numbered continuously (chapters and subchapters should not contain restarted numbering). Every table and figure should have a title and the units of quantitative values are to be indicated. Tables and figures are to be made by MS Word and Excel in Hungarian and English. Notes and sources are to be put directly at the bottom of the tables, figures.
- Equations should be aligned to the right and should be numbered continuously in parenthesis. (Chapters and subchapters should not contain restarted numbering.)
- Manuscripts are to be sent to the Editorial Office of the FER only. Papers are peer-reviewed by two independent and anonymous reviewers.
- Manuscripts should be sent as attachment by e-mail in MS Word file. Figures and tables should be sent in MS Excel file both in Hungarian and English.
- In case of further questions related to the manuscript visit the following website: *http://english.hitelintezetiszemle.hu/letoltes/authors-guide-en-1.pdf*

Thank you!

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