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THE MACROECONOMIC ROLE OF MARKET LIQUIDITY
-
MICROSTRUCTURE ANALYSIS FROM A REGULATORY POINT OF VIEW

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Köszönetnyilvánítás

Először is szeretném megköszönni témavezetőm Dr. Kiss Gábor Dávid segítségét, aki fáradhatatlanul, hasznos tanácsokkal és meglátásokkal segítette munkámat és a dolgozat létrejöttét.

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Köszönettel tartozom kollégáimnak, barátaimnak akik hasznos tanácsokkal és szakmai megjegyzésekkel láttak el. Külön köszönet illeti Dr. Bank Dénest, Forgács Mátét, Für Violát, Halácsy Gábort, Dr. Karsai Gábort, Kuji Tibort, Dr. Losoncz Miklóst, Molnár Andrást, Dr. Molnár Lászlót, Németh Kristófot, Plutzer Bélát, Udvardi Attilát, Veres Mátét, Dr. Vértes Andrást, Vörös Zoltánt.

Hálás köszönettel tartozom családomnak, keresztszüleimnek és barátaimnak, hogy mindvégig támogattak, bíztattak és mindenben segítettek. A legapróbb biztatás is hatalmas erőt adott a legnehezebb pillanatokban. Kiváltképpen köszönettel tartozom feleségemnek, Ivettnek, aki türelemmel, támogatással viselte ezt az időszakot.

A legnagyobb köszönettel azonban Édesanyámnak tartozom, akinek megígértem a dolgozat elkészítését. A dolgozatot Neki ajánlom.

A segítségük nélkül a dolgozatot nem tudtam volna elkészíteni. Az értekezésben maradt hibákért természetesen minden felelősség engem illet.

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I. Introduction

Since the beginning of the modern economic system, liquidity of financial market has been playing an important role in the economy.

As Keynes noted, "*For the fact that each individual investor flatters himself that his commitment is "liquid" (though this cannot be true for all investors collectively) calms his nerves and makes him much more willing to run risk*" (Keynes, 1936, 160 p.). After the financial crisis of 2008-2009, liquidity of financial markets has become a central topic in academia, leading to a wide array of research dedicated to the topic.

In recent decades, financial markets have undergone significant changes. Financialization denotes the rise in prominence of financial activity, financial markets and financial institutions in the economy. The value of global financial assets multiplied as a result of financialization. One of its other equally visible consequences is that the barriers between firms conducting financial activities began to vanish. While previously only financial firms and banks dealt with loans and investment into financial assets, now it has become an ordinary activity regardless of branches. In my opinion, one of the most important consequences of financialization is the propagation of a short-term view. Due to the high profitability of the financial sector, the allure of quick returns replaced the long-term investment view, thereby diverting a significant amount of resources from real investment markets. According to Stein (1989), short-term view can be seen as an understandable and rational response from managers who have long-term objectives but believe that their activity is valued by the current stock price. In this case, managers need to adopt a short-term view in order to maximize their rewards.

As a result of this, managers chase extra profit by decreasing cost and take more risks. As equity is the most expensive way of financing, managers take on more debt. One source of risk is the increased leverage. The short-term view accompanied by financialization has also enhanced the financial companies to take on excessive risk in their balance sheet, thus it has made the financial system more fragile. There are plenty of empirical evidence that the business cycles are shorter going forward in time. Seeing the anatomy of a business cycle, we could detect that it is mostly parallel with the financial cycle. Minsky (1992) carefully described his model and defined its stages. The Minsky super cycle illustrates that the system is allowed to take more financial risk. It can be done by increased risk-taking or regulatory relaxation.

The emergence of new monetary policy instruments was necessary not only due to financing constraints and the need for rapid intervention, but also because of the change in monetary transmission and the emergence of new channels. One of the consequences of

financialization presented earlier is that financial markets play an increasing role in fundraising, as well as saving. The line between the behaviour of financial and non-financial businesses is becoming thinner as many non-financial firms offer loans, manage portfolios and finance their activities by issuing bonds instead of bank loans. As a result, the importance of financial market liquidity has become more visible, which caused that central banks moved away from their position as 'lenders of last resort' towards a new position of 'dealers of last resort' (Mehrling, 2014).

That is why maintaining liquidity has become an important issue nowadays. The aim of the dissertation is to contribute to the understanding of market liquidity and thus provide recommendations for a more effective regulation. The current knowledge about the effect of information asymmetry on market liquidity is still not straightforward. One of the aims of this dissertation is to contribute to the understanding of information asymmetry and its impact on the bid-ask spread.

A new microstructure model is introduced in the dissertation for analysing the price and spread setting methodology in the market. The earlier microstructure models in the literature examine either the inventory risks' role in price setting or information asymmetry's impact on the market. After the empirical analysis of the inventory risks' relevance a risk-based model is shown analytically. In order to make it more reliable and veritable it is necessary to add information asymmetry, monetary policy into the framework and unlock assumptions we identified. After the modification, the interactions between actors cannot be solved by analyticial methods therefore a multi-agent model with Monte Carlo simulation was considered as to be the best method to investigate. Contrary to the earlier models in the literature a microstructure model with inventory risk, information asymmetry and monetary policy is introduced to get a better understanding of price and spread setting mechanisms of financial markets.

The dissertation includes 7 chapters but it can be divided into two major parts. The first larger part (chapter 1 - chapter 3) gives theoretical framework for the research, including definitions, detailed discussion of liquidity, its dimensions and how liquidity emerged as an important feature of financial markets. The second part (chapter 4-7) presents my own empirical analysis.

The structure is the following. Chapter 1 discusses the phenomenon called financialization which is placing the research question into a broader aspect. The chapter aims to give an explanation about how financial integration, globalization result recent trends in

financial markets and how liquidity emerged as a very closely monitored aspect of any financial markets.

Chapter 2 clarifies the definitions, summarises the literature of liquidity research and designs research questions. The dissertation focuses on market liquidity. Market liquidity may be defined as the easiness with which market participants can buy or sell an asset in a market without affecting its price (Elliot, 2015). Bid-ask spread is applied as a proxy for market liquidity mainly because it can be measured any time. The bid-ask spread is classified as a transaction cost measure. Dealers quote bid and ask prices in order to provide liquidity. The price that market makers set for the private buyers are called ask or offer price while the price set for private sellers is called bid price. The bid-ask spread can reflect asymmetric information costs, order processing costs and inventory-related costs (Sarr - Lybek, 2002; Sommer - Pasquali, 2016; Treynor, 1987). The research questions are the followings:

1. What is the source of liquidity in the CEE region as literature principally focuses on the developed countries?
2. How is market liquidity affected by monetary policy as the current microstructure models do not cope with monetary conditions?
3. How can we explain the contradictionary results of information asymmetry as theoretical and empirical works are against each other on that topic?

Based on these research questions four hypothesis are formulated which lead and are set to be tested.

Chapter 3 is still based on literature review but it focuses on the regulation, recent trends and tools of regulation and its theoretical background. Based on the chapter a new research question emerges.

4. How can we apply our understanding of market liquidity to compose a more efficient regulation?

Based on the research question a fifth hypothesis is set to be tested.

The second major part introduces and describes the models and methods applied or created to empirically analyzing the above mentioned and later discussed hypothesis. The chapters include the detailed description of econometric analysis (vector autoregression on detrended data by HP filter), a new microeconomic model for explaining the behavior of market makers and also a Monte-Carlo analysis on an agent-based model supported by the new microeconomic theory of market making. This part includes the results which give us a better understanding of market liquidity. Consequences and recommendations are included in those chapters.

II. Theoretical Background

Liquidity is a multi-dimensional feature of financial markets that economists and financial experts have analysed for decades. The first chapter introduces how financial markets have evolved and what are the recent tendencies that have affected markets. It is due to financialization that a number of phenomena, that were for long considered to be deviations from the norm, began to be characteristics of today's global economy: globally low or even negative interest rates, yields that do not necessarily reflect the risks, the new monetary instruments, the mechanisms of transmission. The purpose of this chapter is to provide the topic with a macroeconomic background and explain how liquidity had become an important and expensive feature of global makets. In the second chapter, liquidity and especially market liquidity is discussed including measurement methods and challenges. In the third chapter, the crisis is introduced together with the measurements that central banks and governments have taken to mitigate it, including both micro- and macroprudential regulations.

1. Financialization

Financialization denotes the rise in prominence of financial activity, financial markets, and financial institutions in the economy. According to Bélyácz, "*financialization means the liberalisation of financial markets, the globalisation and increase in the size of financial processes, and the management of economic processes on the basis of finance*" (Bélyácz, 2014 p.28). Krippner (2004) summarised them overlapping rather than opposing distinctions of the different forms and shapes financialization may take according to different authors who wrote about the topic. Some scholars use the term 'financialization' with reference to the ascendancy of 'shareholder value' as a mode of corporate governance. Some use it to refer to the growing dominance of capital market financial systems over bank-based financial systems. Some follow Hilferding's idea and use the term 'financialization' to refer to the increasing political and economic power of a particular class grouping: the rentier class. For some scholars, financialization represents the explosion of financial trading with a myriad of new financial instruments. Krippner argued that it represents a "*pattern of accumulation in which profit making occurs increasingly through financial channels rather than through trade and commodity production*" (Krippner, 2004, p. 14).

Krippner (2005) sees the importance of financialization show in the fact that the financial sector's contribution to GDP in the US was 15%, in the 1960s but rose to 23% to 2000.

Similarly, in 1980, 20% of firms' profits were linked to the financial sector, and this number rose to 40% by 2000. Kaplan - Rauh (2010) demonstrate the effects of financialization by pointing out that the heads of the five biggest hedge funds in 2004 earned more than the CEOs of all the other S&P500 companies together. Bresser - Pereira (2010) distinguish between three characteristics of financialization. First, there is the separation of the real and financial sectors, second, the continuously high profit rates of financial institutions, and finally the multiplication of financial instruments as a result of government securitisation. This study focuses on the latter characteristic when discussing financialization, but if diverging interpretations arise, this will be highlighted.

In recent decades, financial markets have undergone significant changes. Szunke (2014) identifies five factors that contributed to this process. These are globalisation, deregulation, the fall in prominence of the relay system, technological change and firms' consolidation.

Deregulation and financial liberalisation can be highlighted as strengthening the process of financialization. This meant doing away with the boundaries of financial institutions and other financial service providers in the 1980s and 1990s. For example, the Depository Institutions Deregulation and Monetary Control Act, or DIDMCA for short, was implemented in the United States in 1980. Also in the 1980s, 1982 saw the introduction of the Garn-St German Act targeting mortgage loans, and in 1999 the Glass Steagall Act was repealed, which had strictly separated commercial and investment banks' activities (though after the 2008 crisis attempts were made to substitute the latter with part of the Dodd - Frank financial market regulation package, the Volcker rule). Commercial banks began engaging in more and more speculation as a result of deregulation. The 'revolving door' phenomenon constitutes a barrier on regulation via banks' lobbying (for the details see Cornaggia et al, 2016; Lucca et al 2014; Shive - Forster, 2016). This means that political decision-makers will be chosen from institutions which they then need to tax and regulate as politicians. Moreover, after a political career they mostly take up employment at these large firms, banks and institutions, so they keep their future interests in mind when making decisions.

Technical and technological improvements and market consolidation are important factors in the process of financialization spreading. Improvements in IT contributed significantly to the diffusion of information, the immediate access to markets and it also created the necessary technical requirements for new banking and financial products' creation and propagation. Market consolidation which increased competition in financial markets with the liberalisation and integration of markets and as a result of which the number of purchases and

mergers rose. Firms thus came to be large, posing a system-wide risk, which is known as the too-big-to-fail problem.

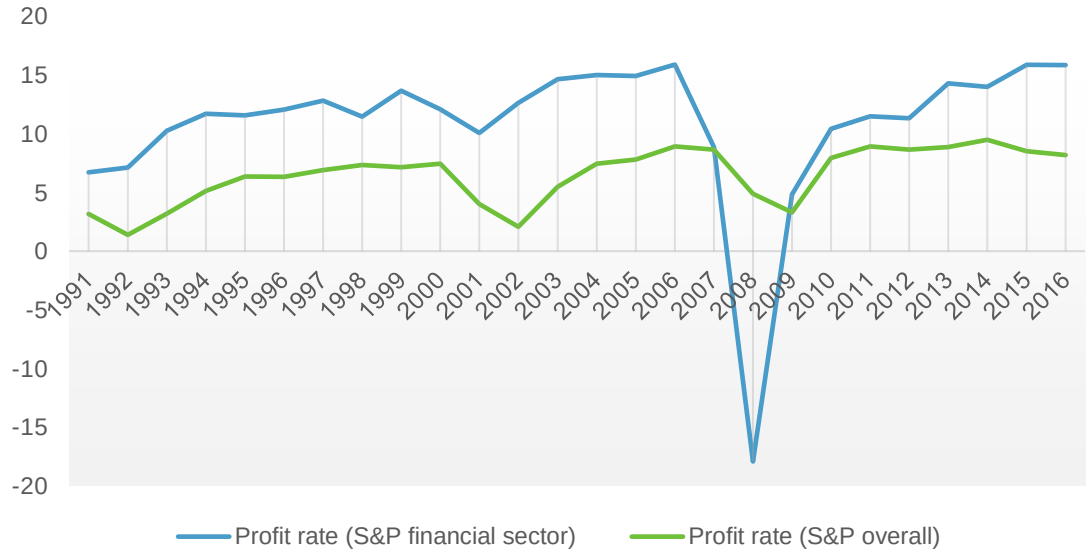
The eradication of the relay sector from financial transaction appears as a factor contributing to financialization in the literature (see Szunke, 2014; Dore, 2008). As firms have immediate access to financial markets, the proportion of immediate capital market financing is rising. Anglophone countries are more advanced in this regard, but the rise in immediate market financing is a widespread phenomenon. Financial innovation is linked to this topic too, because firms are issuing new securities designed to cover their risks. The author of the article, however, agrees with French - Leyshon's study (2004) according to which the dismantling of the relay system is a consequence, not cause of financialization. Thanks to developments in IT, markets can be accessed immediately, leading to a fall in personal relationships and the need for them in transactions. As markets develop and trading and issuing securities become easier and more ordinary, the significance of intermediaries in markets falls.

The causal relationship between globalisation and financialization is similarly debated. Many studies (see Guillen, 2014) argue that globalisation brought about the integration of financial markets, strengthening the relationships and ties between different countries and financial institutions. Since the crises in the 1990s, the integration of financial markets and mobility of resources have been criticised. The argument was that aside from the integration in the trade sector, there was no significant improvement in financial markets and their operation (Bélyácz 2014). After all, rapid capital flows do not necessarily become utilised, but they can cause structural problems (Halmosi 2004). The counterargument raised (O'Rourke - Williamson, 1999; Velde, 2006; Rodrik, 2018) draws the conclusion that the causal chain is reversed, meaning that financialization helped globalisation. This view is supported by how the level of globalisation after 1st World War was only attained again in 2000, which happened thanks to financial markets because of the market fundamentalist political economy and deregulation they entail. Financial globalisation also sped up countries' competition for capital, leading to a fall in capital taxes, which in turn means long term changes are occurring in fiscal policy and will presumably keep occurring in the future as well (see Razin et all 2005; Razin - Sadka, 2018).

These factors did not impact financialization as distinct, separate factors, but they are closely intertwined and reinforce each other. For example, technical and technological change contributed significantly to financial markets' integration, deregulation and technological change contributed significantly to the decline in the intermediary sector's role, the global diffusion of financial innovation, and to the creation of large companies.

The value of global financial assets multiplied as a result of financialization. One of its other equally visible consequences is that the barriers between firms conducting financial activities began to vanish. While previously only financial firms and banks dealt with loans and investment into financial assets, now this became an ordinary activity regardless of branches. These activities usually yield exceptional profits, leading to the continuously high profit rates of financial institutions. Figure 1 shows the profit rates and returns ratio of firms in the index between 1991 and 2016 for the firms that constitute the S&P500 index. The diagram clearly shows that apart from the years of the crisis, the profit ratio of financial institutions is approximately double that of all the firms' in the index (the average contains the high profit ratio financial firms, too).

1. Figure: Profit margin for all S&P companies and S&P financial companies, 1991-2016, percentage

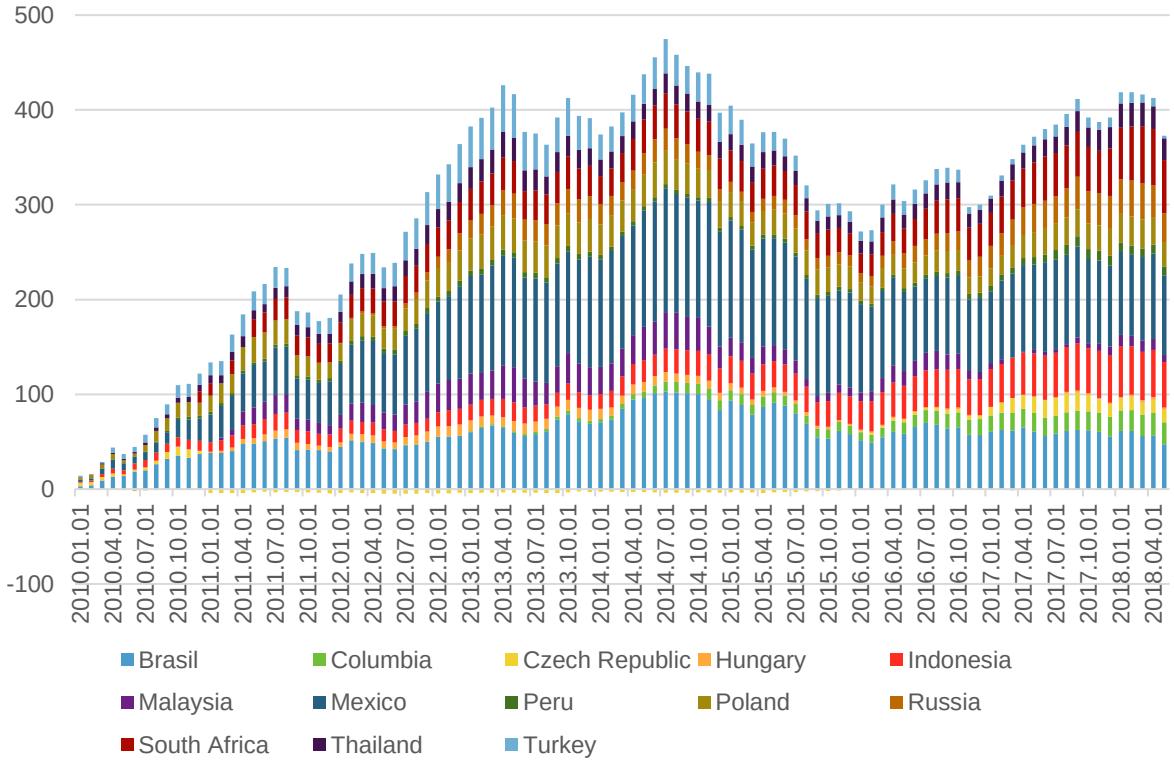


Source: Bloomberg

In my opinion, one of the most important consequences of financialization this article discusses, yet one that the international literature rarely explores, is the propagation of a short-term view. Due to high profitability of the financial sector, the allure of quick returns replaced the long-term investment view, thereby diverting a significant amount of resources from real investment markets. However, it is important to note that there are real economic motives underpinning financial transactions. Even issuing bonds means accessing resources that can be necessary for investment. Moreover, derivative products aim to cover risks associated with some kind of real economic activity (for example, the interest rate risk of issued bonds, or exports' and imports' exposure to the exchange rate). Real economic growth, however, lags significantly behind the growth experienced by financial markets.

As a consequence of financialization, participants in economic life can “trade” risks. According to Zysman (1984), accumulating resources from financial markets and covering risks raises firms’ autonomy, because they are no longer at the mercy of one participant. Still, investors’ loyalty falls significantly as a result, which manifests itself in a fall in the willingness to invest, a rise in the hunger for investment, and in a short-term approach (Hardie, 2008; and Engelen - Konings, 2008). This is shown by capital inflows to developing countries, as there is a significant and strong correlation in emerging countries’ capital flows in all investment categories (firms’ loans, debt in the local currency and debt in hard currency). Figure 2 shows the capital inflow accumulation in many emerging countries since 2010.

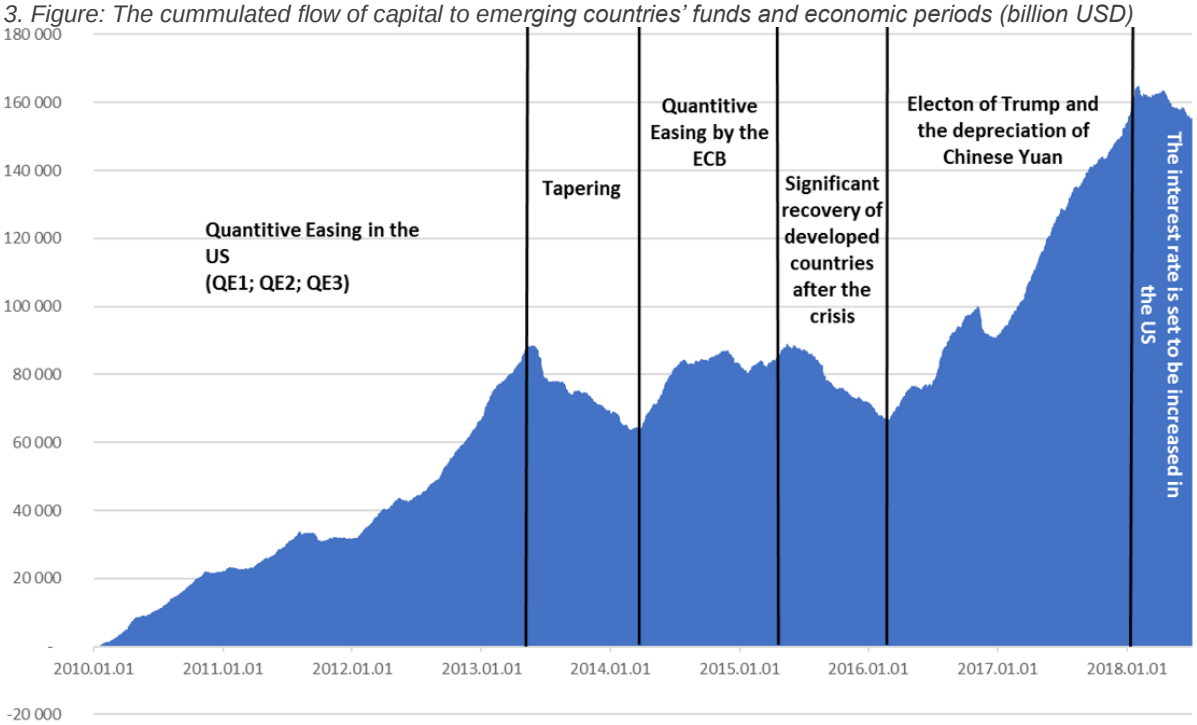
2. Figure: The cummulated flow of capital to emerging countries (billion USD)



Source: Trounceflow

Figure 3 shows the bond fund accumulation of countries listed as developing. The diagram shows that the periods near certain announcements led to quick and significant changes in bond stocks in emerging countries. With strengthening of this short-term view, financialization had a significant effect on exchange rates and real financing risks.

3. Figure: The cummulated flow of capital to emerging countries' funds and economic periods (billion USD)



Source: Trounceflow and the author's own edition

As a result of this, managers chase extra profit by decreasing cost and take on more risks. As equity is the most expensive way of financing, managers take on more debt. One source of risk is the increased leverage. The short-term view accompanied by financialization has also enhanced the financial companies to take on excessive risk in their balance sheet thus it has made the financial system more fragile. There is plenty of empirical evidence that the business cycles are shorter going forward in time. Seeing the anatomy of a business cycle, we could detect that it is mostly parallel with the financial cycle. Minsky (1992) carefully described his model and defined its stages. We can distuingish basic and super cycle. The basic cycle's stages are hedge finance, speculative finance and Ponzi finance. "*Hedge finance units are those which can fulfil all of their contractual payment obligations by their cash flows … speculative finance units are units that can meet their payment commitments on 'income account' on their liabilities, even as they cannot repay the principle out of cash flows. Such units need to 'roll over' … for Ponzi units, the cash flows from operations are not sufficient to fulfil either the repayment of principle or the interest due on outstanding debts by their cash flows from operations. Such units can sell assets or borrow*" (Minsky, 1992, p. 7). The Minsky basic cycle is present in every business cycle and works on firm level and the complementary super cycle operates over several business cycles and works on a system level. The stages of super-cycle contain risk taking, expanded risk taking and excessive risk taking. The Minsky super cycle

illustrates the system is allowed to take more financial risk. It can be done by increased risk-taking or regulatory relaxation.

Before the turn of the century, a debate emerged in the Hungarian literature on the excessive growth of financial markets, and about the role of the real economy (see, among others, Csontos et al 1997, Pete 1999).

Capitalism is organically accompanied by financialization. After all, the diffusion of securities began in the 19th century, as firms were no longer directly owned, but were instead owned via the ownership of the company's securities. This process sped up with the advent of technology, because information became easily accessible and easily propagated. The sale and accounting of securities also became much easier thanks to digitalisation and to improvements in info-communication technologies.

The process of financialization was significantly sped up by neoliberal economic policy. Following the 2nd World War, governments having taken up a greater role in the economy, encountered the phenomenon of stagflation. It was neoliberal policy that moved the world past it. This period saw the creation of a greater role for market forces and the abolition of boundaries, which was also entailed by the deregulation of financial markets (Kotz 2008; Kotz - McDonough 2008).

As Tobin, a Nobel laureate economist puts it, "*we are throwing more and more of our resources, including the cream of our youth, into financial activities remote from the production of goods and services, into activities that generate high private rewards disproportionate to their social productivity*." (Tobin 1984, p. 14-15). Financialization increases the social inequality, increases the information asymmetry between the purchaser of the financial assets and the seller of the financial assets; undermines the stability of financial markets. Therefore, business cycles become shorter and even more volatile (Szunke, 2014).

1.1.Deflationary pressures and the decreasing and eventually negative interest rate

Interest rates had been falling globally even in the decades preceding the crisis. One of the reasons behind this was that China joined the globalisation processes reinforced by financialization. On the one hand, China decreased prices and tamed inflation thanks to its cheap labour force; on the other hand, Chinese savings and resources were seeking investment opportunities all over the world.

Moreover, income inequality was worsened by the way management became wealthier and wealthier in the financial sector due to their rising incomes and the creation of

conglomerates. Aggregate savings rose significantly as a result of rising income inequality as well as other demographic factors (such as the rise in life expectancy and the decline in the number or children). At the same time, investment opportunities could not absorb all savings. Rising savings were met with falling investment opportunities as the number of innovations fell, and some economists even believe that following the IT revolution, there is nothing else to fuel the world economy (Bean et. al 2015; Szanyi 2018).

This process was further strengthened by the crisis and economic actors' reactions to it. Indeed, the crisis itself is one of the consequences of financialization because of the rapid diffusion of securitised mortgages worldwide. During recessions, loan transactions typically fall, as can the entire stock of loans. This was not different in this crisis: economic actors were forced to balance their budgets while profit prospects fell significantly. At the same time, interest rates and price levels fall. The latter is partially caused by a fall in demand, and as a result the economy's output falls below potential. This so-called output gap exerts deflationary or disinflationary pressures. Interest rates also fell because of low inflation and a weak demand for loans.

After the crisis, when demand rose again, it became more and more important to see interest rates normalised to prevent bubbles, which have menacing real effects, from arising in financial markets. At the same time, this normalisation came at a cost. As a first among developing countries, the Fed began raising interest rates in 2015, which in theory affects emerging markets negatively via multiple outlets. These negative effects, however, did not, or have not yet, materialised. In the long run, this interest rate environment is not to last.

For a while, negative interest rates were only a theoretical consideration. In 2012, Denmark reached and surpassed zero interest rates. Today, 10 percent of the bond market with a value of 100 thousand billion dollars contains negative yielding bonds. A quarter of European bonds recommended for investment do so as well, and such securities have even begun spreading on corporate bond markets. In March 2016, the interest rate of deposits at the ECB fell to -0.4%. This took place because despite prior negative interest rates, interbank markets still had positive interest rates, so the ECB could not take advantage of liquidity's crowding out effect in the real economy. This pushed interbank interest rates below zero too.

The nominal interest rate of a financial tool is made up of three components: inflation, risk, and expected yields. Real interest rate sums up risk and expected yields, so the real interest rate cannot be negative in the long run if financial and capital markets are operating well.

The argument for negative interest rates states that the central bank "fines" commercial banks that represent a liquidity surplus greater than theirs. As a result, banks will store their

surpluses not at the central bank, but they will instead try to give it to households, firms or the government as loans. With this money households' consumption rises and firms carry out more investment, thus fuelling growth and inflation. However, due to low credit demand rates for both the general population and firms, these resources were instead diverted to the government securities market. Instead of the negative interest rate central bank deposits, banks invested the surplus liquidity into positive yielding government securities. This meant that the surplus resources became the "problem" of the bank selling government securities. As the liquidity surplus of the aggregate banking system does not change, resources are simply "travelling about" until a surge in demand pushes government securities' yields below 0.

However, with a number of financial assets, the zero lower bound proves to be an effective boundary, because if commercial banks passed on negative interest rates to their customers, then people would all withdraw their savings. As people with deposits bring about capital flight, the financial system itself could collapse. At the same time, financial stability has come to be a first-rate priority worldwide following the crisis. Negative interest rates pose a grave threat to stability because they worsen the banking system's profitability. All the while low interest rates would make the European ratio of non-performing credit rise even further, which is already quite high. Not to mention the particularly indebted South European countries, where governments even risk bankruptcy.

Low yields fuel investment, but they also affect savings. First, they make households take risks at lower rates. Secondly, savings need to rise to guarantee pensions for an ageing population, which goes hand in hand with a fall in consumption. All this can lead to a fall in real demand. Many studies confirm that a negative interest rate is not expansionary, but instead contractionary. Waller (2016) points to the counterproductive effects of negative interest rates, which they see as taxes the banking system is subjected to. A study by Eggerston et al (2017) shows this contractionary effect for six countries, while Heider et al (2017) find the same to hold for the Eurozone. Eggerston et al (2017) also analyse the effect of negative interest rates on the economy with a New Keynesian Dynamic Stochastic General Equilibrium (DSGE) model. The study finds that falling interest rates are expansionary until a certain point, but beyond that, they no longer encourage demand, and they are even contractionary due to falling profits. Gertler - Kiyotaki (2010) also reach similar conclusions.

Investors, naturally, get less than what they invested if interest rates are negative. But real interest rates are more telling than nominal interest rates. The phenomenon of negative interest rates becomes particularly interesting in a deflationary environment, because in such a setting, there can nonetheless be a positive real interest rate. At the same time, cash that "interest

rate" cannot be changed can restrict monetary policy, because cash can be interpreted as securities with an interest rate of 0. Still, holding cash is expensive, and even securities with negative interest rates can give surplus yields if interest rates keep falling via the exchange rate. Investors need not worry about not being able to let go of such tools in the current situation, because central banks ensure market liquidity with/instead of market actors.

Though the ECB has been using negative interest rates for years, its effects were not felt for a long time. This was because inflation could not be galvanised and there was no economic growth in the eurozone. During 2016 and 2017, inflation and economic growth seem to be growing, but the world economic boom is particularly favourable in this period. Banks' holdings of physical money rose in the years hallmarked with negative interest rates. In certain countries, the income lost via negative deposit interest rates was passed on to customers, so they attained the opposite of the desired effect: a rise in expenditure. On the credit side, banks improved their profitability, which had been damaged because of falling credit interest rates, by raising the rate of other expenses, such as contributions. Negative interest rates led to asset portfolios being rearranged, so it created a significant explosion on the market for goods and risky assets.

While the loosening of monetary conditions might be needed due to low demand and growth rates, the low interest rate means that classical monetary policy instruments are not accessible neither in the eurozone nor in the US. This is called liquidity trap. A similar phenomenon to the liquidity trap or, according to some economists, a special form of it is the risk aversion trap. In this case, economic actors' inclination to take risks falls drastically. This leads to a surge in demand for securities deemed low-risk, which can force yields near zero and can even keep then at that level (for more details, see Caballero - Fahri's studies, for example Caballero - Fahri, 2017; Caballero - Fahri, 2013 or in the Hungarian literature Horváth - Szini, 2015).

A demand surplus can come about not just due to a fall in the inclination to take risks, because risk-free financial assets can have several economic roles. If the amount of risk-free assets is not sufficient to fulfil those roles, then the risk of falling into a trap emerges too. These assets play a key role in investors' portfolio decisions, and they serve as a hedging instrument during financial operations for example, during interbank or central bank transactions. They also serve as regulatory tools, and one of their most important roles is to act as a benchmark during portfolio sales as a discount rate. Of course, the excess demand for risk-free assets can also come about on the supply side, as was the case during the crisis. During securitisation, the

CDOs created and previously deemed safe that served as hedging instruments proved quickly to be risky when the crisis broke out, and simultaneously, the need for safety rose too.

Being in the risk aversion trap means the excess demand places a pressure on interest rates, and it can even push them below zero. This means optimal real interest rate levels cannot emerge, because inflation is already low and the economy has already surpassed the zero lower bound, meaning the economy has entered a spiral. At that point, falling inflation leads to rising real interest rates, which in turn leads to inflation falling even more and so on. Once a certain 'breaking point' interest rate level is reached, the economy attempts to return to equilibrium through a fall in real economic activity. This means that in the risk aversion trap, the endogenous tightening of monetary conditions is key.

When examining countries faced with a risk aversion trap, we can observe, contrary to financial theory, that countries deemed to be riskier have lower yields than those deemed safer. Examples of such countries from the Visegrad group include Poland - Hungary. While Polish debt is deemed to be much safer than Hungarian debt by credit raters, Poland nonetheless has to finance its debt with higher yield rates than the Hungarian government. In such countries, the demand for risk-free assets is weakened by capital inflows to foreign assets given the exchange rate risk, which further fuels the integration of financial markets.

In order to avoid the liquidity trap, the central bank relies primarily on forward guidance and managing expectations, but these are not appropriate to deal with the risk aversion trap. Therefore, it was necessary to renew the instruments monetary policy operated with after the crisis.

1.2.Post-financialization monetary policy instruments

One of the leading factors in global monetary policy over the past decades has been the increasing influence of central bank decisions on long-term interest rates. The study conducted by Hanson - Stein (2015) supports this phenomenon and, by applying a vector auto-regressive methodology, shows an approximately 0.5 percent increase in the long-term interest rate following a 100 basis point increase in the central bank interest rate. This is mainly the consequence of the increasing prominence of short-term views, the investment actions of commercial banks, as well as the increased presence of mutual funds on the market. Yield searching causes that investors react to a change in the yield of short-term securities by adjusting portfolios. Therefore, when short-term yields decrease, their preference shifts towards long-term securities, and if short-term yield increases, they decrease the share of long-term

securities in the portfolio. Ábel (2015) emphasises the stability risk which originates from this process, as in an economy with extremely low interest rates, even a small increase in the interest rate can result in losses for bond investors and can reverse the direction of capital flows. In that case, it is not only the investors' yield curves that shift, so do the preferences between various asset classes - a development that had also been observed following quantitative easing.

In line with the empirical description of monetary policy provided by the Taylor rule (Taylor, 1993), the short-term interest rate determined by the Fed was expected to decrease well below zero after the crisis. This, however, had raised problems due to the factors discussed above, and as a result, the tools available to monetary policy-makers came under a severe constraint (Bernanke, 2017).

Several innovative expansionary monetary policy instruments have been invented all over the world, of which two played a particularly important role in shaping global monetary policy trends - quantitative easing (QE) and qualitative easing (QuaE).

Quantitative easing increases the monetary base through the purchase of bonds on the secondary market, causing an increase in the central bank's balance sheet (see Blinder 2010; Chodorow - Reich 2014; Joyce et al 2012; Taylor 2013).

The Bank of Japan was the first to use quantitative easing when it started purchasing large amounts of Japanese government bonds in 2001, since then Bank of Japan intensified quantitative easing and introduced qualitative easing as well (Shirai, 2013). During quantitative easing, the central bank purchases mortgage bonds and/or government bonds from banks and bond traders, and as a result, the market for the given securities remains liquid. In addition, the price of bonds increases while their yield decreases due to a rise in demand (Kiss – Balog, 2018). Profits generated by the European bank system in recent years have been largely due to the appreciation of government bonds. Accordingly, a future increase in the interest rate will cause a loss for the banking system.

If faced with appreciation, investors and banks will try to switch to different types of securities which promise higher yields. This phenomenon is called yield hunting and it enables the integration of various maturity or financial asset classes. This way, the central bank is able to influence long-term yields directly. By holding them low, it weakens the country's currency, and encourages investment through low interest rates. The effects of QE can be usually observed in the rise in the value of shares, real estate and art works. It was common for market participants to reinvest or save the accounting profit generated by the rise in price, which caused that the demand for real goods did not increase. However, these markets do have important secondary effects, such as the effect on firm acquisition. Higher share prices do not mean greater

value creating ability, but at the same time, acquisition requires a significantly higher loan. Thanks to an increasing share price, the loan to own capital ratio changes within the firm's balance sheet, implying higher loan capacities for firms. Share repurchases increased significantly after the crisis, which means that significant resources were transferred to this sector from the real economy. This also came about as a result of short-term preferences, since the valuation of the performance of managers was influenced by the current valuation of the market for shares, while profitability played a less significant role. The rise in prices in the real estate sector further intensified the rearrangement of incomes between owners and non-owners.

Quantitative easing is often associated with the risk of hidden inflation. Since consumer demand did not increase, the CPI did not change significantly either. However, the price of securities and the value of real estate etc. increased significantly - a change not included in traditional inflation data. One of the main advantages of QE is the fact that government financing becomes cheaper. This, however, requires a responsible state, as cheap financing can encourage holding excessive debt, and can lead to a soft budget constraint. Thus, during quantitative easing, the expenses related to state financing decrease, and expansionary fiscal policy and borrowing become unnecessary. At the same time, in the event of another crisis it would be extremely challenging to increase the central bank's current balance sheet without making greater sacrifice later. A decrease in the central bank's balance sheet will have very limited effects.

The other typical tool of non-conventional easing is called qualitative easing, when the composition of the central bank's balance sheet shifts towards more risky, less liquid assets (Farmer 2012). Qualitative easing is also considered to be one of the tools of monetary policy. At the same time, Buiter (2010) argues that since it is accompanied by an increase in the riskiness of the aggregate state balance sheet - which will be financed by taxpayers - it can also be classified as a fiscal or quasi fiscal policy tool.

The literature on qualitative easing is much more modest than is the case with quantitative easing, yet the tools used by the National Bank of Hungary (NBH) do fit into the framework of qualitative easing. Therefore, we illustrate their effects, consequences and risks through their detailed introduction. Similarly, to quantitative easing used in developed markets, the NBH attempted to relax monetary conditions by increasing the liquidity of the market for government bonds. One of its important goals was to make home processes more predictable, as well as independent from the processes on world markets. This was not achieved by direct purchasing, but by extra risk taking, providing incentives to the bank sector, and by diverting resources from its vaults to the market for government bonds. This is justified by the fact that

while 3-5 percent of bank assets were held in central bank deposits before the crisis, this number approached 20 percent towards the end of the crisis.

In accordance with the self-financing programme, the central bank is trying to reduce government debt and foreign exposure by purchasing short-term securities through its foreign securities purchase programme. Thus, it is eliminating those effects which could have appeared on the secondary market after the closure of a more significant position. Since the announcement of the programme, the value of government debt held directly by foreign entities has decreased significantly.

By intervening in the government bond market, the NBH solves one of the problems posed by quantitative easing, which is that even though money is theoretically injected into the economy, a significant portion of it remains in central bank deposits. The decrease in the amount of debt directly held by foreigners is one of the short-term consequences of the Hungarian programme, which reduces the risk of government budget refinancing.

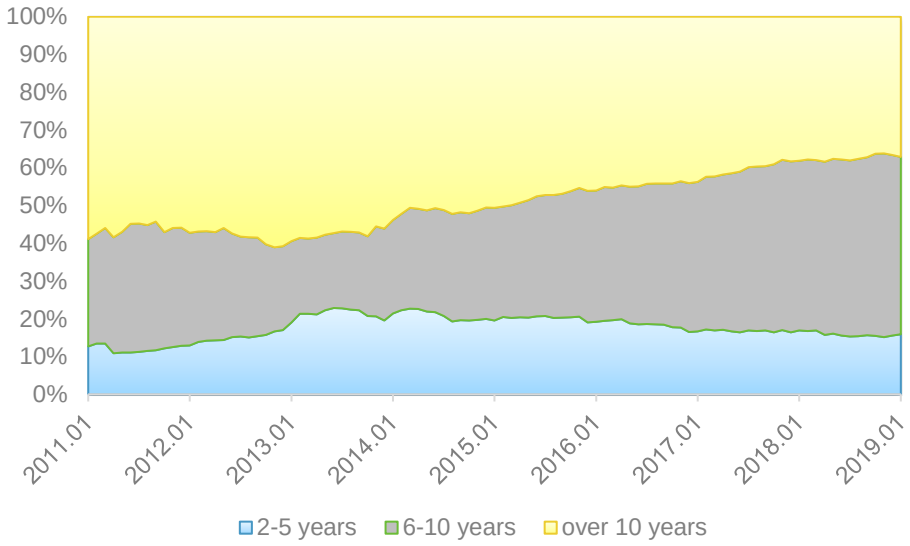
The NBH encourages banks to switch to the government bonds market through conditional interest rate swap transactions, by paying variable interest instead of the fixed interest provided by the market. This means that the central bank is profitable in the event of a decrease in the interest rate, while it suffers losses when the interest rate rises. Thus, it relieves banks from interest rate risk. The inclusion of market and interest rate risks in the central bank's balance sheet is a non-conventional expansionary monetary policy tool which has been an unavoidable step taken by central banks in many developed countries.

Keeping these risks within its balance sheet can become a huge burden for the central bank, and later for the government budget, too. This comes about mainly as a response to the current restructuring of Hungary's government debt - from foreign to home financiers - as the outflow of foreign capital depresses the value of the forint in the short-run. And the depreciation of the forint is the central bank's main source of profit.

Moreover, another risk the programme poses is that the market for government bonds, thus the financing of government spending, is mostly dependent on the home banking system, which ultimately puts future economic growth at risk. If problems arise on the market for government bonds, this could imply that the banking system is also vulnerable, and vice versa. The problems facing the banking sector can therefore threaten the government too, which could endanger future lending processes. One could say that banks are captives of the state. At the same time, the government might have more incentives to settle its relations with the banking sector.

The low interest rate environment has significantly decreased the interest expenses of the government, consequently improving its position. However, this effect is only temporary, and it motivates the state to decrease the length of maturities. This is illustrated on Figure 4. The temporary improvement and shorter maturities are also a consequence of a short-term view.

4. Figure: The term structure of Hungarian government bonds at issuance



Source: National Bank of Hungary

Unlike the expansionary programmes implemented in many developed economies, the Hungarian method decreases the central bank's balance sheet (decreased almost by 25% between 2015 january and 2019 january). Thus, the increase in interest rate risk is partly offset by the reduction in the balance sheet of the NBH. In order to reduce these risks, the central bank has started to decrease its balance sheet. This is relevant since the revenue from the asset side of the NBH's balance sheet is lower than the cost of its liabilities, and therefore the lower the bank's balance sheet, the lower the resulting losses. The central bank is able to decrease its balance sheet through reducing the amount of foreign currency reserves. As a result, its reserves have decreased by 40 percent over the course of three years. The decrease in the bank's balance sheet implies a decrease in bank liquidity, or, based on recent experience, a decrease in the interbank market's excess liquidity. This reduction is caused by the decline in the amount of short-term loans denominated in foreign currency and supported by the Guidotti - Greenspan rule for central banks' reserves. Overall, this is linked to the conversion of foreign currency loans to forints (Greenspan, 1999).

The long-term goal of policy-makers is presumably to make monetary policy, which has been passive for decades, active again i.e. to influence monetary conditions through loans instead of deposits. One of the steps taken to this end was the constraint placed on deposits during an era of excess liquidity, while the reduction in the central bank's balance sheet implies the absorption of liquidity. Active central bank intervention usually means more effective monetary policy, and more importantly, it implies that the NBH can be profitable in times when interest rates increase.

1.3.Liquidity, as the channel of monetary transmission

Central banks are responsible for maintaining macroeconomic stability, they perform the role of the regulator and the supervisor as well as the lender of last resort.

Since the Great Depression of 1929-1933, there have been many changes in central banking. After the Great Depression, governments took over central banks and their actions were mainly of political nature without theoretical basement. According to the general view at that time, competition in the financial sector was clearly harmful, therefore oligarchies were built up wittingly. Due to the overregulation there was no space for financial innovations. After the collapse of the Bretton Woods System, central banks turned their view to inflation targeting in 20 years so it was a conflict between price and financial stability and the expansion policy of the governments, which implicated the independent central banking. Since the crisis of 2008, central banking has changed and we can see the development of the future of central banking. (Goodhart, 2010)

Central banks invented new tools, while shifting their focus from interest rate policy to balance sheet policy which has had significant impact on assets and thus on markets as well. Normally, central banks during the times of financial crisis assume to the role of lender of last resort, thereby providing the market with unlimited funding. However, today central banks assume the role of the dealer of last resort. The crisis pointed out that the macroeconomic stabilization cannot be reached by only price stability. As we will see later, monetary policy actions cannot be influenced solely only by domestic factors, therefore financial stability cannot be reached exclusively by managing the domestic expectations of the long-run price level (Mehrling, 2014).

As a new policy tool, central banks trade with a very wide bid-ask spread in both the money and the capital market. The very wide bid-ask spread is necessary, otherwise central bank actions could substitute the dealer level while in this case central bank just puts a floor to

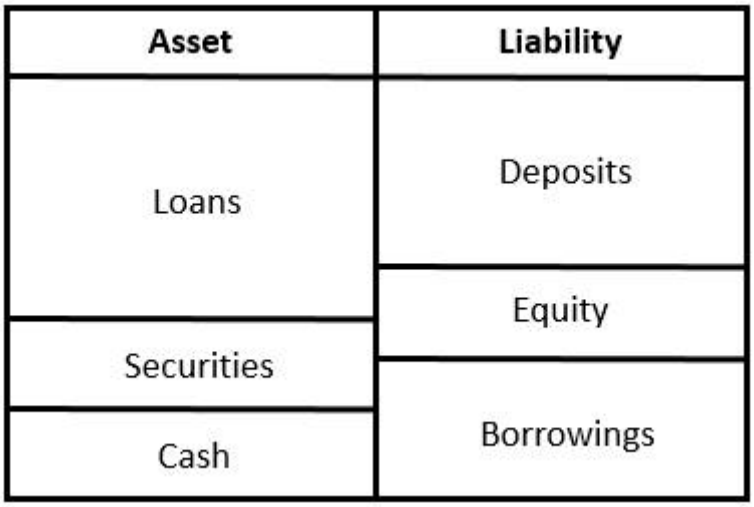
the market until it recovers and supports the start of trade again at the narrower, market-based bid-ask spread. In the previous decades, proper central bank regulation, quick market adjustments were considered by market participants. Due to the recent changes in monetary policy practice and tools, regulation illusion would be substituted by liquidity and safe asset illusion in the market. In this case, the Kornai developed soft budget constraint would be relevant for markets as market actors would underestimate liquidity risks or take too much liquidity risk due to irresponsible management behaviour. However, in this case, not companies would be bailed out but markets with exceeded liquidity. In this case, small companies can act like companies described as too-big-to-fail because additional liquidity provision can be rationally expected by market participants.

The role of commercial banks has also changed before and during the crisis. Commercial banks have two roles in the modern economy. First of all, they collect savings and provide loans and, furthermore, provide the infrastructure for payments. One of the misconceptions in the modern economy is that banks are only intermediaries and they lend out what savers have in the bank. Theoretically, banks can increase their loans unlimitedly since whenever the bank provides a loan, it simultaneously creates a deposit on the client's account thereby creating money. But of course, there are some limits in this practice. They include i.a. liquidity risk, credit risk, regulation, behaviour of money owners, monetary policy, etc. (McLeay et al., 2014). For maintaining the payment system, banks need to have financial assets in their balance sheet in order to be able to manage transactions on the level of banks, so there is market and liquidity risk in their balance sheets, too.

The classical view of commercial banks is that they make their money through what is called maturity transformation this is illustrated in Figure 5. They have short term liabilities and they lend them long-term. Sources of bank funding can be broadly categorized into retail and wholesale funding. Retail funds include various type of deposits kept in banks and this is considered unsecured funding as banks do not provide collateral against these sources. Banks can also use the wholesale funding market where they can lend their excess funds and can borrow quickly if they need additional sources. Wholesale funding can be secured and unsecured as well. Due to the payment system, banks always do overnight businesses but it is empirically proved that banks are aiming at achieving a constant debt ratio (see for example Memmel - Raupach, 2010; Halaj, 2013). Previously banks were thought to be fundamental investors so they were investing for long term considering both loans and securities and they were not keen on changing their positions due to instantaneous and perhaps temporary economic situations. Then, the border was getting lighter between investment companies and

commercial banks. That is why regulation started focusing on the clear separation of the two which has improved transparency in the financial system.

5. Figure: Balance sheet of commercial banks in the model



Source: author's own edition

Investment funds recently became more important actors of the financial system. These are typically speculator actors but not in the terms of Minsky. Investment funds are connected with each other as they hold deposits in each other but most of the assets are securities from the market while these are funded from deposits and equity. Due to globalized financial markets, speculators are searching for better investment opportunities throughout the world and they can be daily traders in order to maximize their short time profit and loss accounts. For example, in the recent case of short rate cutting we could see that funds were flowing to longer terms and then emerging markets. This phenomenon is called search for yields. This is why changes in short term rates can significantly affect the long-term rates and not because of the changes in investors' expectations since long term rates are linked to future short-term rates.

The split of households' and firms' savings between banks and investment funds can be impacted by current economic conditions therefore the importance of the different channels in the transmission mechanism changes over time. The shareholders are looking at the interest rate and their expectations about the future including profit expectations, liquidity expectations and further changes in interest rate. Hence, managing expectations can also affect the importance of different instruments in the monetary policy as fundamental investors look for long term returns whereas speculative investors for short term ones.

Liquid financial markets are desirable for financial economists for many reasons. Higher liquidity means higher efficiency in source and information allocation. Therefore, central banks

can intervene in the market in a more efficient way and central banks can even use indirect monetary policy tools as the transmission channel is stable and the effects of central banks' operations are predictable. Liquidity has significant role to determine financial institutions' behaviour as liquid markets allow banks to take larger maturity mismatch and also currency mismatch between assets and liabilities. Liquidity also has an impact on crisis management as financial and non-financial companies can fund their operation more easily, therefore reducing the risk on central banks to act as a lender of last resort during a recession.

However, the emergence of new monetary policy instruments was necessary not only due to financing constraints and the need for rapid intervention, but also because of the change in monetary transmission and the emergence of new channels. One of the consequences of financialization presented earlier is that financial markets play an increasing role in fundraising, as well as saving. The line between the behaviour of financial and non-financial businesses is becoming thinner as many non-financial firms offer loans, manage portfolios and finance their activities by issuing bonds instead of bank loans. As a result, the importance of financial market liquidity has become more visible, which caused that central banks moved away from their position as 'lenders of last resort' towards a new position of 'dealers of last resort' (Mehrling, 2014). This implies that the central bank fulfils the role of a market maker in cases when no other economic agent does or is capable of doing so. In times of crisis, this essentially means purchasing bonds in order to help economic agents in the process of balance sheet adjustment. This is important especially in the markets for goods which serve as collateral for financial transactions.

Collateral instruments play an essential role mainly in interbank markets. Hence, other financial instruments are also crucial to financial markets, which are responsible for the allocation of liquidity among financial institutions. These collateral instruments include loan instruments, which are the most widely accepted type of collateral instruments. One of the reasons behind this is the need for symmetric information on bond cash flows when it comes to products used during financial market transactions.

A change in the value of collateral instruments therefore affects the liquidity they receive or offer on financial markets. Thus, the financial market's liquidity depends on the value of the collateral product, its volatility and the discount rate applied to the collateral product, the so-called haircut which also depends on volatility and the liquidity of the products (Youngman, 2009). In general, debt securities, primarily government securities, are considered to be the best collateral, since they are the least information-sensitive.

From a monetary policy perspective, the liquidity of instruments affects investment and the balance sheets of firms. Through the latter, it also affects loan capacity and thus the demand for loans, as well as household wealth.

1.4.Chapter summary

Financialization, the rising prominence of financial markets and the financial sector, is a natural part of the development of capitalism. Several factors supported and aided this process. In my opinion, the market fundamentalist economic policies of the 1970s were one to the most influential of these. The securitisation of risks and thus the reduction in the intermediary system's role led to the increased prominence of short-term views through a reduction in investor loyalty and a rising risk appetite. Financialization and the consequent short-term views propelled globalisation and integration processes, increased income inequality and caused that business cycles became shorter and more intensive (faster growth, faster depression), which peaked during the financial crisis of 2008/2009. The crisis acted as a catalyst and brought about phenomena like the globally low interest rate environment and the risk-aversion trap. These developments called for new monetary policy instruments, as traditional approaches proved to be ineffective in dealing with new challenges. The topics addressed in this article were subject of research in recent years, but they have mostly been treated as separate factors. They, however, are closely linked phenomena whose roots can be traced back to financialization. Due to financialization, liquidity has become more important from monetary policy point of view. Not just because, liquid financial markets make transmission channels stable and make the interventions predictable but because financial markets have been playing an increasing role in fundraising not just for financial corporation but for non-financial corporations as well. As a result, central banks moved away from their position as 'lenders of last resort' towards a new position of 'dealers of last resort' (Mehrling, 2014). This implies that the central bank fulfils the role of a market maker in cases when no other economic agent does or is capable of doing so.

2. Market liquidity

Recently, liquidity has been in focus of theory and practice. Although liquidity and liquidity risk have been researched for decades, there are still various misconceptions about liquidity in practice and theory. Liquidity usually refers to the avaibailty of funds to settle a transaction or the easiness to trade with a financial asset (Eickmeier et al., 2011). The different concepts of liquidity are introduced by Váradi (2012a) and described shortly as the followings.

- Liquidity for a company means whether the company is able to meet its financial obligations.
- Liquidity for an asset market means whether the security can be traded quickly in a large volume without impacting the current price on the market.
- We can also use the concept of funding liquidity which means if a company/bank is able to add additional financing to its operation quickly on the current market price. This dimension of liquidity can be impacted by the market but by also a single company.
- Liquidity for the financial system means the excess of available cash in the whole system.

"*These liquidity concepts are related to each other as the liquidity of a company is determined by its assets' market liquidity which is determined by the liquidity of the financial system*" (Váradi, 2012a, 3. p).

The concept of liquidity is really broad and complex therefore in this dissertation only on a particular type of liquidity is focused which is market liquidity. Market liquidity may be defined as the easiness with which market participants can buy or sell an asset in a market without affecting its price (Elliot, 2015).

Measurement of liquidity has been a challenging issue as liquidity has various definitions and various characteristics. According to Tirole (2011), liquidity is such a complex, multidimensional characteristic of the financial markets hence a single statistic cannot describe well this phenomenon. According to Harris (1990) building on Grossman - Miller (1988) introduced that markets can be described by the following interconnected dimensions:

- Tightness or also called width which represents the cost of executing transactions, so it shows the cost of consuming liquidity immediately but this measure is not able to capture the impact of larger trading volumes
- Immediacy which represents the amount of time it takes to execute a transaction so basically how quickly a large trade can be accomplished
- Depth which shows how redundant the market is so the quantity of liquidity supplied
- Breadth which shows the price impact of executed trades
- Resiliency which infers how quickly the market can correct the imbalances so how quickly the price can return to the equilibrium after liquidity was consumed by a large trade

According to Sarr - Lybek (2002), liquidity measures can be classified into four groups which are strongly related to the characteristics listed above. The classifications of liquidity measures are (i) transaction cost measures, (ii) volume-based measures, (iii) equilibrium price-based measures, (iv) market impact measures.

The transaction cost measures can be distinguished to explicit and implicit transaction cost. The former is related to every expense regarding a trade including taxes while the latter capture only the cost of execution. The most commonly used transaction cost measure is the bid-ask spread which is known to capture the implicit cost of trading for the best available price level at order booking markets. High transaction costs reduce demand for the security as the investors is encouraged to seek other counterparties in order to execute the trades. If the transaction costs are lower, the investors prefer to trade with market makers therefore lower transaction costs are associated with more liquid markets. "*Lower transaction costs … generally allow more decentralization, diversification, and result in more transaction. These aspects will typically allow more of the various participants' information to be disseminated via the price mechanism. Prices will adjust quicker, smoother and in principle tend to reduce excessive volatility due to arrival of new information and thus become more resilient*" (Sarr - Lybek, 2002, 9.p). Alternative methods are also considered in the literature to measure liquidity especially on order driven markets. Xetra Liquidity Measure (XLM) calculated daily, weighted spread for impatient traders trading against the limit order book (for the details see for example Stange - Kaserer (2008)). Budapest Stock Exchange also introduced its own method to measure liquidity. Budapest Liquidity Measure (BLM) is based on the model of XLM. BLM is a weighted spread measure on stocks in order to take into consideration not just the bid-ask spread

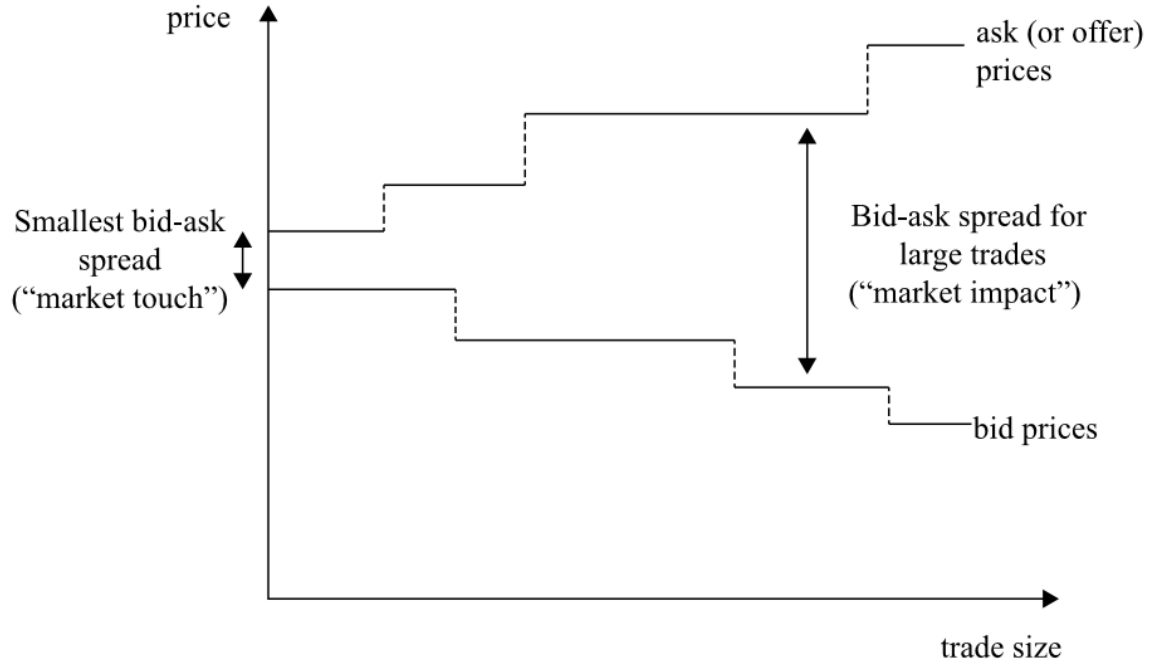
but also the transactions not being executed at the best price level. For the details see Kutas - Végh (2005), Gyarmati et al. (2011).

The volume-based measures traditionally used to analyse the price impact of the trades so large number of larger trades contain useful information about the imbalances and the returning price to market equilibrium. This method takes into account the trading volume which shows how difficult to trade a particular bond. This measure is usually applied to analyse the number of market participants and transactions.

The theory and practice of price-based measures are built on the Bernstein's (1987) work. This tool helps to measure the resilience of markets to news related to the underlying security. Bernstein (1987) introduced the market efficiency coefficient which is a ratio of long-term return variance to the short-term return variance.

Figure 6 shows how different liquidity dimension are linked to each other in the order book. Bid-ask spread is often referred as market touch by practitioners. This can be measured any time on the market as it is a proxy for market liquidity. On order driven markets, bid-ask spread is related to the best available price level, while on dealer driven markets bid and ask prices are the relevant and available prices for market participants set by the market makers. The Figure illustrates how the transaction costs change and the spread varies when transaction is made in significantly larger amount, this is an illustration how the depth can be proxyd and used for measure liquidity.

6. Figure: The bid-ask spread and its change over the size of trade



Source: Foucault et al. (2013)

Liquidity of government bonds is in the focus of this dissertation which is typically quote driven or so called dealer driven market. In dealer markets, the investors do not trade directly with each other, instead they trade with the dealer or so called market maker who is a kind of special intermediary. So, in dealer markets the market makers provide liquidity, and final investors are liquidity demanders while in limit order type markets investors can choose whether they would be on the side of liquidity suppliers or liquidity demanders.

"*Dealers' quotes are typically valid for only a limited volume and short period of time. A large order may be executed by splitting it among several dealers. In that case, effectively, a seller/buyer is walking down/up on the demand/supply curve resulting from the aggregation of dealers' bid-ask quotes*" (Sommer - Pasquali, 2016, 4. p.).

In practice, the quantitative modelers use market touch -the initial bid-ask quotes- until the point from the modelers assume the trading size impact the quoted prices. The turning point is called the point of endogenous illiquidity which reflects the depth of the market. After the point of endogenous illiquidity simple convex/concave functions or liquidity cliff (concave/convex until a point then convex/concave) can be assumed. These stochastic models usually include central bank floors as the new role of central banks is called as dealer of last resort instead of lender of last resort.

The bid-ask spread is classified as a transaction cost measure. Dealers quote bid and ask prices in order to provide liquidity. The market makers act as intermediaries as they buy from private security owners who want to sell while also selling to private actors who want to purchase securities. The price that market makers set for the private buyers are called ask or offer price while the price set for private sellers is called bid price. The bid-ask spread can reflect asymmetric information costs, order processing costs and inventory-related costs (Sarr - Lybek, 2002; Sommer - Pasquali, 2016; Treynor, 1987).

The market makers or so called security dealers make their profit from the difference between ask and bid price so they are paid for providing market liquidity. The difference between ask and bid price is a good proxy for market liquidity as a narrow spread can mean liquid market while wide spread can signal an illiquid market.

The bid-ask spread can be calculated as the absolute difference between bid and ask prices or as a percentage spread from the mid price. For quantitative models, absolute bid-ask spread is considered to be a better option while for comparison between markets percentage spread is supposed to be the better choice. In order driven markets bid and ask prices are related to the best available price level on the market. This dissertation focuses on dealer driven markets in which bid and ask prices are set by the market makers.

$$S = P_a - P_b \quad (1)$$

$$S = (P_a - P_b)/[(P_a + P_b)/2] \quad (2)$$

, where P_a means the ask price and P_b means the bid price.

There has been dynamically growing literature in both theoretical and empirical modelling of the bid-ask spread and its components. The field which is addressed to explain the components and the predictability of the spread is called as microstructure theory and the methodology of the field is mainly based on game theory.

The significant majority of literature identify three main elements which determine the bid-ask spread. These elements are the inventory carrying cost, adverse selection cost and order processing costs. Some theoretical model also considers market structure costs mainly for oligopolistic markets.

In spite of the popularity of bid-ask spread as liquidity measure, there are two shortfalls. First, however bid-ask spread data are available, these data are usually determined by indications or weighted average of trades and do not show the real commitment of market makers. Second, bid-ask spread is not a useful measure to grab the market depth hence the spread is only useful for smaller trades which fit within the quoted depth.

The liquidity of OTC markets is difficult to measure as the amount of available information is limited. "T*he different levels of transparency in equity and bond market impact models are not as easily formulated for the latter as they are for the former. While transaction prices and volumes are made available by exchanges, fixed income markets are significantly less transparent and moreover, bonds are generally traded with slower turnover*" (Sommer - Pasquali, 2016, 6.p.).

As bond markets usually have significantly less available information, there is consensus in the literature about what the useful and valid proxies are regarding to liquidity of a fixed-income security. One of these asset characteristics is the rating so the credit risk related to the security. Typically, bad credit rating means greater information asymmetry so it makes the bond less liquid. In practice, the causality is assumed back and forth so if a bond is typically seems to be illiquid, we can assume lower credit quality (European Banking Authority, 2013). Maturity is also a related characteristics as longer maturity is usually associated with higher degree of risk therefore longer time until maturity means less liquid asset (Jankowitsch et al., 2011). In general, the financial literature does not provide any strong evidence for the significant relationship between maturity and liquidity. The issued amount can also be a proxy

which can grab the liquidity of a bond as smaller securities tend to be locked into a buy and hold situation with more probability while bonds issued by large amount have larger number of investors and they also have different type of investors (Houweling et al., 2005). The most important factor which can affect a fixed-income security's liquidity is the central bank eligibility. If a central bank accepts a type of bond as a reserve asset it ensures that the asset can be converted into cash without trading with it via the market.

Basically, as we could see the above mentioned factors are related to risks whether risk increase and market participants increase their inventory risk the liquidity of the asset falls.

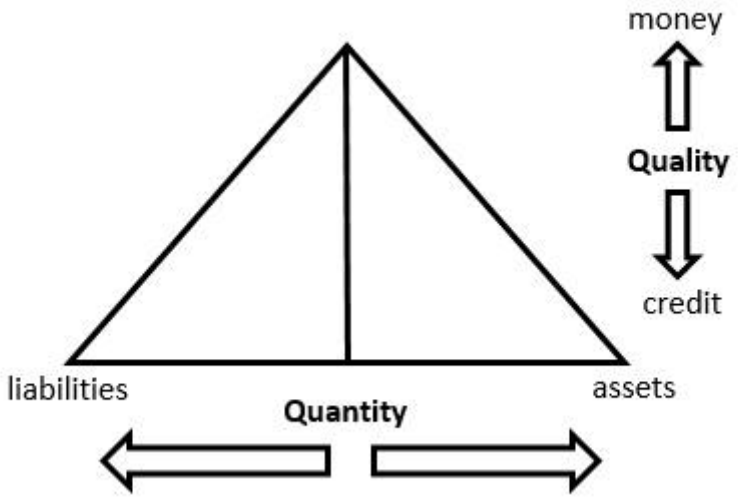
2.1.Source of liquidity

The first distinction is related to two forms of money, which are '*money'* and '*credit'*. This posits only a two-layer hierarchy, which does not really help us to understand the system until we start studying institutional levels. The perspective of the hierarchy can determine what money and credit.

Importantly, money from one perspective is credit from another one. To see this point more clearly, we can analyse what happens in reality. The top of the hierarchy is SDR or US Dollar or in the case of gold standard gold is the ultimate money or ultimate form of money, the international means of payment. Within this framework, people use the currency of the country, which is backed by gold and it may represent the country's gold reserve in case of gold standard. Of course, in this case it does not mean that gold is equal to currencies as it is money for the participants in the country but a promise for international settlements. Going down on this hierarchy, bank deposits are promises to pay currencies and securities are promises to pay bank deposits. These categories are very close to the classic money supply categories but in this four-layer hierarchy we are unable to draw a line between credit and money as it depends on where we are standing. Going down the hierarchy, the quality of money is decreasing while the quantity is increasing. This is illustrated by a pyramid in Figure 7. This pyramid can be expanded at the time of recovery and shrink at the time of crisis. It even fluctuates during the day. Here, the fluctuation does not only change the quantity of different levels but the distance between the levels of the hierarchy as well. For example, during crisis no one wants to have credit, no one wants to have promises to pay as everyone wants to have tangible money, money on the particular level. For an ordinary person, the means of settlement is bank deposit whilst banks use higher money. Of course, this hierarchy is not as striated as it is in the real world.

E.g., bank deposits are not the same as money market mutual fund deposits or currency can be central bank reserves as a form of higher money and there are plenty of forms of securities and derivatives but this four-layer example certainly shows how the hierarchy of money has been built up. (Mehrling, 2012)

7. Figure: Hierarchy of money



Source: Mehrling (2012)

Similarly, to the forms of money, the participants are also placed in a hierarchy and every level of the above mentioned money hierarchy is owned by an actor. Hence, the pyramid above shows the balance sheet of the participants. Every agent is able to set the price and the quantity of credits up on its own level and the money on the levels below them; hence they maintain the convertibility between the levels. The liability of a level is an asset on the other level therefore if we sum the participant's balance sheets up the remaining is the ultimate money. It is because ultimate money is exogenous whereas the others are endogenous. The market makers in the hierarchy are the central bank, commercial banks and security dealers (Mehrling, 2012).

Recently the causal relationship between funding liquidity and market liquidity has received a lot of attention. Gromb - Vayanos (2002) in their frequently cited paper built a theoretical multiperiod model where some traders are able to trade with two identical risky financial assets in segmented markets. In this case, the traders need to collateralize their positions separately in each market, which results in financial constraints. The financial constraints in the traders funding liquidity lead to an optimal level of liquidity being provided.

A recently formed concept about financial flexibility however implies that liquidity of financial assets determines the funding liquidity of corporations. That is because companies can easily liquidate their assets thus finance their activities (Acharya et al., 2006 and Gamba - Triantis, 2007).

Brunnermeier - Pedersen (2009) provides a theoretical model which link assets' market liquidity to the traders' funding liquidity. Their findings show that traders' ability to provide market liquidity depends on the availability of the underlying funding but the availability of their capital depends on the assets' market liquidity. Their model leads to understand that market liquidity and funding liquidity are mutually reinforcing, leading to liquidity spirals.

Adrian - Shin (2009) empirically tested broker-dealers' balance sheets and their role in providing liquidity. The paper argues that the availability of liquidity is significantly linked to fluctuations in the leverage of financial actors. The paper also states that the changes in dealers' balance sheets can result changes in liquidity conditions therefore the financial intermediaries balance sheet can be used as macroeconomic variables to capture monetary policy framework.

According to BIS (2011), liquidity can be distuingished to official and private liquidity. Official liquidity is defined as the unconditionally available form of liquidity provided by the central banks. While private liquidity is generated by the financial sectors. The financial intermediaries provide market liquidity to securities market for funding liquidity throughout interbank lending. There is interaction between the mentioned liquidity categories. In normal times liquidity is generated by international financial actors while during financial turbulences liquidity is provided by central banks. The paper outlines three major categories which are drivers of liquidity. These are the (i) macroeconomic factors, (ii) other public sector policies, including financial regulation and (iii) financial factors. Jean - Pierre Landau who actually was the Chair of the working group accepted BIS (2011), also uses the categories of private and public liquidity in his paper (Landau, 2013). The paper summarizes the behavior and interactions between the two components. „*Global interactions between private and official liquidity are both similar and different from those happening in domestic financial systems. I will argue that, depending on how they develop in the future, the shape of the international financial system could be very different: either moving toward more integration; or, following recent trends, introducing some progressive segmentation*" (Landau 2013, p 224).

Just a few papers analysed different dimensions of liquidity on emerging markets and these papers mainly focused on equity markets. IOSCO (2007) summarises the responds for a survey questionnaire about the source and determinants of market liquidity. 21 juisdictions responded and disclosed four categories which drive market liquidity. These drivers are (i)

macro drivers (ii) market microstructre (iii) regulation and (iv) products and services. As the paper says „*Liquidity is becoming a critical issue in capital market development initiatives. As markets become global, an accompanying threat to small and less developed markets is the drying up of liquidity in domestic markets with a concurrent transfer of that liquidity to other major markets in the region*" (IOSCO, 2007 p. 8.).

Hedegaard (2011) empirically investigates the relation between the two liquidity categories by using time-varying margins on futures contracts traded on the Chicago Mercantile Exchange (CME). The results show that higher margins cause lower liquidity.

Jylha (2016) shows that funding liquidity causally affects market liquidity by using an exogenous reduction in margin requirements. In 2005, SEC accepted a new methodology for margin requirements for index options but no changes were implemented for the margins of equitiy options. As an exogenous shock from market conditions affecting only a part of the market the method were handled as a quasi-experiment allowing the identification of the causal link between funding and market liquidity.

Not many theoretical and empirical studies examine the causality relationship between market liquidity and funding liquidity. Both theory and empirical works have been divided by the liquidity direction between the two. Mehrling (2014), Gromb - Vayanos (2002), Brunnermeier - Pedersen (2009) argue that increasing funding liquidity will result in elevated market liquidity because financial institutions provide liquidity of financial assets therefore their liquidity will impact the markets of financial assets. On the other hand, the broad literature of financial flexibility - a concept that emerged recently - consider financial markets' liquidity to determine the liquidity of the banking system and other companies. According to financial flexibility, a liquid financial market would provide liquidity to the banks as they would be able to easily raise funds by selling their assets, therefore they do not need to worry about the liability side of their balance sheets. Recently, the statement about funding liquidity determines market liquidity dominates the empirical works. Nevertheless, these papers are based on the data of the US financial markets. Based on the above, the research question is that: what is the source of liquidity in the CEE region? Transfering the research question into a hypothesis is considered as the hypothesis 1.

Hypothesis 1: Funding liquidity of market makers determines the market liquidity in the CEE region.

An empirical analysis is considered to test the hypothesis. For this empirical work, bid-ask spread and funding liquidity proxy are supposed to be collected for a group of CEE countries. Since Sims (1980), unrestricted estimation in system of equations of vector

autoregression has become common in the economic literature. Therefore, analysing the effects and their significance can support or reject the hypothesis.

2.2.The literature of microstructure analysis

Market microstructure is defined as "*the study of the process and outcomes of exchanging assets under a specific set of rules. While much of economics abstracts from the mechanics of trading, microstructure theory focuses on how specific trading mechanisms affect the price formation process*" (O'Hara, 2000, 1 p.). Krishnamurti defines market microstructure as "*a field of study that is devoted to theoretical, empirical, and experimental research on the economics of security markets. It includes the role of information in the price discovery process, the definition, measurement and control of liquidity, and transaction costs and their implication for efficiency, welfare, and regulation of alternate trading mechanisms and market structures*" (Krishnamurti, 2009, 13 p).

Market microstructure literature focuses on the price setting problem. In the 1960s when the field arose, mainly inventory-based models were built to analyse how the price of a security is affected by market participants' behaviour. In these models, market participants managed their inventories to balance their supply to demand over time.

In the 1980s, a new modelling way appeared on the field which focuses on the learning problem. This modelling approach pays higher attention to the effect of information asymmetry. So how the price will be affected if we can detect a group of traders how they have superior information about the underlying value of an asset. Nowdays, the information-based approach has become more popular for understanding the behaviour of markets i.e. price setting and market liquidity. This is because the empirical analyses of inventory effects have been facing data limitation issues.

Amihud - Mendelson (1980) published their famous paper about the Dealership Market – Market Making with Inventory. Their study describes the behaviour and profit maximizing conditions of price setting monopolistic market makers. The main purpose of the paper is to describe the inventory dependent behaviour of the market makers. The study uses various underlying assumptions for their model which are related to the behaviour of the dealer, the distribution of the trading activity, transaction costs and so on. The dealership market is dominated by a centralized market maker who has monopoly on price setting and quoted the bid and ask price hence the spread. The price setting is conducted as a stochastic mechanism which generates sell and buy orders. A stochastic analogue of supply and demand functions are

used for the traders which is based on classical thoughts thus the market demand and supply is price sensitive. The paper finds that the prices are monotone decreasing functions of the stock at the market maker's inventory while to bid-ask spread set by the market maker must be positive all the time. The paper concludes that market makers have a preferred inventory position which are aimed by the dealer's pricing. It confirmed Bagehot's (1971) results that market makers trade with liquidity motivated traders. In case of linear demand and supply functions, analytical solution proved the explicit behaviour of the spread and the expected trading volume as a function of inventory position. The paper also proves that extra profit over the market return is not possible to achieve by speculating on the market which is in line with the market efficiency hypothesis. The paper confirms Bagehot (1971) findings as the market maker always loses against the informed traders because of inside informations which enable the informed traders to make better estimates about the demand and supply functions. Therefore, market makers always make money on deals traded with liquidity traders.

Kyle (1985) examined the price dynamics in a three-agent model including risk-neutral market maker, informed -inside- trader and uninformed -noise- traders. Informed traders have proper knowledge about the value of a security which will be revealed at a certain date. The aim of informed traders to maximize their profits. Market makers try to infer the real value of the security from the order flow but due to the large proportion of uninformed noise traders, who trade only for liquidity purposes, the market maker can never be fully aware of the real value of the underlying security. In the model, price reacts linearly to order flow. The model confirms that the more the inside trader the larger the price impact and furthermore larger the bid-ask spread will be.

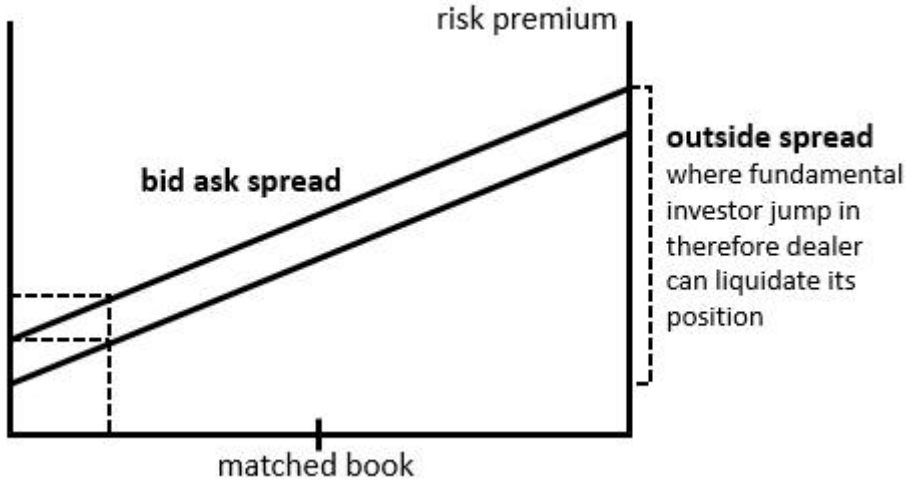
Glosten - Milgrom (1985) mainly analyses how information and inside trading affect the price and the spread and how large the inside profits are. "*The approach taken is based on the idea that a bid-ask spread can be a purely informational phenomenon, occurring even when all the specialist's fixed and variable transactions costs (including his time, inventory costs, etc.) are zero and when competition forces the specialist's profit to zero. The core idea is that the specialist faces an adverse selection problem, since a customer agreeing to trade at the specialist' ask or bid price may be trading because he knows something that the specialist does not*" (Glosten - Milgrom, 1985, 71-72 p.). Their model is based on the concept of informed and uninformed traders and by that dealt with the information asymmetry between the market participants. The third actor in the model is the risk-neutral competitive market maker who has no transactions costs and its expected profit for each trade is zero while the market maker is also assumed to have unlimited inventories of cash and securities and there is no carry cost

neither for the infinit money nor the seucirites. In the Glosten - Milgrom Model, the market maker sets the bid and ask price and a trader is randomly chosen each time an order of unit is submitted. If the chosen one is an informed trader then it is willing to buy if it can purchase the security at a price better than its real value and opposite for selling. If the randomly chosen trader is an uninformed one, the options are buy or sell in a random manner. Two important consequences are regarded as the result of the model. One is the learning process of the market makers as the market maker does not know which type of trader the order is from so the dealer continuously adjusts its belief about the value of the security and the insider information is dessiminated into the market prices by time. Another justification is that asymmetric information induces the spread. An interesting feature of Glosten - Milgrom (1985) model is that the market can shut down, whenever the informed traders' proportion is too high. It is because the elasticity of liquidity traders' demand and supply is not flexible enough and market maker sets too wide bid and ask spread thus no trade is managed on those conditions.

O'Hara - Oldfield (1986) analysed how the bid-ask spread is set on a dealer driven market by a risk-averse market maker. The paper states the market maker faces with uncertainty problems related to the future order flow and the future value of the underlying security. O'Hara - Oldfield (1986) builds the model on factors like limit orders, nontrading periods and auction characteristics. The authors applied an explicit multiperiod framework for analysing the price setting. The study points out that bid-ask spread affected by three components: a portion of the known limit orders, a risk-neutral adjustment for expected market orders, and a risk adjustment for market order and inventory value uncertainty. It is demonstrated that inventory has a pervasive role in affecting both the placement and size of the spread. It also demonstrates that risk averse market maker may set tightener spread than it is set by a risk neutral market maker therefore risk tolerance is assumed to play an important role in spread placement and size.

Treynor (1987) explains the asset prices by constant bid-ask spread based on their own liquidity and other risk exposures. According to Treynor, the larger the long market risk exposure of the market maker the higher the price will be; while the larger the short market risk exposure of market maker the lower the price will be, it is shown in Figure 8.

8. Figure: Behaviour of market makers



Source: Treynor, 1987

Treynor (1987) introduced the term of value-based investors. They are able to fulfil the dealer function, but at a significantly larger bid-ask spread than the market maker. Compared to the value-based investor, the dealer has limited ability and willingness to absorb risk therefore the market makers suffer constraints based on the position-long or short-he is willing to take. The value-based investors in fact determine the price which in turn drives the dealer's price. Treynor's revolutionary idea was very simple but useful as it was built to security market but it could be adapted to money market as well. His model describes the behavior of markets in which the participants face price risk.

Wang (2014) used a simulation method to analyse the bid-ask spread. Wang (2014) used an extended Glosten - Milgrom Model (1985) under a Bayesian Markov Chain Monte Carlo model based on high frequency trade data. The basic assumptions are equal with Glostem - Milgrom Model's assumptions, i.e. the market maker sets the bid and ask price in every period, while there are two types of traders: uninformed and informed. The true underlying value of the stock at time t is assumed to follow a random walk. At a given moment which is a discrete time period in the model, a single trader is randomly selected and allowed to place either a buy or a sell order for one unit of the security. The market maker sequentially updates its belief about the real value of the financial asset and thus set new bid and ask prices. The information asymmetry causes adverse selection problem which result in wider bid-ask spread, therefore the spread is a compensation for the market maker to having information deficit relative to the informed traders.

The above introduced microstructure models played an essential role to help us understanding the price and spread setting mechanisms. The majority of the literature assume a

risk neutral, uninformed market maker which is a kind of exogenous, fixed point of the system. Therefore, bid-ask spread is usually described and considered as a market feature affected only by exogenous factors like the proportion of informed traders, transaction costs and selling/buying probabilities by liquidity traders. However, in the real world, market makers are profit oriented vehicles who face with risks and uncertainty thus their decisions and continuously changing behavior matters for market liquidity point of view.

Hypothesis 2: Bid-ask spread is not just determined by exogenous factors as the behaviour of market maker also have impact on the bid-ask spread.

None of the above introduced leading studies examine the role of monetary policy in market liquidity. Neither direct nor indirect effect have been studied. The value of the financial asset may be affected or the probability of trade but the impact is not obvious. That is why one of the research questions of the dissertation is how market liquidity is affected by monetary policy as the current microstructure models do not cope with monetary conditions at all?

Hypothesis 3: Monetary policy plays a more significant role from market liquidity point of view than it is considered by the literature as monetary conditions have direct and indirect effects on market liquidity.

As it was introduced in details in this chapter, the majority of microstructure literature with information asymmetry concludes that increasing information asymmetry results in wider bid-ask spreads. Contrary to the literature, the existing empirical literature finds that bid-ask spread may be reduced when information asymmetry is greater. For details see Cornell - Sirri (1992), Shacher (2012), Collin-Dufresne - Fos (2015) who empirically analysed the relationship of adverse selection and liquidity. The papers surprisingly find that liquidity increases when there is more active informed trading.

Collin-Dufresne - Fos (2012) extended Kyle (1985) model where noise trader volatility can change stochastically over time. However, the volatility of uninformed trading is measurable, price impact is following a stochastic process. According to their findings, the informed traders adjust their strategy and trade less when uninformed trading is less and they trade aggressively when the quantity of noise trades are higher. However, in this dissertation the increased information asymmetry is the consequence of the bid-ask spread and not vice versa.

Hypothesis 4: Information asymmetry is directly affecting the spread however an increase in the information asymmetry between traders may decrease the spread.

For analysing Hypothesis 2-4, a new microeconomic model is set and based on this microeconomic model of market makers an agent-based model is considered to apply to identify

the determinants of bid-ask spread. For studying the determinants of the bid-ask spread and the positioning of prices, a multi-agent model with Monte Carlo simulation was considered as the most appropriate method to investigate. This is because it allows us to analyse a wider variety of scenarios and also let us analyse the impact of different factors. The conducted model captures the complexity of the market so parameters which was previously ignored by the literature and their impact on the bid-ask spread can be analysed i.e. risk sensitivity, risk taking willingness and so on.

2.3.The importance of liquidity – shocks

Systemic shocks affect the real economy mainly through investments and partly through consumption. Investments can be affected by asset prices, liquidity, outlooks and expectations while consumption can be impacted via wealth effect and expectations hence the scope of consumption can be influenced.

Systemic shocks can be impacting either only one element, one institution in the financial system or the whole system simultaneously (Battiston et. al., 2009). Freixas - Rochet (2008) distinguish four possible channels through which shocks can spread in the system. They include changes in investors' expectation, the operation of the payment system, the OTC and the interbank market. Furthermore, the literature uses three common ways how shocks can spread through the whole system. First, shocks can affect the creditworthiness of borrowers (Bernanke - Gertler, 1995). Second, shocks can affect lenders' balance sheets hence make them unwilling to lend, which will result in a lack of capital in real economy (Bernanke - Lown, 1991). Third, '*the development and structure of the financial system determine the degree of interconnection between real and financial sectors in the economy*' (Lo Duca - Peltonen, 2011, p. 10).

Systemic shock can hit either the dealer or the intermediaries. The shock hitting the dealer level causes market liquidity shock for the whole system whereas the failure of an individual bank can cause a confidential shock for the whole system that is depending on the complexity of the intermediary level. Fundamental changes in the intermediary level can cause system-wide funding liquidity shock leading most probably to market liquidity shock, however, the root of the shock is not in the dealer level.

The liquidity of the money and the capital market and therefore the prices of the financial assets are determined on the dealer level, which depends on the size of balance sheet and the risk exposure of the dealer. This price simultaneously defines the desired level of risk exposure

for other agents on different levels. If the broker business is not profitable enough or the outside spread disappears, as it happened at the beginning of the recent crisis, then security market makers stop working, thereby the asset prices lose their informative roles and the system becomes unstable (Mishkin, 1999). Therefore, there is a very strong linkage between liquidity and asset prices which has a rich literature. The basic explanation between liquidity and asset prices is provided by monetarists who say that liquidity affects the quantity hence the marginal utility of money relative to other assets (Friedman, 1988). Meltzer (1995) says that the large liquidity share held by institutions shows the uncertain trend of future asset prices and it can indicate increasing demand for financial assets in the future. Congdon (2005) argues that asset prices are determined by portfolio choices of non-bank financial institutions as they tend to rebalance their liquidity/asset ratio.

We can divide the interest rate into at least two components, one of them is the market rate or risk-free interest rate the other one is an addition representing a specialized rate including liquidity and credit perspective and expectations for the company, country or any other counterparty.

$$R_i = R_f + R_s \qquad (3)$$

When a shock hits the dealer level and market liquidity suddenly decreases, and therefore the market rate causes the liquidity issue as the asset prices start declining in parallel the interest rate increasing and the volatility is increasing. We can analyse what happens with fundamental and speculative participants. Fundamental investors who mainly make money on maturity transformation will face with increasing funding costs on their short term liabilities.

Before the shock the return of 'i' fundamental investor is R_{i0} whereas the wholesale funding cost of it is C_{i0} where $R_{i0} > C_{i0}$ in order to be able make profit on the transformation. This is also shown by the 'normal' shape of the yield curve. Right after the shock hits the system, the sources are available on a higher rate, thus, the cost of funding will be higher in the first period than it was in the initial point. Hence, $C_{i1} > C_{i0}$ which means the total cost of funding at 'i' institution is $(1-\alpha)C_{i0} + \alpha C_{i1}$, where α is the funds applied in period #1. We assume that there is no change in the asset side between the initial period and the first period after the shock and the assets are fixed rated for long term. That means the profitability decreased and the reachable profit can be below zero. There are three possible outcomes.

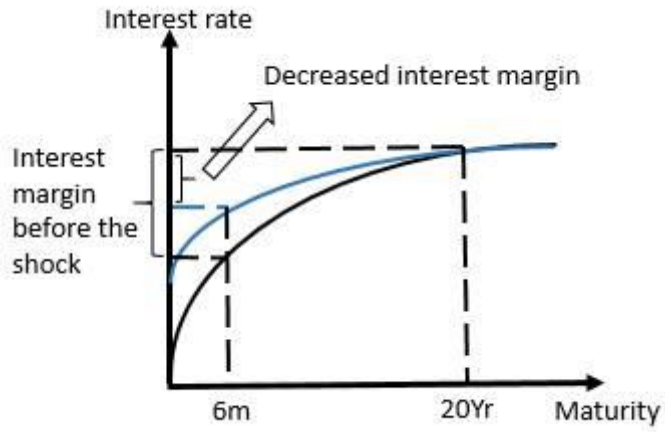
1. Fundamental investors work with reduced profitability or even with operational loss.
2. Fundamental investors increase the interest rate on loans, hence pass the increasing rate to borrowers as the market rate increased significantly.
3. Fundamental investors raise the interest rate on loans hence pass the increasing rate to borrowers as the market rate grew significantly but there is no demand for credit at the higher rate.

In the first and third cases the reduced profitability or even the loss would raise the probability of the default of the 'i' institution, which may additionally increase the funding cost of the institution. In this scenario the lower profitability can change the expectation of deposit holders as well, therefore they start withdrawing their deposits so the bank needs to replace them with the more expensive wholesale sources. Market liquidity shock can have an additional impact on this scenario as well. Diamond - Rajan (2006) emphasizes the importance of liquidity in the willingness of borrowing and Mishkin (1995), too, mentions the balance-sheet effect of market liquidity shocks as the shock affects not just the behaviour of the lender but that of the borrower as well through their demand for liquid and durable assets.

In the second scenario, the increased interest rate on loans would raise the proportion of non-performing loans with almost the same impact on profitability and indeed on further funding opportunities such as in the scenarios above.

In any cases the bank has the opportunity to move on the flattener yield curve and hence increase the maturity mismatch, which means further risk for the institution as shown in Figure 9.

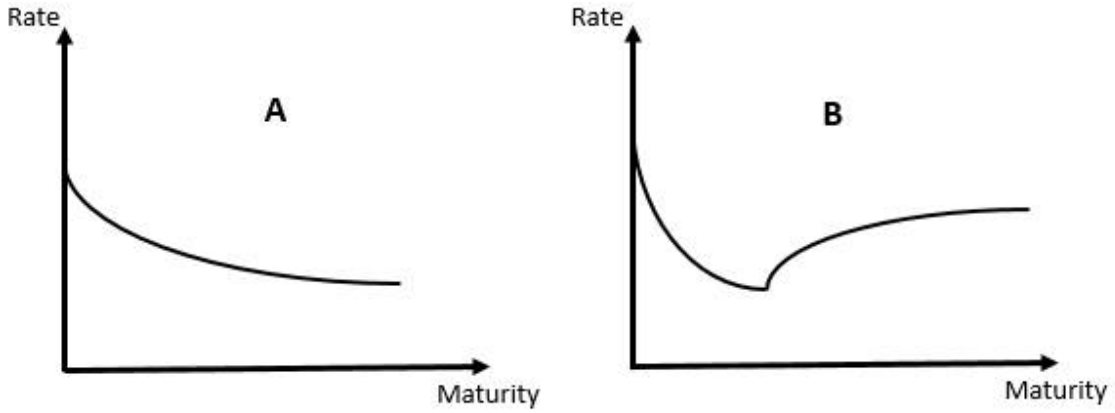
9. Figure: Decreased interest margin due to flattener yield curve



Source: author's own edition

It is important to emphasize that in the case of liquidity shocks the yield curve can be an inverted one even in funding or market liquidity shocks. Inverted yield curve in this term means any type of curves where short rates are higher than long ones. It can look like either A or B in Figure 10.

10. Figure: Two types of inverted yield curve



Source: author's own edition

The A curve in Figure 10 shows the typical reversed curve in the literature, whereas the B curve in Figure 10 shows a special reversed curve, which was recorded in the case of Greece. The relevance of the reversed curve presented in the B curve in Figure 10 is that investors think short term financing can be problematic until a given point or date (e.g. debates with the IMF) but investors assume if the market survives this period there will be a return to normal circumstances. After that point or date usually there is a huge decrease in the curve and after that point until the longest term the curve looks like a normal yield curve. In case of a reversed yield curve institutions have limited ability to widen their maturity mismatch, therefore they have less ability to allocate risks in time through non-performing loans but they have a worse outlook in terms of profitability.

As in this case the root of the shock is in the dealer level, there is no valid asset price, which makes access to sources on repo or wholesale market more difficult, therefore it can cause problems in the payment system. As a bank fails to meet the market requirement due to the lack of liquidity or confidence in the repo market, the deposits can decrease due to the expectations of the deposit holders and the wholesale funding cost can increase due to the increase in the institutional specific component of the interest rate.

The speculative participants in the market are mainly affected in the asset side of their balance sheets. As they are looking for short term profitability, their behaviour can be explained

by yield searching. So whenever the short term rates decrease, they will turn to longer term investments, which will necessarily decrease as a result of an increasing demand, after that they will look for riskier assets with the increase of the probability of default for the speculative agent. However, the asset prices and hence the interest rates are set in the dealer level, the speculative participant can impact them within the outside spread. In this dissertation I argue the asymmetric behaviour of the speculative agents.

According to the basic theory of bond pricing, a bond price is equal to the present value of future cash-flows,

$$P = \frac{C}{1+r} + \frac{C}{(1+r)^2} + \cdots + \frac{C}{(1+r)^n} + \frac{M}{(1+r)^n} = \sum_{n=0}^{N} \frac{C}{(1+r)^n} + \frac{M}{(1+r)^N} \qquad (4)$$

where C means the coupon payment, r the risk-free interest rate, n the number of years and M the payment at settlement if we talk about a fix coupon payment annually.

If a bond is involved that pays coupons and notional at settlement we can get equation 5,

$$P = \frac{M}{(1+r)^n} \qquad (5)$$

,where r means the risk-free interest rate, n the number of years and M the payment at settlement including coupons.

That implies that we get a parabolic figure, where the bond price depends on the interest rate. If the interest rate goes up, the prices will decrease and vice versa. The slope of the linear in any point in the parabolic graph (first derivative) depends on where we put that point. That slope shows the convexity of the bond so how significantly the price changes when the interest rate changes and vice versa. Near zero lower bound, the price can move significantly for only a little increase in the interest rate. This convexity is very often used in fixed income risk management.

As we defined speculative agents as short term profit seekers, they are willing to close their open positions and realize profit any time when the rates are decreasing because they can sell the assets at higher prices and re-invest at higher rates but they will close their positions and re-invest during increasing rates only if the rate is high enough and the rate changes do not significantly affect the bond prices. Otherwise they would realize a huge loss but if they hold the assets until expiry they do not have to count with unrealized losses.

In dealer driven markets liquidity can evaporate if dealers are not able to adjust their inventory or do not want to allow their balance sheet to expand. In these cases, liquidity cannot be restored by lending to financial institutions but central banks can offer wider bid-ask spread than the market would offer under normal conditions – peacetime – thus the central bank puts a liquidity floor to key markets. Overall, central banks can significantly moderate both the probability and impact of liquidity shocks. In spite of the significant relevance and beneficiaries of this role of central banks, the rise of moral hazard, adverse selection and soft budgetary constraints are considered as significant adverse effects of the dealer of last resort. We need a better understanding of how the prices and spreads are positioned on dealer driven markets and how the liquidity is affected by the asset purchasing programs of the central banks in order to increase liquidity and maintain financial stability with less social costs (Bélyácz - Szász, 2014; Mehrling, 2012).

Funding liquidity shocks have a similar impact on market participants but since the root of the shock is not in the dealer level, there is no main effect on asset prices, so repo markets hence payment systems are not involved. As a consequence of this a market liquidity shock can also cause funding liquidity issues but a funding liquidity shock does not lead to market liquidity issues.

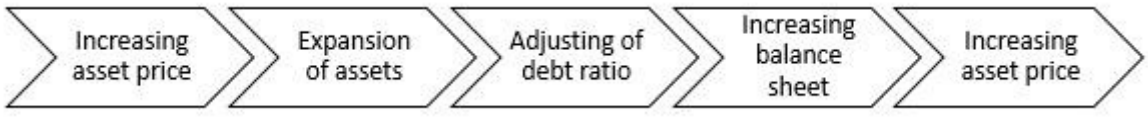
2.4.The cyclicality of risk

Systemic risk can be cyclical, which is enhanced by security lending and repo agreements, they are very common deals within banks. These are very important elements of the security dealer level because these types of deals can allow the dealer to make market without holding a large balance sheet. However, the increased leverage depends on the market price of the collateral, which can have systematically important elements. In this case, firms can raise their debt ratio relying at the price of the underlying security and that is why the market and funding liquidity can be connected to asset prices. The cyclicality impact depends on (i) how many securities are available and on what price, (ii) how volatile the asset price is and what (iii) the applied haircut is on the security. Change in the security price does have an impact on the value of the collateral; therefore it has an impact on the liquidity of money market, hence establishing the connection between asset prices and money market liquidity. The proportion of the applied haircut also contributes to the cyclicality as its magnitude has to represent the potential change in the market price of the collateral in the case of the default of the counterparty. However, this proportion depends on the asset volatility and market liquidity,

which are also cyclical. In the case of collaterals' valuation, the shortfall of Value-at-Risk models can be expensive. As a consequence, changes in the asset prices affect the debt ratio and the maintenance of positions' funding as they have an impact on market liquidity and also on asset prices and volatility due to reinvestment, which also affects the size of the applied haircut. In addition, the abundance of liquidity also encourages the participants to borrow/lend using less liquid collaterals (FSB, 2012).

The interest rate and asset prices are set on the dealer level, which has immediate effect on the participant's balance sheets. The interest rate has an impact on profitability, which means an improvement in the bank balance sheet over time. The improving balance sheet can raise confidence in institutions, so their future outlooks can improve and hence their cost of funding can decrease. Furthermore, it also has an impact on the risk allocation over time as a result of changes in banks' behaviour. Due to decreasing profitability and cheap loans, banks are more willing to turn their views to worse creditors implying a risk allocation over time. As simple as that, a low interest rate convinces decision makers to take on more risky assets and reach more risky creditors. Once the rates start increasing, these assets and loans can significantly lift the ratio of non-performing loans, therefore reduce profitability and future outlook. Increasing prices of risky assets, which are alternatives for low yield bonds like stocks, will moderate the debt ratio of firms, so a slight increase in stock prices can reduce corporate leverage, which makes the securities of the company more desirable for holding. As previously assumed, banks aim at achieving a constant debt ratio which is also affected by the asset prices even if they have been determined on the dealer level. If asset prices go up, the debt ratio decreases as the same amount of debt is covered by excessed amount of assets. As a reaction from the bank, it starts purchasing assets from debt, so pushing the demand of the security; hence the price goes up again and resulting a cyclical period. Of course, the same can be experienced to the other direction when asset prices go down.

11. Figure: Asset prices and debt cyclicality



Source: The author's own edition

From the perspective of household, due to expectations about future asset prices and interest rate households can change their investment split between intermediary participants.

Wealth effect also can constitute an important element here because various types of loans can help to emphasize the slope of consumption as households can delay their consumption or can do it before the planned date.

The increased integration of financial markets, the intensifying capital flows and the wide spread of derivatives led to increasingly strong connection between real and financial cycles. Monetary policy decisions can affect asset prices through the risk appetite of the dealer level, which can cause real and financial cyclicality. As a result of expectations and so monetary actions the financial system can be overheated or underperformed, which have really similar impact to the positivity and negativity of output gap. The adjustment of the overheated economy can be resulting reduction in inflation and output throughout above discussed liquidity crisis. According to Lucas aggregate supply function, the economy can only produce above its potential level if the actual inflation is higher than it was previously expected. However we could experience '*the overheating in the economy, does not necessarily entail a rise in inflation … stable, low inflation rates are favourable for the build up positions which result in instability*' (Csermely - Szalai, 2010, page 7). Borio - Lowe (2002, 2004) also show that stable macroeconomic conditions, i.e. stable and low inflation periods were followed by widespread financial distress. Basically, overheated economy usually entails inflationary pressure hence the inflation forecast can be a guide for decision makers but asset prices and financial imbalances can get the pressure instead of the inflation. In the absence of additional inflation the central bank rate can be lower than the neutral one would be, which can mean a significant credit increase in non-sustainable projects resulting in unused capacities later. Excessive investments, which are not maintainable, are a common feature of an overheated economy. Consumption can also mount significantly, which can also result overcapacities and this can trigger a pro-cyclical financial adjustment during a correction period. Government's budgetary revenues can also be higher than they are usually in normal times. Cycles in financial system have an impact on the value of portfolios, profitability and willingness of lending, so monetary actions can allocate risk over time as well (Csermely - Szalai, 2010).

Therefore, two dimensions of systemic risk can be distinguished, which are the time dimension and cross-sectional dimension. Both dimensions are analysed individually, however, as it was described above, they are very much related to each other. Horváth - Wagner (2013) explains that the counter cyclical macroprudential regulation can raise systemic risk in the cross section. However, macroprudential tools, which aim to reduce systemic risk in the cross section dimension will make lower counter cyclicality at the same time.

Due to the high integrity of money and capital markets, the presence of yield search speculative actors, the increasing importance of capital markets in credit market, and global funding market the real interest rates are converging to each other. Therefore, the monetary policy actions are highly dependent not just on domestic but on foreign effects i.e. capital inflow/outflow and hence decreasing/increasing interest rate, increasing/decreasing asset prices and currency appreciation/depreciation can be caused by monetary policy decision of other countries.

2.5. Chapter summary

Liquidity has been in focus of theory and practice but in spite of this, there is still no consensus about the definition. The concept of liquidity is really broad and complex therefore in this dissertation only on a particular type of liquidity is focused which is market liquidity. Market liquidity may be defined as the easiness with which market participants can buy or sell an asset in a market without affecting its price (Elliot, 2015). Market liquidity has multidimensional characteristics hence we cannot describe this market feature with a single statistic. It has dimensions of tightness, immediacy, depth, breadth and resiliency (Harris, 1990).

According to Sarr - Lybek (2002), liquidity measures can be classified into four groups which are strongly related to the characteristics listed above. The classifications of liquidity measures are (i) transaction cost measures, (ii) volume-based measures, (iii) equilibrium price-based measures, (iv) market impact measures.

In the dissertation, market liquidity is proxied with bid-ask spread. The bid-ask spread is classified as a transaction cost measure. Dealers quote bid and ask prices in order to provide liquidity. The market makers act as intermediaries as they buy from private security owners who want to sell while also selling to private actors who want to purchase securities. The price that market makers set for the private buyers are called ask or offer price while the price set for private sellers is called bid price. The bid-ask spread can reflect asymmetric information costs, order processing costs and inventory-related costs (Sarr - Lybek, 2002; Sommer - Pasquali, 2016; Treynor, 1987).

The chapter summarises the literature related to liquidty sources. Not many theoretical and empirical studies examine the causality relationship between market liquidity and funding liquidity. Both theory and empirical works have been divided by the liquidity direction between the two. Mehrling (2014), Gromb - Vayanos (2002), Brunnermeier - Pedersen (2009) argue that

increasing funding liquidity will result in elevated market liquidity because financial institutions provide liquidity of financial assets therefore their liquidity will impact the markets of financial assets. On the other hand, the broad literature of financial flexibility consider financial markets' liquidity to determine the liquidity of the banking system and other companies. According to financial flexibility, a liquid financial market (i.e. a liquid financial asset) would provide liquidity to the banks as they would be able to easily raise funds by selling their assets, therefore they do not need to worry about the liability side of their balance sheets. Recently, the statement about funding liquidity determines market liquidity dominates the empirical works. Nevertheless, these papers are based on the data of the US financial markets. Based on the above, the research question is that: what is the source of liquidity in the CEE region?

The chapter also includes a literature review related to microstructure models which explain the determinants of bid-ask spread. The majority of the literature assume a risk neutral, uninformed market maker which is a kind of exogenous, fixed point of the system. Therefore, bid-ask spread is usually described and considered as a market feature affected only by exogenous factors. However, in the real world, market makers are profit oriented vehicles who face with risks and uncertainty thus their decisions and continuously changing behavior matters for market liquidity point of view. None of the above introduced leading studies examine the role of monetary policy in market liquidity. Neither direct nor indirect effect have been studied. The majority of microstructure literature with information asymmetry concludes that increasing information asymmetry results in wider bid-ask spreads. Contrary to the literature, the existing empirical literature finds that bid-ask spread may be reduced when information asymmetry is greater. For details see Cornell - Sirri (1992), Shacher (2012), Collin-Dufresne - Fos (2015) who empirically analysed the relationship of adverse selection and liquidity. One of the research questions of the dissertation is How can we explain the contradictionary results of information asymmetry as theoretical and empirical works are against each other on that topic?

3. Financial crisis and the regulation of financial markets

According to a study that was published under the auspices of the International Monetary Fund (IMF) in 2010, since the 1970s there has been 122 systemic banking crashes, 208 monetary crashes and 72 sovereign debt crises (Leavan - Valencia, 2010), while in the eight years that passed since an additional three debt crises could be added to the list with, Greece, Argentina and Turkey facing financial challenges. One of the most intriguing aspect of the IMF study is the starting date against which the number of financial crises in the world were investigated, i.e. the 1970s. The decade exemplifies an initially slow, but with time, accelerating shift in the way academia thought about the role of regulations within the economy and the way finance functioned. The shift brought about profound changes within the international economy, one that today authors often refer to as "financialization".

In this section we are going to discuss the theoretical origins that enabled the fostering of the financial economy over its real counterpart and discuss in some detail how it manifested itself at the level of policy leading up the 2008 financial crisis.

3.1. Crisis of 2007-2009: causes and impacts

Economists faced a major challenge in the face of the global financial crisis after Lehman Brothers collapsed. Numerous theories and studies were born to explain the 2008 crisis. In the papers of Reinhart - Rogoff (2008, 2009), that were published just after the crisis, argued that there was nothing new under the sun, crises come and go; even if at times they surprise even the experts and their effects are significant. According to the authors' the most recent crisis was more significant than before, but in its most important characteristics it did not differ from them. A number of factors, however, do appear to possess novel characteristics, since the crisis was able spread to the rest of the world swiftly and it affected countries irrespective of their former economic policies. Meanwhile, the collapsed industries carried a much larger weight in the global production processes than earlier (Dymski, 2010). Reinhart - Rogoff (2009) identify the irresponsible indebtedness -credit boom- and the asset bubbles as the main conduits of the crisis. According to the article of Herring - Watcher (2003) these two components are common in the case of any banking and financial market crisis. Several other studies also derive the origins the 2008 crisis from these two. These include, Allen - Carletti (2009), Brunnermeier (2009), Király et al. (2008). In addition, a number of researchers have analysed the implications of the crisis for Hungary as well, amongst others Ábel (2015),

Berlinger et al (2011), Bélyácz - Pintér (2011), Kovács - Halmosi (2012), Kiss -Kosztopulosz (2012), Kiss (2017), Váradi (2012b), Voszka (2009). Every study leads to the same conclusion: the roots of the 2008 crisis can be found in the monetary policies that were employed after the 2001 dot-com bubble. The American central bank, the Federal Reserve (FED) and other – primarily Western – central banks created very loose monetary condition, while maintaining a low interest rate environment. Coupled with these, the declared objective of the US's housing policy was to encourage homeownership, which incentivized even those to buy homes or move to bigger ones that would not have been able to do so. Eventually retail prices went sky high, reaching their upper limit in 2006 after which the bubble burst. Due to the downfall of the retail prices from then on, the securitized mortgage loans also began to fall. This swiftly caused issues within the global financial system since the security packages also served as aids in interbank markets and they were also used as repo and hedge against securities. As a result, the conditions quickly altered within the interbank markets, central banks were forced to carry out a significant liquidity injection. In spite of the banking system having been put under severe pressure, the crisis only first made its affects felt within the real economy upon the collapse of Lehman Brothers, which later escalated into a full-blown confidence crisis.

This explanation about the crisis is strongly supported by the emerging field of behavioural finance. Behavioural finance considers the pshychological characteristics of market participants and the role these characteristics play in decision making process. Scholars of the field argue that these aspects have significant impact on markets. This approach emerged because mainstream models failed to explain anomalies in financial markets. Therefore, financial experts and market actors have not been able to refuse that irrational or at least bounded rational behaviour, high risk appetite, irresponsible management, overconfidence are characteristics of market participants. Various papers of Patt, Kahnemann, Kőszegi, Tversky are important for the field.

In the discussion and analysis of the crisis the efficient market hypothesis plays an important role. A great advocate of this thesis was Eugen Fama, who in his 1970 paper, laid down the foundations for what came to be known as the Efficient Market Hypothesis (Fama, 1970). According to followers of the EMH, stock markets cannot be cheated by a single actor within it, as the prices of financial assets already contain all past publicly available information. The hypothesis was praised by policymakers, especially in the USA, leading to a hands down approach when it came to regulating and monitoring the financial markets. Deregulation, self-regulation of the markets, the credit rating agencies as well as the contribution of the mark-to-market to the short terms incentives had important role in the explanation of the crisis.

Most of the studies, when looking for the more structural sources of the crisis consider the global imbalances. Among these are Feldstein (2008), Obstfeld - Rogoff (2009), Borio - Disyatat (2011), Losoncz - Nagy (2012). There are also such studies that attribute little significance to the same global imbalances, such is the Whelan (2010).

The dynamic rise in inequality among the major social layers in individual countries had proved to be an equally intriguing topic for researchers to study in conjunction with the crisis. See for example Wade (2009), Rajan (2010), Stiglitz (2012), Stockhammer (2013). Bordo - Meissner (2012) on the other hand found no significant causal relationship between the two variables.

Rising inequality -in theory - decreases aggregate demand, as the declining middle class finances its consumption from credit, while the richest mostly consume imported good. All this leads to imbalances by causing a deficit within the national current account balances. Moreover, the richest accumulate an ever greater wealth, which is invested in ever more risky assets. In addition, the global imbalances were upheld for much longer than before due to the more sophisticated financial markets of the day.

For analyzing the roots of different arguments, we need to look back to financialization what we discussed in Chapter 1. A very visible outcome of the market fundamentalist policy making that began to take shape in the 1970s came in 2008 with the worst economic crisis of modern history since the Great Depression. Beyond what financialization has led to in terms of wealth and income inequality, the most troubling aspect was always the potential effects of the race to the bottom lending standards of the financial sector. Pre-2008 investments banks were increasingly trading with irregular financial assets, so called derivatives. So much so, that by the second half the 2000s the derivative market was able to outpace the more traditional stock and bond markets by some distance. In 2006 for example, stock and bond markets traded $105K worth of assets, in the same year, the traded volume on derivative markets' reached $405K (Luchetti, 2007). With such staggering numbers the downfall of the American financial markets in 2008 due to the large percentage of nonperforming loans came as little surprise to critiques of the vast financialization of the economy (see e.g. Schiller, 2005). The crisis soon spread to Europe and then to the rest of the world as well, as most countries in the West had a stake in the rather lucrative derivative markets, forcing Western governments to bail out their largest and systemically important banks. In the US alone, the money spent on saving the banks was around $7.4 trillion, according to Bloomberg, however former Goldman Sachs analyst, Nomi Prins puts the number somewhere closer to $14.4 trillion. To put it into perspective, the inflation adjusted cost to the US of WWII was $3.6 trillion dollars (Prins, 2011; Ritholtz, 2011).

'*Too-big-to-fail*' institutions were well aware of their importance and took excessive risk and created moral hazard before the crisis. Investors expected governments to step in and prevent large banks from defaulting on their debts and started charging less for lending to large banks than they would have lent, without the expectation of government support (Chennels - Wingfield, 2015). The lower price of funding consequently motivated managers to take more risk than was ideal for society as a whole.

To ensure that the firm itself, not the public, bears the cost of firm failure, a new measure, known as bail-in, was introduced. The aim of bail-in is to preserve a firm's financial stability and ability to perform critical economic function while protecting public money. The main idea behind bail-in is to write down claims of shareholders and unsecured creditors and convert them into equity and recapitalise the firm in cases when the firm's losses exceed the existing equity. This is done in a manner which respects the hierarchy of claims prescribed in insolvency law (Chennels - Wingfield, 2015). Consent of shareholders, creditors or the management would not be required, nor would a court approval be needed.

The new measure has been understandably criticised for ignoring the property rights of the shareholders and creditors. However, the regulation clearly states that no creditor will be worse off than would be the case had the firm been put into insolvency. Otherwise, compensation would be in place for the parties affected.

One of the financialization's consequences is the emergence of shadow banking which radically diminished the role of commercial banks. The term of shadow banking was created by McCulley (2007) and it referred to private credit intermediation, mainly non-bank credit intermediation (or NBCI) which complete markets when other financing is not available or less efficient. Recently, the characteristics of shadow banking have been focused which are (i) no direct public backstops; (ii) money market funding of capital market borrowing; (iii) market pricing of both capital market assets and market liabilities (Pozsar, 2011; Mehrling et al. 2013).

3.2.Regulation, Deregulation and The Theories Behind Them

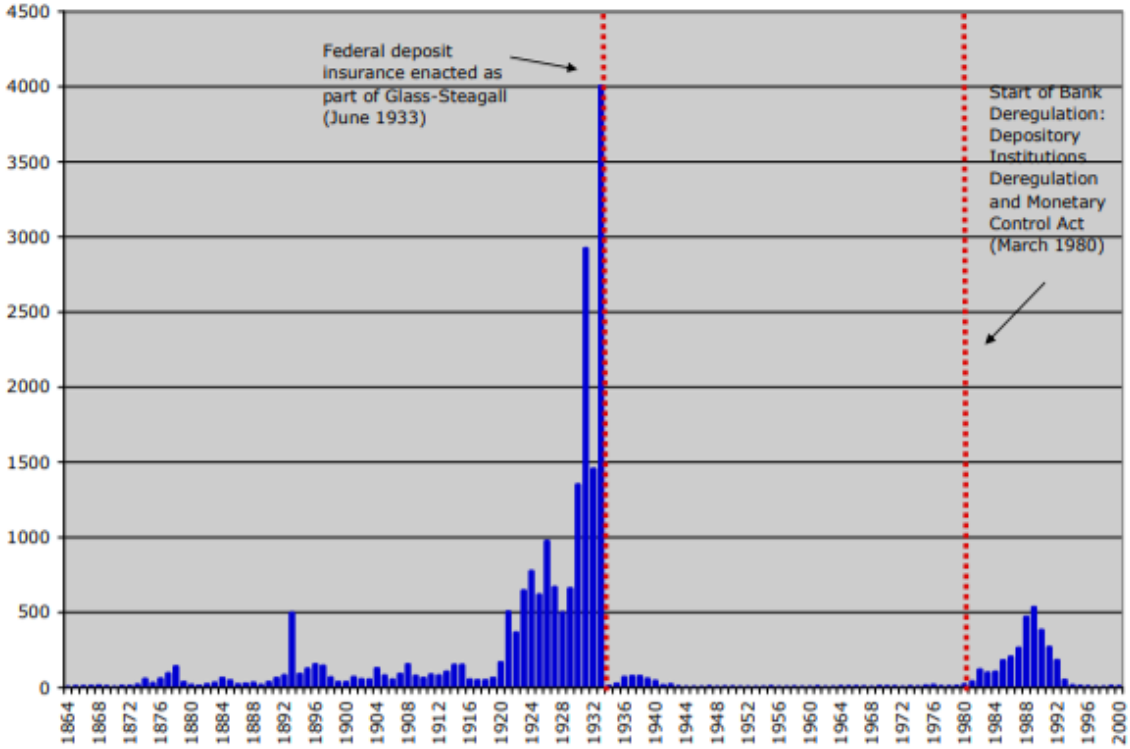
When John Maynard Keynes famously said that the "*ideas of economists and political philosophers, both when they are right and when they are wrong, are more powerful than is commonly understood. Indeed, the world is ruled by little else*" (Keynes, 1964, p.383), he exemplified perfectly how a gradual transformation started in the 1970s within the thinking of economists on the role of government, led to an even greater one within the world economy, leading to a phenomenon that is commonly referred to today as financialization. However, in

order to gain a proper grasp on the shift that took place, first we need to discuss the academic thinking on the relationship of regulation, finance and the economy that preceded the 1970s.

Going back all to way to Adam Smith and his well-known theories on the functioning of state, society and the markets, which he penned down in *The Wealth of Nations* economic theory did not particularly deal with the financial economy for the greater part of the 18th and 19th centuries. There were several works published on how the government played an important role in enhancing social welfare within a capitalist economy, starting with Henry Sidgwick's *Principles of Political Economy* in 1887 where he argued – unlike Smith – that the needs of the individual can diverge from the utility of the society (Sidgwick, 1887). Decades later, already in the 20th century, Pigou (1912; 1932) was the first to argue in several of his works in favor of raising taxes in order to rebalance the negative externalities that the market created. The bases for state involvement within the economy, thus were present in the academic thinking, even the necessity of regulation, however it was only the Great Depression of the 1930s when the financial sector gained the attention of thinkers and regulators alike.

A plenty of new financial regulations were introduced within the framework of the New Deal in the United States -the source of the financial crisis of 1929-, which included the Banking Acts of 1933, the Securities and Exchange Act of 1934, and the Investment Company Act of 1940. Amongst the many regulatory acts of the time, one of the main objectives was the separation or risky speculative finance from traditional forms of banking. A wall was raised between capital markets and depositary institutions in order to separate money markets from the activities of capital markets. Only investment banks were allowed to trade with corporate shares and bonds, deposit banks could not hold or deal with speculative assets. The most prominent piece of legislation ensuring all this was the Glass - Steagall Act that ensured the separation of commercial and investment banking. As the Figure 12 below highlights the American economy and due to the Bretton Woods system in place, the rest of the world as well, enjoyed a relative calm from the perspective of financial crisis in the post- Great Depression era all the way to the 1980's.

12. Figure: Number of bank failures



Source: Moss (2009)

However, academia soon began to question the needs for state involvement in the economy and the need for regulation. The first writing questioning the need for control over the markets appeared in already in 1960, when Ronald Coase argued that externalities can be eliminated through trade in case there were no transaction costs (Coase,1960). Known as the "*Coase Theorem*", it was popularized and further developed a decade later by George Stigler (1971) in his paper, "*A Theory of Economic Regulation*", where he argued that state involvement in the markets would lead to "regulatory capture" due to rent-seeking of the parties involved. His paper would eventually become the economic theory on regulation, defining for a generation to come its possible shortcomings, without offering much benefits on the other hand. Meanwhile Milton Friedman published his work, *Capitalism and Freedom* in 1962, where he famously argued that the best course of action by a government when it comes to markets is no action at all, can only guarantee political freedom and efficient allocation of resources. The emerging narrative among the "*anti-regulation*" authors was that even if markets failed at times, government intervention would only lead to unintended consequences making the problem worse. This shift in the thinking is what Moss (2010) referred to as the new "null-hypothesis", whereby scholars adopted the idea "*that government was perfect and did everything to reject it*". Moss (2010, p.5) argued thus, that "*the prevailing null would*

fundamentally reshape academic research on the role of state, encouraging scholars over the last third of the twentieth century to focus relentlessly on the theory and practice of government dysfunction". The research thus conducted during the 1970s laid down the bases for the famous inaugural speech of President Reagen, where he argued in 1981 that the government was not the solution to the problems, but the problem itself thereby setting the tone for what was to come on the level of policy in the next two-three decades.

Up until the 1980s policy makers' primary concern in the US was to ensure full employment and to maintain a system where wages grew in parallel with productivity. However, in the 1970s a new period of stagflation characterized the Western economies and no amount of state involvement seemed to remedy the situation. While a very important cause of the simultaneous economic stagnation and rising inflation was the artificially limited oil output by the *Organization of the Petroleum Exporting Countries* (OPEC), economists who followed the government failure hypothesis saw found this to be an opportunity to further their agenda and transform US economic policy. A new growth model was introduced, where on the one hand, full employment was abandoned as a policy objective due to its perceived inflationary effects, while on the other, the engine of demand based growth was replaced: instead of wages, borrowing and price inflation became the main conduits (Palley, 2009). Corporations were ready to embrace the new paradigm as they were suffering from declining profits, thus the financial markets seemed to be and ideal and untapped set of fresh resources to make up for their faltering income, while they were also happy to see workers' bargaining power decline.

Since both the political and the business spheres were on the same page regarding the necessary policies, soon the dismantlement of regulations of the previous era were set on course. Regulated industries such as transportation, communication and power were deregulated. But from the dissertation's perspective the 1980 Depositary Institution Deregulation and the Monetary Control Act that were more significant, as they paved the way for the 1999 repeal of the most important provision of the regulations from the previous decades, the Glass - Steagall Act. In the meantime, as globalization deepened, the largest conglomerates moved abroad in search for markets and finance. American banks were unable to provide them with the credit they desired as the 1963 Interest Equalization Tax barred them from financing oversees operations in order to stop the movement of the US dollar. The American banks resolved this problem by opening foreign branches, allowing them to meet the borrowing needs of the corporations there. Of course, with the spread of the most significant players of the American economy, soon first all the major Western economies incorporated the ideals American corporations embraced so readily at home and later emerging economies joined – often through

the coercion of the IMF and World Bank (Karwowski - Stockhammer, 2017). Financial markets, thus began their journey on more than three decades long road, called deregulation, everywhere in the world. In the process, strong interlinks were created between the many countries and their business spheres involved, paving the way for potential domino effect in case of a major crisis. The first major banking crisis – after the great recession – was the mutual saving bank crisis in the beginning of 1980s as you can see an increased number of bankruptcy in Figure 12. At the end of the 1970s, rising interest rate, enlarged competition and restrictions on portfolio diversification lead to increasing losses at the beginning of 1980s. The huge losses resulted a significant depletion of capital which caused insolvency in a large number of saving banks (Brumbaugh - Carron, 1987).

The major impetus for financial deregulation was not only provided from the prevailing macroeconomic theory at the time, but by financial economists specifically. Scholars dealing with finance came up with theories and clever mathematical models that under given assumptions "proved" that financial markets would always correct themselves and produce efficient outcomes. These papers were based on the assumption of EMH. Meanwhile financial practitioners were coming up with more and more advanced forms of financial assets, bundling in underperforming securities and selling them as if they were risk-free both in the US and abroad. Perhaps Tymoigne explained the best the outcome of all these when he argued that "*Risk management techniques encouraged unsound financial schemes involving massive leverage; self-regulation led to loose, hazardous and even fraudulent business practices; and market discipline meant an emphasis on short-term profitability and a "race to the bottom" in terms of lending standards*" (Tymoigne, 2010, p.2).

Had regulators listened to some of the critics regarding of theorized – though in practice never proved – functioning of the market, and try to contain the financial sector, they would have been too late by the end of the 20th century due to the segment's sheer size. In the US, total assets of security dealers and brokers increased from $45 billion (1.6% of GDP) in 1980 to $262 billion (4.5% of GDP) in 1990 to more than $3 trillion (22% of GDP) in 2007 (Moss, 2010). Moreover, compared to the 70s, the share of the sector from corporate profits doubled in three decades, leading to generate 28% of all corporate profits in 2004 and if we include a more extensive understanding of financial services (finance, real estate, insurance - FIRE) than the number rises to 50% (!) (Leonhardt, 2008). The consequences of this extensive financialization had gone on to drastically alter global wealth distribution as well, with the richest enjoying an ever increasing wealth from capital gains, while the productive part of the economy struggling keep pace with them in terms of GDP growth. The divide between the

richest one percent of the west and the rest of the society has been increasing since the 1970 and several thinkers, like political economists like Thomas Piketty argue that this can have dire political consequences eventually – if not already (Piketty, 2013).

3.3. Microprudential regulation

The aim of prudential regulation is the safety and soundness of banks, for example by ensuring that they have sufficient capital and liquidity resources, to perform the critical services they provide in the economy (Farag, 2013). This chapter will look at the development of microprudential regulation over the recent decades and examine the possible consequences that the new regulations could have on individual institutions.

The aim of microprudential regulation is to reduce the likelihood of failure of individual institutions, regardless of their impact on the economy, and limiting idiosyncratic risk that institutions face.

When talking about financial regulation, mentioning the recent financial crisis of 2007-2009 is unavoidable. It is a mainstream view that the credit crunch of 2007-2009 was a result of insufficient financial regulation, as well as the fact that regulators focused more on micro, as opposed to macro prudential regulation. Therefore, the right solution to regulating the financial sector must involve rethinking regulation as a whole and introducing new different regulation, as well as adding to existing regulation where needed.

Recent development in regulation has been centered around the following measures: increasing capital adequacy requirements on the basis of inherent risk, ensuring that there is an interaction between micro- and macroprudential regulation, detecting institutions that pose systemic risk, creating the right incentives for bank executives to encourage long-term behaviour, introducing counter-cyclical measures which would help institutions in stressed period, and reducing the amount of public money used for the resolution of too-big-to-fail institutions (Ekpu, 2016).

3.3.1. Development in Microprudential regulation – the path towards Basel III

The dissertation aims to asses the Basel regulation's impact in the empirical calculations therefore the guidance of Basel is in the focus of the chapter.

Changes in bank regulation in the 1970s and 1980s came about as a response to three factors: deregulation of interest rates and exchange rates in times when high and variable

inflation generated a demand for new hedging products, made savers seek higher yields, intensifying banking competition; advances in technology began breaking down the frontier between banks and non-banks; the globalisation of banking made domestic banks compete with foreign ones, initiating a global debate on comparing the efficacy of regulatory frameworks (Chami et al, 2003).

As a result of technological advancement, new companies were able to enter the banking market which led to increased competition within the banking sector. The sales experience of these retail firms, as well as their reputation helped them compete for customers of traditional banks. The privileged status and uniqueness of banks slowly began to vanish, and through this process, technology was contributing to the demolition of regulations that once defined and differentiated financial institutions (Chami et al, 2003). This process began increased the incentive for institutions to take imprudent risks and began to complicate the conduct of financial regulation. Moreover, consolidation started to create institutions that were becoming too important and too big to fail, as their failure could possibly endanger the health of the whole financial sector, as well as the economy.

After a German bank called Herstatt collapsed in 1974, the central bank governors of G10 established the Basel Committee on Banking Supervision (BCBS), which despite not having any statutory authority, has become one of the major bodies to set international standards for banking supervision (Acharya, 2013). The debt crisis of the 1980s galvanised the international banking community to look for global best practices and establish official banking standards. One of the major concerns was that without coordination, individual countries would be tempted to relax capital standards and indulge in forbearance for selfish reasons. To address this issue and to minimise risks, the First Basel Accord was formulated and signed in 1988.

Basel I introduced a framework that categorised assets according to their riskiness. Banks' core capital -common stock, retained earnings, capital surplus, capital reserves- was required to be at least 4 percent and total capital to be no less than 8 percent of risk-weighted total assets. However, the accord mostly dealt with credit risk, which lead to banks taking on more market interest rate risk. Several studies have argued that Basel I was partly responsible for the "credit crunch" of the early 1990s in the US and in emerging countries (Bernanke - Lown, 1991).

To address the deficiencies of the Basel I, the committee formalised a new set of rules and proposed a three-pillar approach to regulating banks - a regulatory framework that came to be known as the Second Basel Accord or as it is usually referred Basel II and was formalised in 1999. The first pillar consisted of rules set by official regulators, the second was monitoring

and enforcement of regulations, while the third dealt with the enforcement of good behaviour by financial markets and institutions. Basel II was an improvement because it dealt with more types and sources of risks and introduced more sophisticated models for risk assessment. It also incorporated value-at-risk-based capital charges for trading books (Acharya, 2013). The supervisory role was there to ensure that banks develop and use suitable procedure to assess the risk and calculate the required amount of capital to hold. Biggar - Heimler (2005) highlight the improvements in maintaining a continuous dialogue between banks and their supervisors, as well as improving the flow of information to the public on banks financial conditions. Market discipline was strengthened through implementing a core set of disclosure recommendations for timely information revelation to supervisors and the public.

Despite these improvements, the second accord left enough space for too-big-to-fail institutions to exploit the conflict of interests of rating agencies and to play off external versus internal risk models, while minimising value-at-risk (Acharya, 2013). The recent financial crisis demonstrated how little these accords dealt with systemic risk which was growing within the system and how little did they do to address the fragility of the banking system at the time. The issue of liquidity emerged as well, since many institutions who were meeting the existing capital requirements experienced difficulties during the crisis due to imprudent management of liquidity (BCBS, 2014).

Regulators' response to the above shortcomings was a Third Basel Accord or Basel III which was the first set of Basel regulations to truly recognise the importance of liquidity risk. The new accord treats the definition of capital more strictly and introduces a minimum leverage ratio, as well as higher, counter-cyclical capital ratios. This means that banks have to prepare in advance for situations when they might experience financial hardship and use these funds when the trouble arrives. As a result of the new regulation, banks will be subject to two quantitative metrics - the Liquidity Coverage Ratio (LCR) and Net Stable Funding Ratio (NSFR) (Liebmann - Peek, 2015).

The Liquidity Coverage Ratio, intended to promote the short-term resilience of banks to potential liquidity disruptions, came into effect on 1 January 2015. It ensures banks have sufficient high-quality liquid assets to withstand a 30-day period of financial stress in which various shocks can apply, such as increased market volatility or the run-off of a proportion of retail deposits (BCBS 2013). The LCR numerator consists of a stock of unencumbered, high-quality liquid assets that must be available to cover any net outflow, while the denominator is comprised of cash outflows less cash inflows subject to a cap at 75% of outflows that are expected to occur in a severe stress scenario (Ingves, 2014).

However, only certain high-quality liquid assets are to be included in the liquidity buffer. These need to satisfy fundamental and market-related characteristics, such as being less risky, less volatile, unencumbered, central bank eligible and liquid in markets even during times of financial stress (Liebmann - Peek, 2015). The classification is as follows:

"*Level 1 assets include cash, central bank reserves and certain marketable securities backed by sovereigns and central banks. Level 2 assets are divided into two subgroups: Level 2A assets include certain government securities, corporate debt securities and covered bonds, while Level 2B assets include lower-rated corporate bonds, residential mortgage backed securities and equities that meet certain conditions*" (Bech - Keister, 2013, p 196).

Level 1 assets are the most liquid and carry a 0% haircut. Level 2A assets are somewhat less liquid, but still relatively stable - the BCBS recommends applying a 15% haircut to the current market value of each asset which is held in the liquidity buffer. Level 2B assets are less liquid and more volatile, hence a 25 - 50% haircut is applied to their value (Liebmann - Peek, 2015).

The minimum requirement for the LCR will initially be set at 60% in 2015, and will then rise by 10% each year, until it reaches 100% in 2019. In the EU, the regulatory authorities require banks to be fully compliant one year earlier, that is, by 2018. Most major institutions, however, are already fully complacent with the new regulations and go as far as publicly disclosing their LCRs ahead of the required deadline. Banks are expected to calculate the LCR regularly and inform their supervisors about its value at least monthly. If the ratio falls below the required level, immediate action is required. During periods of stress, financial institutions would be expected to use their pool of liquid assets, thereby temporarily falling below the required level.

The other major metric, the Net Stable Funding Ratio (NSFR), is the ratio of liquid assets maturing in a year and expected outflow past one year. It will require financial institutions to maintain a stable funding profile in relation to the composition of their assets and off-balance sheet activities. The aim of this regulation is to reduce the likelihood that disruptions to a bank's regular sources of funding will diminish its liquidity position, and to avoid the spread of broader systemic stress. The mandatory threshold was set to 100%, which means that a bank has to be able to offset its long-term outflows. However, due to an overcomplicated approach to the ratio's calculation or unfavourable impact study results, the implementation of the NSFR was delayed (BCBS, 2014).

The most regular complaint with regards to the NSFR is that it will kill banks' fundamental role in maturity transformation. However, Liebmann - Peek argue that this is not

going to be the outcome of the new metric. The financial crisis has demonstrated the need to prevent over-reliance on short-term and volatile sources of funding, which the NSFR addresses through encouraging banks to maintain more stable and long-term sources of funding by limiting the extent to which illiquid assets can be funded by volatile short-term borrowing.

In addition to the LCR and the NSFR, the BCBS also developed a set of liquidity risk monitoring tools to measure other dimensions of a bank's liquidity and funding risk profile to ensure global consistency in the supervision of banks' liquidity and funding risk exposures (Liebmann - Peek, 2015). The accord also included a proposal for unified rules for remuneration for risk-taking staff.

Apart from the above development in financial regulation, Penikas (2015) discusses the regulatory wave that came about after the discussions centered around Basel III, which brought about innovations such as the introduction of intraday liquidity management, revision of capital charge with respect to securitizations, adding capital charge for purchased credit protection, revision of approaches to managing credit concentration risk, as well as the revision of information disclosure standards that Basel III addressed.

As with any new regulation, Basel III has its proponents and opponents. Perhaps the biggest shortcoming is that the accord is not macro prudential in nature and that it addresses micro related risk of financial firms instead of the macro prudential, systemic risks (Ingves, 2014). The model has also been criticised for its lack of treatment of government intervention and guarantees which create moral hazard on the financial market. All these proved to be critical topics before and during the financial crisis and it is questionable how efficient can any set of regulations be without properly addressing these concerns.

The following is the big dilemma of any regulation attempting to govern the banking sector. Inadequate resolution of the challenges from the past will create the wrong incentives and could lead to banking fragility. On the other hand, overregulation carries the danger that it might retard the development of national financial systems, hinder the best use of domestic savings, prevent countries from accessing international capital, and ultimately lead to slower growth (Chami et al, 2003). While finding the right balance between regulation, supervision, and reliance on market discipline is the true aim of financial regulation, past experience has never failed to teach regulators a lesson and point to missing pieces in existing banking frameworks. Therefore, new, more thorough standards are likely to be implemented in the future, based on events we have yet to experience.

3.3.2. Beyond Basel

Financial institutions have been in the focus of regulation but financial markets and their underlying infrastructure are also under strict regulation. Clearinghouses are unavoidable elements of the financial system as they act as intermediaries between buyer and seller to make sure the trading process and payment are smooth. Clearinghouses are supposed to be registered at the derivative clearing organisation, for example Commodity Futures Trading Commission (CFTC) in the US. Based on Dodd - Frank regulation, The Financial Stability Oversight Council can designate clearinghouses which are considered to be systemically significant to be registered at the SEC as well. Dodd - Frank also provides risk management standards for these institutions. "*The Principles for Financial Market Infrastructures (PFMI) established in 2012 by the Committee on Payment and Settlement Systems of the Bank for International Settlements (BIS) and the Technical Committee of the International Organizations of Securities Commissions (IOSCO) are the most important international standards for financial market infrastructures such as clearinghouses. These twenty-four principles address legal considerations, governance issues, risk management (including general, credit, liquidity, and operational risks), settlement, central securities depositories and exchange of value settlement systems, default management, access, efficiency, transparency, and related areas"* (Baker, 2016, p. 28.).

The European equivalent of Dodd - Frank act is the European Market Infrastructure Regulation (EMIR) which came into action in 2012. EMIR was constructed to mitigate risk, enhance transparency and increase the stability of infrastructure. EMIR sets reporting requirement for specific financial assets, the margin exchange obligation for uncleared contracts, the rule for clearing obligations and registers and regulates clearinghouses. As a part of the infrastructure stabilization, EMIR ensures that clearinghouses are robust. The regulation specifies that all standardised assets traded on OTC markets should be traded throughout clearinghouses. Every clearinghouse is provided with a harmonised framework for operation within the Union. The transactions which are not requiring the operation of clearinghouses should be handled with strengthened risk management requirements. As a result of EMIR, transparency increased in the market, and the way collateral is calculated has become stricter (Berg, 2016).

3.3.3. The impact of the new regulation

It is important to examine the impact that the new regulations might have on the banking sector. According to the European Banking Authority's (EBA) evaluation, banks will shift towards more deposits, reduce reliance on short-term funding, and have an increased incentive to hold high-quality assets as a reaction to the new, more constraining liquidity standards. In case of banks' business models, retail banks are expected to securitise illiquid assets to generate cash inflows and remove these assets from their balance sheet in order to meet the new requirements (BCBS, 2014).

Investment banks, on the other hand, might come under increasing pressure to hold high quality liquid assets on one side of their balance sheet and to post collateral for possible margin calls on the other side (BCBS, 2014). Thus, maintaining a higher liquidity buffer will possibly put some pressure on banks' earnings which could encourage riskier behaviour. In addition, diversified business model banks will find it easier to comply with the new standards in comparison with specialised banks.

Another question that may arise is whether the lending activity of banks will change in face of the new regulations. According to the EBA impact assessment (BCBS, 2014), banks may have to decrease the amount of loans they make while adjusting to the new requirements. The constraints, however, should not be significant and it is expected that excess demand will be met by other banks.

No significant spillover effect - caused, for example, by a LCR shortfall - is expected at the macro level either. Hesse - Schmitz (2014) conclude that neither the analysis presented in the EBA reports, nor the experience of countries that recently introduced regulation similar to LCR, nor the evidence in the literature provides supporting evidence that the LCR should reduce lending to the real economy of the European Union.

When it comes to bail-in, there is little evidence of how it works in practice, because it is a relatively new measure which has not been used extensively. Discussions around this new method are taking place and practical mechanisms are evolving alongside extensive preparation for its use, thus motivating the market to price in its effects. In spite of not being tested, this new tool has reduced rating agencies' expectations that government intervention would take place to save a "too-big-to-fail" institution (Chennels - Wingfield, 2015).

3.4. Macroprudential regulation

The 2008 financial crisis showed the world that microprudential regulation is not enough by itself to avert financial disasters. As a result, the past decade has seen much research focus on macroprudential regulation to analyze the ways that can be used in conjunction with other policies to safeguard the stability of the financial system. There is still more research to be conducted on macroprudential regulation as some of its aims and possible drawbacks remain disputed by academics, but nonetheless, we can firmly conclude that macroprudential regulation will shape the future, especially the way we think about financial stability.

While microprudential regulation takes risk as exogenous, macroprudential regulation takes it as endogenous. Moreover, microprudential regulation neglects the systemic implications of common behaviour which calls for macroprudential regulation to address this pro-cyclical nature of the financial system and to treat risk as endogenous, so that actions of individual institutions do not have detrimental effects on the system as a whole (Ekpu, 2016).

To protect the financial system as a whole, macroprudential regulation attempts to tackle the market failures that three kinds of negative externalities entail. The sale of an asset by a troubled financial institution reduces the price of similar assets for other institutions, and this entails a credit constraint which means that profitable investments will not be carried out (Kenc, 2016). Essentially, the externality represents the fact that one firm's fire-sales have adverse effects on others' balance sheets (Hanson et al, 2011). The second externality relates to the interconnectedness of the financial system: financially affecting one bank often entails affecting the entire sector, but when people consider taking a risk, they only take into account how it will affect one institution, and not the way it will influence the entire financial system. The final negative externality is that of strategic complementarities, which arise as agents lead to the buildup of vulnerabilities during the boom phase of financial cycles and the magnification of vulnerabilities in downturns. Individual agents act in this way independently of others' actions, but together, this leads to a system-wide accumulation of risk (Kenc, 2016).

These three externalities arise because firms are not able to internalize the costs of the balance sheet shrinkage that occurs when multiple financial institutions are hit with a common shock. Following a decline in lending and the ensuing economic contraction, banks experience a debt overhang, whereby an indebted bank is reluctant to raise new equity even if it would be beneficial for them to do so. Moreover, if a certain bank accumulates debt, that means the collateral value of the assets it has in common with other banks falls too, which means the thin

capital buffers financial institutions are incentivized to operate with lead to too much risk in the financial system as a whole (Hanson et al, 2011).

3.4.1. The History of Macroprudential Regulation and challenges ahead

While macroprudential regulation only came to receive a substantial amount of academic attention in the past decade, its origins stretch back to the second half of the 20th century. The term ‘macroprudential’ was coined in the 1970s, when it denoted the systematic supervision of the macroeconomy, but what we now call macroprudential regulation had been used even before that date (Galati - Moessner, 2012). The Unites States had been facing excessive capital inflows throughout the 20th century, so it implemented policies like interest and lending rate ceilings, as well as reserve and capital requirements with the aim of achieving price stability and smoother economic and financial cycles. These policies proved successful in tightening credit, but at the time macroprudential policy never eased credit adequately. As its effectiveness was perceived to be declining, it was largely abandoned by the end of the 20th century (Kenc, 2016).

The US was not the only country to use macroprudential regulation in the 20th century; indeed, several postwar European countries did so as well. With the primary aims of preventing financial bubbles and controlling inflation, credit control instruments were implemented and liquidity and reserve requirements were imposed (Cornford, 2015). However, policies placing direct limits on credit expansion proved to be controversial, and macroprudential regulation was largely abandoned in the 1970s. The one exception to this was Germany, where speculative capital inflows were tackled with a variety of capital management policies such as a reserve requirement ratio of 100% on foreign currency denominated deposits (Kenc, 2016). Despite these early examples of macroprudential regulation, it was only in the 1980s that public references to the policy began to emerge, though scholarship on the topic was still in its infancy (Galati - Moessner, 2012).

The use of macroprudential regulation soon became a global phenomenon. In the wake of the 1990s financial crisis that damaged the economies of many East and Southeast Asian nations, countries such as Hong Kong began to adopt various forms of macroprudential regulation (Schoenmaker - Wierts, 2016). Indeed, many emerging market economies began adopting the policy towards the end of the 20th century, in large part to limit system-wide currency mismatches and to tackle the domestic financial consequences of capital inflows.

Policies such as the imposition of limits on foreign exchange positions were particularly popular (Galati - Moessner, 2012).

It was, however, the 2008 financial crisis that highlighted the necessity of macroprudential regulation for all countries. Microprudential policies had helped safeguard the interests of individual economic actors, but that was not enough; regulation needed to be implemented to safeguard the financial system as a whole (Hanson et al, 2011).

While the positive effects of macroprudential regulation are undeniable, there are both theoretical and practical issues to consider concerning the policy. From a theoretical perspective, two main objections have been raised in relation to our current understanding of what macroprudential regulation entails. First, although these policies aim to uphold 'financial stability', there is actually no commonly accepted definition of what that is. Studies on the effectiveness of macroprudential regulation either characterize it as some sort of 'systemic risk', or they focus on assessing the importance of individual financial institutions (Galati - Moessner, 2012). Given that there is this divergence in basic definitions, research into macroprudential policies becomes challenging. Secondly, the cross-border spillover effects of regulation are not adequately accounted for in research on their effect on the economy; indeed, in an interconnected world, it certainly seems likely that the implementation of macroprudential policy in a certain country would have an effect on the economy of another (Kenc, 2016).

Even if these theoretical issues were resolved, there are some practical difficulties that can arise when macroprudential regulation is implemented. Firstly, these kinds of policies can entail lower levels of credit and credit growth for banks on the long run. This would then spill over to affect ordinary people as well, making them face higher costs for their loans (Budnik - Kleibl, 2018). This seems to suggest that while the issue of risks in the financial system might be resolved with macroprudential policy, this can come at the cost of a number of disadvantages for financial institutions and their clients. Still, there is no academic consensus on these effects, as other researchers have found that following an initial shock during a transition period, macroprudential regulation will only have a small long run impact on the cost of loans (Hanson et al, 2011).

Given that macroprudential regulation only recently rose to prominence, there is still much research being carried out on the field and three key issues are particularly frequently discussed by academics. Firstly, there is disagreement on the relationship macroprudential regulation does, or should, have with monetary policy, with some economists arguing that they work better if operated separately, while others like Borio argue that these two policies should work in tandem (Schoenmaker - Wierts, 2016). Equally, more research is needed to quantify

the spillover effects of monetary policy on financial stability, and the spillover effects of macroprudential policy on output and price levels (Kenc, 2016). Secondly, there needs to be more research to determine who or what entity should be in charge of implementing macroprudential policy. All around the world, countries have found a variety of solutions to this question, ranging from a separate institution set up for this very purpose to handling all responsibility for regulation to central banks, so more research is needed to determine which of these solutions is best for the economy. Finally, there might be a difference between the types of macroprudential regulation that countries should implement based on their level of economic development (Galati - Moessner, 2012). Swings in commodity prices and capital flows matter especially for emerging market economies, and others see a greater role for these countries to use macroprudential policy to limit system-wide currency mismatches (Cornford, 2015). All three of these points indicate that further research needs to be carried out into various aspects of macroprudential policy in the future.

3.4.2. Macroprudential Solutions

By and large, there is a consensus that macroprudential regulation can tackle the issue of systemic risk in the financial system by internalizing the negative externalities that are created (Gauthier et al, 2010). Broadly speaking, it does so by imposing time-varying capital requirements such that those requirements are countercyclical (Galati - Moessner, 2012). This means that debt financing rises to maximize profits when asset values are high and risk is low (Schoenmaker - Wierts, 2016). Many also emphasize the importance of having higher quality, contingent capital requirements, while others focus on the importance of applying these policies to the shadow banking sector in particular (Hanson et al, 2011). The aim is for these capital requirements to act as a buffer to prevent financial destabilization and losses in the banking sector during an economic downturn (Cornford, 2015). Overall, while numbers can vary among researchers, one paper finds that systemic capital requirements can reduce the risk of a crisis by around 25% (Gauthier et al, 2010).

Macroprudential policy can also be used to tackle specific sources of financial instability. The pecuniary externalities can be best dealt with by implementing countercyclical capital and liquidity requirements.

Interconnectedness as an externality, on the other hand, should be tackled with taxes and resolution procedures for financial issues. Finally, strategic complementarities can be dealt with through the imposition of restrictions on bank asset allocation; the Basel III accords, for

example, encourage banks to internalize the costs of risky lending to prevent them from taking on large risk exposures (Kenc, 2016). The hope is that through the implementation of these policies, macroprudential regulation can be used to prevent crises of the magnitude of the 2008 financial crisis from happening again.

3.5.Conflict between microprudential and macroprudential regulation

Since the rise of macroprudential policy, many studies have investigated its impact on real economy. Aikman et al. (2016), Kim - Mehrota (2017), Monnet (2014) show macroprudential tools have effect on financial cycle and also have real economic effects. These effects are coincident in most of the literature. Macroprudential measures have negative effect on output growth, price level, industrial output and also reduces output volatility but it also reduces the tail risk of output growth by its nature. Bachmann - Rueth (2017) by using a VAR framework could quantify that 10% increase in loan-to-value ratio has the same impact on price level and output than 25 basis point increase in policy rate. Therefore, monetary policy and regulation can replace, complement each other but they can be clashed. The conflict between monetary policy and regulation is still under dispute as the real economic impact is still unclear when the two authorities' aims are contradictiory.

The conflict between microprudential and macroprudential policy has insufficient literature so far. According to Tinbergen (1939) counting rule, there should be at least as many tools for policy interventions as many objectives were set by the policy makers (Hallett, 1989). These policy tools are required to be alterable and they are required to have a clear way to effect at least one policy objectives. Fisher states an even stricter condition: "*the pattern of effects of one tool on all objectives cannot be perfectly reproduced by changing any other tools singly or in combination i.e. the policy tools are each unique in their precise pattern of effects*" (Fisher, 2014, p. 3). However, the author of the dissertation does not particulary agree with the statement as in various market condition can affect the effectiveness of a policy interventions and some tools can certainly be replaceable.

Some other conditions can be mentioned to create a successful set of policy means.

(1) A policy and thus the policy tools should be assigned to meet its primary objective in an effective way.

(2) The objectives must be achievable.

(3) The authorities must communicate and co-ordinate their policy interventions.

The condition (3) shows a potential conflict situation between microprudential regulation and macroprudential regulation and even monetary policy. It is because the distinction of micro- and macroprudential regulation is based on the policy targets however they consider the same measures and instruments (Crockett, 2000). The tools are mainly the same but must target two different purposes and applied by two different authorities. Angelini et al says "*if the tools are broadly the same but must serve two purposes and be used by two different authorities, the potential for conflict arises, just as in the case of the interaction between macroprudential and monetary policies*" (Angelini et al., 2012, p. 19).

Due to counetrcyclical regulation applied by macroprudential regulation, the conflict can be even more serious during a downturn. Macroprudential regulator probably wants financial institutions to get rid of equity buffers and capital to enhance lending and thus economic growth. In the meanwhile, microprudential regulator is not able to let this happen as they want financial institutions to capitalize their operation thus maintain the safety of individual institutions. This is why the countercyclical macroprudential policy was so limited during and after the crisis. This irresolvable situation was addressed by raising the capital requirements in normal times by significant amount therefore a not-effective compromise was made between the two authorities. This solution however is also in line with market expectations because probably in a market downturn market demand for banks' recapitalization would increase (Diamond - Rajan, 2009).

Financial institutions which are too large and therefore posing a system-wide risk, which is known as the too-big-to-fail can cause moral hazard issues. They are too large and important for the financial network for regulatory authorities let them go into bankruptcy. They may be willing to take too much risk or they may be willing to leave risk unhedged. Regulation and moral hazard can alter the financial institutions' behaviour therefore it can also get on the way of monetary policy targets.

The most popular models - Amihud - Mendelson (1980); Kyle (1985); Glosten and Milgrom (1985); O'Hara - Oldfield (1986) - Wang (2014) – do not explain the effects of regulation. However, in counter to monetary policy, we are able to infer the impact of regulation on market liquidity from those models. Regulation can have impact on trading probability, the proportion of liquidity traders and so on. Due to these models assume a passive market maker, we are not able to analyse the direct effects of regulation. In real world, market makers face with risks and uncertainty thus their decisions and continuously changing behavior matters for market liquidity point of view and regulation can have impact on their behavior and thus on their decisions. That is why one of the key research questions is the following. How can we

apply our understanding of market liquidity to compose a more efficient regulation? This leads us to the fifth hypothesis of the dissertation.

Hypothesis 5: The purpose of regulation is to prevent financial institutions from causing extreme fluctuations within the markets, however due to direct and indirect effects on market makers' behaviour it influences the spread as well.

For analysing Hypothesis 5, a new microeconomic model is set and based on this microeconomic model of market makers an agent-based model was applied to identify the determinants of bid-ask spread. For studying the determinants of the bid-ask spread and the positioning of prices, a multi-agent model with Monte Carlo simulation was considered as the most appropriate method to investigate. This is because it allows us to analyse a wider variety of scenarios and also let us analyse the impact of different factors. The conducted model captures the complexity of the market so parameters which was previously ignored by the literature and their impact on the bid – ask spread thus regulation can be considered as a feature with direct impact on market liquidity.

3.6.Chapter Summary

Due to the crisis regulation and its importance have become more common recently. The chapter summarises the history of crises and regulation. The chapter put emphasize on the development of micro-, and macroprudential regulation. The aim of prudential regulation is the safety and soundness of banks, for example by ensuring that they have sufficient capital and liquidity resources, to perform the critical services they provide in the economy (Farag, 2013). While micro prudential regulation concerns itself with the stability and soundness of individual banking institutions, macro prudential regulation deals with the health of the whole financial sector. The conflict between microprudential and macroprudential policy has insufficient literature so far. According to Tinbergen (1939) counting rule, there should be at least as many tools for policy interventions as many objectives were set by the policy makers (Hallett, 1989). The distinction of micro- and macroprudential regulation is based on the policy targets however they consider the same measures and instruments (Crockett, 2000). The tools are mainly the same but must target two different purposes and applied by two different authorities. One of the key research questions is the following. How can we apply our understanding of market liquidity to compose a more efficient regulation? This leads us to the fifth hypothesis of the dissertation**.**

III. Empirical analysis

The following chapters are going to empirically analyse and test the hypothesises based on the theoretical background.

4. Market liquidity and funding liquidity: empirical analysis of liquidity flow using VAR framework

The literature distuingishes various types of liquidity however two of them are in focus in this chapter: funding liquidity and market liquidity. The funding liquidity describes a company/bank's abitlity to add additional financing to its operation quickly on the current market price, while market liquidity entails the pace at which a security can be traded at large volumes without impacting the current price on the market. These liquidity concepts are related to each other.

The dissertation aims to contribute to the ongoing debate regarding the flow of liquidity which can conclude important messages for financial stability point of view.

In order to maintain the financial stability, we need to understand the source of market liquidity. Gaining a better comprehension on the drivers and directions of liquidity is not only necessary when financial markets unwind, but also during times of no turbulance in order to gain a sense of the vulnerabilities of the system. A finer comprehenshion of the liquidity flow's direction would allow policymakers to fine-tune the current regulation regime.

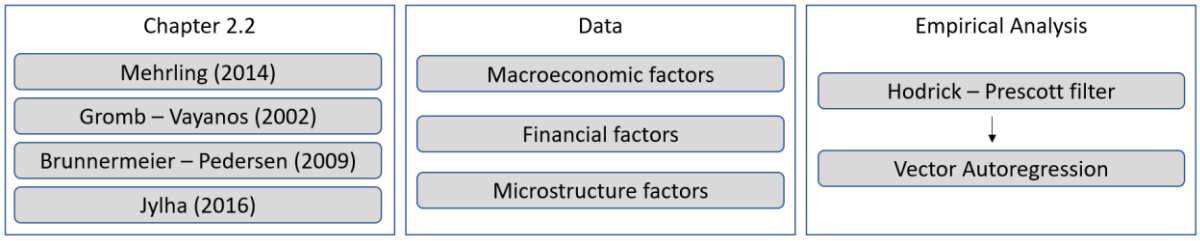
Empirical papers of the field focus on large, developed countries, with special attention given to the USA. In the meantime research on the market liquidity's components on emerging markets and open economies remains scarce. Empirically analysing market liquidity on small, open economies is ineviatble because of the increasing financial integration. Small, open economies are integrated into the global financial system and global financial conditions have a growing impact on domestic economic conditions in those countries. Changes in the global market liquidity can directly lead to a change in market liquidity of domestic financial markets. On the other hand, changes in global market liquidity can lead to changes in the cost of financing thereby resulting in a new conditions in funding liquidity therefore impacting market liquidity. From the results it may be implyed that due to gloabalisation, the largest domestic financial market actors are also global actors. Therefore if they are facing difficulties worldwide that can lead to a change in their way of conducting business locally within the domestic market

environment. Based on the above, the research question is that: what is the source of liquidity in the CEE region? That leads us to design Hypothesis 1.

Hypothesis 1: Funding liquidity of market makers determines the market liquidity in the CEE region.

Recursive vector autoregressive model is utilized to empirically analyse the ways of detecting the causality relation between funding and market liquidity in the cases of four small and open countries in Europe. The analysed countries are the Czech Republic, Hungary, Poland and Slovakia from the Visegrad countries. The background of the study is visualised in Figure 13.

13. Figure: The background of the empirical analyses showed in this chapter



Source: The author's own edition

4.1. Countries

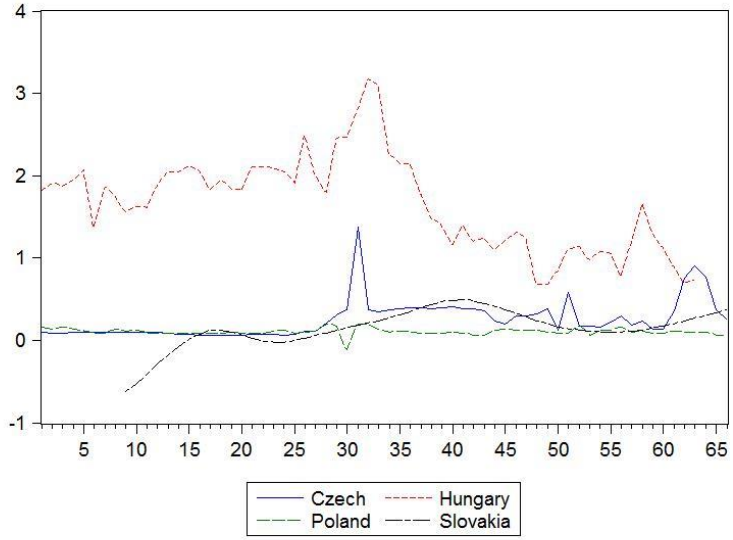
The Visegrad group is the alliance of four countries from Central Europe. These countries are Czechia, Hungary, Poland and Slovakia. The group aims to advance their military, cultural, economic and energy cooperation with each other with strong financial market interdependencies (for the details see Czelleng 2019). All four countries are members of the European Union and NATO. The origin of the group is at the summit meetings of political leaders from Czechslovakia, Hungary and Poland held in the Hungarian town of Visegrád in 1991. This meeting in Visegrad, Hungary, was held in the town to link the meeting to a similar meeting, which took place there in 1335.

Visegrad countries have taken largely the same steps in an attempt to transform their economies in line with the capitalist economies of the West since the fall of the Soviet Union. This, as we argued, resulted in the emergence of a political-economic landscape in each country that made them to share a high degree of structural resemblance. However, there have also been fine differences.

4.2.Data

Measurement of liquidity has been a challenging issue as liquidity has various definitions and various characteristics. Quarterly bid-ask spreads (described in chapter 2) were applied in our model and it is generated as an average of daily bid-ask spread for every country. This is illustrated in Figure 14.

14. Figure: Quarterly bid-ask spread for each country



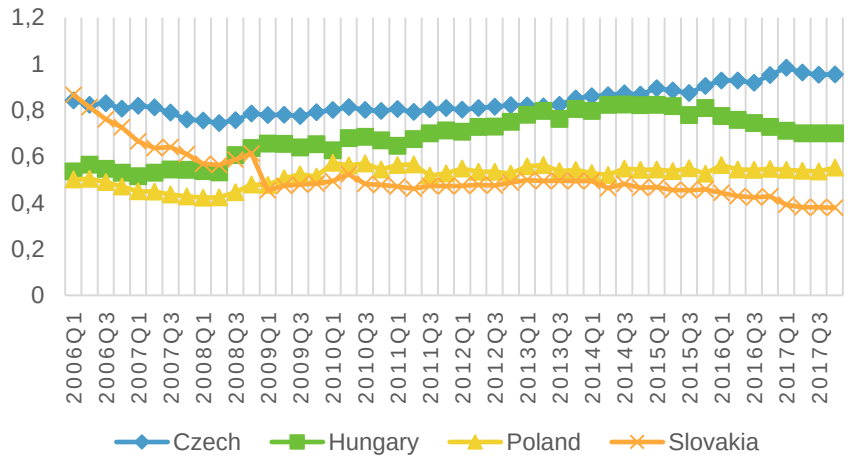
Source: Reuters

Measurement of funding liquidity is difficult. A common way to capture the funding liquidity is to use the TED spread. However, the TED spread would be a sufficient proxy only for the US market. Altough Jylha (2016) argues that TED spread would not even be acceptable for such an analysis. Drehmann - Nikolaou (2013) considers banks' bidding aggressiveness at the European Central Bank's auctions as a good proxy. The funding liquidity proxy applied in this model is built on the earlier work of Brunnermeier et al. (2012) - Bai et al. (2017) in which balance sheet data were used to construct liquidity mismatch index to gauge the mismatch between asset and liability side. Freely accessible data were utilized to gather information about the balance sheets of aggregated banking sectors in every analysed country. As funding liquidity cannot be observed directly, the calculation of proxy variable is illustrated by equation 6.

$$funding\ liquidity\ proxy = \frac{liquid\ assets\ ratio}{deposit\ ratio} = \frac{\left[\frac{(i.e.\ cash, liquid\ securities, deposits\ at\ CBs)}{total\ assets}\right]}{\left[\frac{(i.e. deposits, short-term\ debts)}{total\ liabilites}\right]} \qquad (6)$$

The deposit ratio shows the proportion of deposits and short-term obligations for the banking system. The larger the ratio, the larger the funding liquidity risk as the banking system face larger refinancing risk. This ratio can be seen as a funding liquidity measurement, however, in order to maintain their financial flexibility banks may not fulfill their full credit capacity. They might call for more credit when they need to finance their growth or finance a bank run. That is why a ratio of deposit ratio and liquid assets ratio is applied. The liquid assets in proportion of the deposit ratio can demonstrate the extent to which financial institutions adjusted their asset side flexibility to their funding liquidity risk. The larger the funding liquidity proxy (liquid asset ratio / deposit ratio), the higher the funding liquidty (or less the funding liquidity risk). The variable is very similair to the maturity mismatch calculations, which are commonly used to capture the funding liquidity risk of financial institutions (see de Haand - van den End, 2012; Bai, 2015). As Figure 15 shows at the beginning of the financial crisis in 2007-2008, financial instutitons faced with a drop in funding liquidity then it restored. It is important to mention that, because of the introduction of Basel 3 and thus the Liquidity Coverage Ratio (2015) and Net Stable Funding Ratio (2018), the time series is not entirely homogeneous in terms of the systemic behaviour.

15. Figure: Time series of funding liquidity proxy for the analysed countries



Source: author's calculation based on central banks data

Macro variables were also considered in the models based on the literature. Gross Domestic Product was considered as a main macrodriver for markets as a proxy primary related to macroeconomic performance. Chain link volume indexes where 2005 is 100 for GDP were collected for each country from Eurostat.

Harmonised Consumer Price Index was considered as a proxy for inflation. It measures the change over time in the prices of consumer goods and services which certainly contains

important information regarding price stability therefore macroeconomic conditions regarding the countries. The source of the data was Eurostat as well.

Overnight Index Swaps were also included into the model in order to capture the cost of funding liquidity. OISs are financial instruments that allow financial institutions, intermediaries to swap interest rates and cash flows overnight to manage liquidity positions. The data was collected from the countries' central banks.

The empirical analysis showed in this chapter includes Visegrad countries, therefore Czech Republic, Hungary, Poland. The data is summarised by table 1.

1. Table: The availability of data for countries

	Funding liquidity proxy	***Market liquidity proxy***	***GDP***	***Inflation***	***OIS***
Czech Republic	2002Q1-2018Q1	2002Q1-2018Q1	2002Q1-2018Q1	2002Q1-2018Q1	2002Q1-2018Q1
Germany	2002Q1-2018Q1	2002Q1-2018Q1	2002Q1-2018Q1	2002Q1-2018Q1	2002Q1-2018Q1
Hungary	2006Q4-2018Q1	2002Q1-2018Q1	2002Q1-2018Q1	2002Q1-2018Q1	2002Q1-2018Q1
Poland	2002Q1-2018Q1	2002Q1-2018Q1	2002Q1-2018Q1	2002Q1-2018Q1	2002Q1-2018Q1
Slovakia	2009Q1-2018Q1	2004Q1-2018Q1	2002Q1-2018Q1	2002Q1-2018Q1	2002Q1-2018Q1
US	2002Q1-2018Q1	2004Q1-2018Q1	2002Q1-2018Q1	2002Q1-2018Q1	2002Q1-2018Q1

Source: Eurostat, Bloomberg and central banks

4.3.Methodology

Vector Autoregressive models are applied in order to capture the determinants and direction of liquidity in emerging markets. In the interest of structural impacts and changes, it is more convenient to detrend the data before fitting such models. Perhaps the most popular trend filter is Hodrick - Prescott filter or shortly HP filter based on Hodrick - Prescott (1997). The famous methodology was originially developed to capture the cyclicality and fluctuations of US' real GDP and therefore assume the output gap. The HP trend is extracted from a scalar time series xt using a two-sided symmetric moving average filter. Given a time series x_1, ..., x_T, the trend component τ_1, ... ,τ_T is determined as the solution to the following minimization problem:

$$\min_{\{\tau_t\}_{t=1}^{T}} \sum_{t=1}^{T}(x_t - \tau_t)^2 + \lambda \sum_{t=2}^{T+1}[(\tau_{t+1} - \tau_t) - (\tau_t - \tau_{t-1})]^2 \qquad (7)$$

The objective is to minimize the variance of the cyclical component $c_t \equiv x_t - \tau_t$ subject to a penalty in the second difference of τ_t, which measures the acceleration of the trend line. The parameter λ controls the degree of smoothness of the trend component. In the limit, as $\lambda \rightarrow \infty$, the trend component will coincide with a linear deterministic trend. At the other extreme, for $\lambda = 0$, $x_t = \tau_t$. Hodrick and Prescott recommend $\lambda = 1600$ for quarterly data so this is what was used to detrend the data in the dissertation as well.

Vector Autoregressive (VAR) models were designed to provide an alternative to the large macroeconometric models. In spite of the fact that VAR models do not necessarily satisfy the Lucas' criteria for policy interventions, the methodology has become a widely used and popular technique in applied macroeconomic research. Sims (1980) introduced the methodology first in a since famous paper, where he argued that empirical macroeconomic research should use small-scale models with less assumptions and with fewer constraints. Therefore, one of the method's main advantages is that results are not an output of a black box but a relatively understandable and reliable model structure, hence the outputs can be interpreted with relative ease.

We can distuingish three types of VAR models: reduced, recursive and structural. A recursive VAR models are introduced. In this type of model, the error terms in each regression equation to be uncorrelated with the error in preceding equations. As a result of this, some variables cannot realise the shocks in other variables simultaneously. Contemporaneous values as regressors can be considered to add. Therefore, the result of the equation system will depend on the order of variables. This is called Cholesky decomposition so the variance-covariance matrix defining a diagonal matrix in which the elements on the main diagonal are equal to the standard deviation of the respective shock.

With n number of variables we would be able to build n! number of recursive VAR models resulting in different equations, coefficients and residuals. All countries' models include GDP; inflation, proxy for banking system funding liquidity and government securities bid-ask spread, respectively. Sousa - Zaghini (2004) and Ács (2013) argue that real variables like GDP adjust slowly that is why GDP is the first in the order. Inflation reacts quicker but still not as fast as financial variables, the banking sectors' reaction farily quick, while the financial markets react instantly.

$$\begin{bmatrix} 1 & 0 & 0 & 0 \\ a_{21} & 1 & 0 & 0 \\ a_{31} & a_{32} & 1 & 0 \\ a_{41} & a_{42} & a_{43} & 1 \end{bmatrix} * \begin{bmatrix} u_t^{GDP} \\ u_t^{HICP} \\ u_t^{Funding} \\ u_t^{Market} \end{bmatrix} = \begin{bmatrix} \varepsilon_t^{GDP} \\ \varepsilon_t^{HICP} \\ \varepsilon_t^{Funding} \\ \varepsilon_t^{Market} \end{bmatrix} \quad (8)$$

See Bjornland (2000), Canova (1995) and Uhlig (2005) for the technical details. In an unrestricted VAR we assume that z_t is a (n×1) vector of macroeconomic variables, which can be described as the following:

$$\beta_0 z_t = \gamma + \beta_1 z_{t-1} + \beta_2 z_{t-2} + \cdots + \beta_p z_{t-p} + u_t \quad (9)$$

where γ is a constant, β_i is a (n×n) matrix or coefficients and u_i is a (n×1) vector for the error terms, which has zero expected value and one unit of standard deviation with a covariance matrix Σ. A reduced form of z_t can be described like in equation 10.

$$z_t = \delta + \alpha_1 z_{t-1} + \alpha_2 z_{t-2} + \cdots + \alpha_p z_{t-p} + e_t \quad (10)$$

where $\delta = \beta_0^{-1}\gamma$; $\alpha_1 = \beta_0^{-1}\beta_i$ and $e_t = \beta_0^{-1}u_i$ are white noise processes with nonsingular covariance matrix **Ω**. The covariance matrix for u_t (Σ) is diagonal and β_0 has unity on its main diagonal. **Ω** can be estimated by using OLS method.

$$\Omega = \text{cov}\,(e_t) = cov\,(\beta_0^{-1}u_i) = \beta_0^{-1}\Sigma(\beta_0^{-1})' \quad (11)$$

There are n(n+l)/2 distinct covariances in **Ω** due to symmetry. The assumption that Σ is diagonal and contains n elements, implies that one need n(n-1)/2 further restrictions to identify the system.

Based on the literature we identify four determinants of liquidity. These are (i) macroeconomic factors, (ii) financial factors, (iii) microstructure factors. Therefore, the following system of equations to estimate were applied in the following order:

1) GDP,
2) inflation (HCPI),
3) quarterly average bid-ask spread of the exchange,
4) quarterly average funding proxy variable,
5) cost of funding liquidity (average OIS spread)

4.4.Tests

Augmented Dickey - Fuller (ADF) unit root test was performed to assess the degree of integration of the variables. Applying ADF, we can identify whether the time series is stationary or not, which is a key underlying assumption for vector autoregression methodology. We assume no autocorrelation among the error terms during the test to identify how many lags are supposed to apply. The data in our analysis was assessed to be non-stationary, therefore the appropriate variables were applied in the models.

The model describes the causal relationship between the selected variables that is why vector autoregressive models are highly sensitive to length of lags involved. That means the number of lagged values, which are added to the system of equation needs to be detected by an econometric method. The appropriate number of lags for the estimated VAR model has been decided based on the Akaike information criterion (AIC). The econometric technique was developed by Akaike (1974). The widely used technique for model selection is a biased estimator.

$$AIC = n(\log \sigma^2 + 1) + 2p \qquad (12)$$

where p represents the number of parameters, σ^2 represents the variance of the subsets model. Optimally that model should be considered, where the AIC (described by equation 12) is minimized. AIC is an asymptotically unbiased estimate. It is important to keep in mind that relatively large lag length to the number of observations will likely result in inefficient estimates of parameters or unstable models. While too short lag length will eventuate to misleading results as casuality structure will remain unexplained.

Johansen's cointegration test also was applied to confirm that the series are not cointegrated. The test helps us to ensure that the VAR is stable. In addition, we also use a residual correlation test to determine whether the residuals are correlated.

4.5.Flow of liquidity: empirical results from VAR analysis

The analysed countries are small, open economies therefore we can empirically test how financial integration influence the liquidity of those financial systems.

In the 90s Hungary was deemed as one of the champions of the capitalist transformation by many observers. The country implemented market reforms that went beyond any of its neighbours' pace of transformation. However, soon after joining the EU the country became the sick child of the region. From 2002 onwards, the state began to extend its welfare programs far beyond its means, while also substantially cutting taxes. This combination of policies is what some referred to later as "fiscal alcoholism". This went against the cyclical needs of the country's economy as GDP growth was relatively high during the period that preceded it, reaching 3-4% annually.

Results of Hungarian VAR model is shown in Table 4 in the appendix. In the case of Hungary, a shock in GDP has an effect on the harmonised consumer price index (HCPI). HCPI is a widely used proxy to measure inflation. An increase in inflation for a GDP shock is understandable and expected because higher demand would lead to higher prices. The reverse effect is not clear however as unexpected rise in inflation can have impact on production because firms which already set their contracts for the period – and hence their costs - can realise higher revenue and profit by increasing their production. The bid-ask spread which is used as a proxy for market liquidity also has a significant impact on GDP shocks as market liquidity increases. A shock in inflation results in a significant jump in overnight swap prices just as expected.

From the perspective of the liquidity direction, both ways are significant thus it can be argued that market liquidity has impact on funding liquidity while funding liquidity has an impact on market liquidity, however the latter's influence is clearer and more significant. Therefore, we can clearly detect the inventory effect on market liquidity.

Unexpected results emerged from the impulse functions for OIS shocks. According to the result of the VAR model based on the Hungarian data, a shock in the funding cost leads to rise in inflation and results in better liquidity positions for financial intermediaries while causes worse market liquidity in parallel. This can be a sign for a phenomenon called the "cost channel", when due to the structure of firms' credits, higher interest rates make firms to increase their prices hence create inflation.

Poland followed a starkly different fiscal and monetary path compared to Hungary before the crisis. During the years leading up to 2008 Poland and the Czech Republic had the

lowest rate of credit inflows among the CEE countries. Following the outbreak of the 2008 subprime crisis the country turned to the IMF for a one-year flexible credit line arrangement, that it was dully provided with, due to its healthy public debt position. This allowed for the country to maintain confidence in the eyes of foreign investors and put an end to further depreciation of the exchange rate. Domestic demand grew even in 2009 by 2% and remained positive later as well, which was partly due to the government's counter-cyclical measures, primarily tax cuts. Additionally, with the inflow of EU funds and the necessary investments for the Euro 2012 football championship, Poland ended up being the only country to avert a recession in the whole of the EU after 2008.

Results of Poland VAR model are highlighted in Table 5 of the appendix. Many similarities can be detected in the results. An unexpected boom in economic growth points to higher inflation and thus higher overnight interest rates. However, funding liquidity decreases for economic growth shock. As Poland focused on domestic sources for economic growth we can infer that increasing GDP implies an increase in investment willingness, which does not necessarly provide liquid assets to the banking system. According to the VAR model, the balance sheets of financial intermediaries have significant impact on the market liquidity, while changes in bid-ask spread have no significant impact at all on the liquidity positions of financial corporations. Contrary to the Hungarian results, VAR model for Poland serves outcome in line with the expectations for a funding liquidty shock. This type of event produces higher bid-ask spread thus lower market liquidity and reduced funding position for financial firms.

Slovakia's experience of transition differed somewhat from the aforementioned Eastern European countries. Breaking free and becoming a sovereign nation only in 1992 the country based their initial transformation primarily on domestic rather than international capital. Due to the resulting lack of incoming FDI, the government had to borrow heavily and in less than five years it more than doubled its debt to GDP level from 21% in 1995 to almost 50% by 2000. Due to the increased pressure the government decided to open its borders to foreign capital and in the 2000s a great deal of the incoming capital was utilized for the reduction of the state debt, which allowed its debt to GDP level to return to 28% by 2008 and with other macro indicators of the country showing similarly positive results Slovakia was allowed to introduce the Euro by 2009.

Results of Slovakian VAR model are shown in Table 6 of the appendix. An unexpected shock to GDP, inflation and interest rates thus cost of funding increase while market liquidity hikes as well due to decreasing bid-ask spread. However, funding liquidity has a contradictory reaction as it increases for economic growth shock. The VAR model based on the detrended

Slovakian data, the balance sheets of financial intermediaries have significant impact on market liquidity, while not statistically significant link from the other way. In contrast with the Hungarian results but in line with Poland's, a shock in the overnight interest rates generates higher bid-ask spread thus lower market liquidity and reduced funding position for financial firms.

In hindsight Czech Republic can be considered to have done the best overall of the Visegrad countries based on its macro indicators. The country had the best debt/GDP ratio from the outset already in the 1990s, reaching only 11.6% in 1995 and while going through a steady rise in the decade that followed, it still remained the lowest of the four countries before the crisis in 2008 (a mere 28.4%)

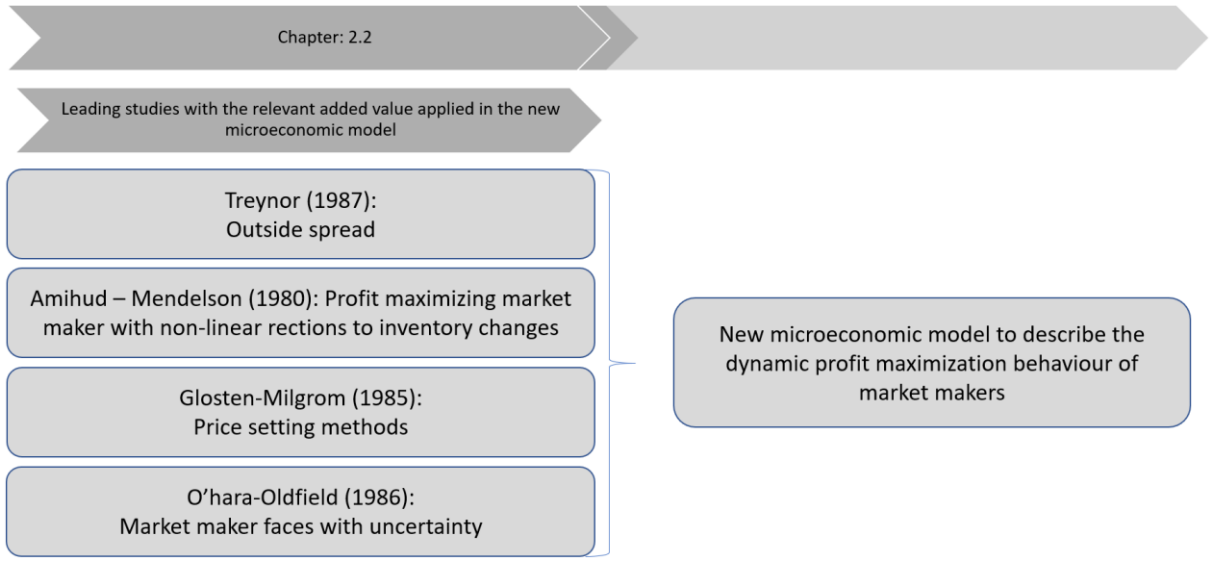
Results of Czech VAR model are highlighted in Table 7 of the appendix. The impulse functions are similar to the previous findings, however inflation has contradictionary results. A shock in GDP results in a decrease of the inflation and an increase in the inflation results in a decreased interest rate. Overall, the direction of liquidity is statistically significant from the financial intermediaries to market liquidity. However, in the case of Czech Republic a shock in the funding cost has significant direct impact on funding liquidity, yet no significant direct link to market liquidity.

Overall, we can state that the model provides empirical evidence that funding liquidity drives market liquidity. The results are clear, significant and robust and supported by the theoretical models of Gromb - Vayanos (2002) and Brunnermeier and Pedersen (2009). Similar evidence was found by Jylha (2016). The results can be seen as evidence for the important role of trader's funding liquidity for the liquidity of financial assets' markets. As a consequence of this hypothesis we can conclude that central banks can indirectly increase the asset's liquidity by boosting the funding of dealers. By reason of the financial integration and globalization, small and open economies are seemed to have not efficient sovereign monetary policy by many economists. Based on the empirical results, however these countries have strict limitations when applying monetary policy but central banks can have impact on financial markets' liquidity. Maintaining the liquidity of financial markets is a key element of the current regulation system. The findings in this model confirm that maintaining or even boosting the liquidity of the dealers can have positive effect on the financial market's liquidity. **As a result of the analysis, significant evidences were found to accept Hypothesis 1.**

5. New theoretical model for liquidity on dealer driven markets

For analysing Hypothesis 2-5, a new microeconomic model is set which can be the base for the agent-based microstructure model. The background of the model introduced in this chapter is visualised in Figure 16. The purpose of the new microstructure is to synthesize the separate advantages of often quoted models within one model and thus analytically describe the behaviour of market makers.

16. Figure: The background of the chapter

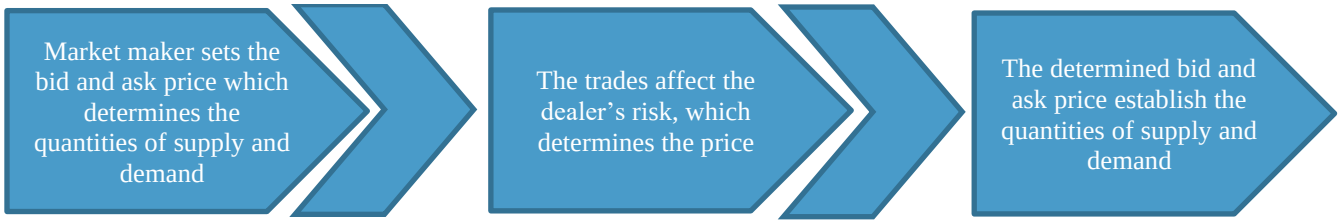


Source: The autor's own edition

The role of market maker is to provide liquidity for the market so market makers act as intermediaries as buying from private security owners who want to sell while also selling to private actors who want to purchase securities. The price that market makers set for the private buyers are called ask or offer price, while the price set for private sellers is called bid price. The market makers make their profit from the difference between ask and bid price therefore they are paid for providing market liquidity. The difference between ask and bid price is a good proxy for market liquidity as a narrow spread can mean liquid market, while a wide spread can sign an illiquid market. Bid and ask can characterize the market any moment and they are set as a result of the dealers' optimisin behaviour. The market maker or so called dealer aims to maximize its profit throughout buying and selling an interest paying security and holding or shorting it with the revenue or the cost of interest payment. The market maker is able to adjust the market price around the economic value of the security within a range called outside spread.

The dealer accepts every trade claim from the market but throughout the price adjustments it can affect the quantity of demand and supply. After the trades the net short or long market risk of the dealer determines the price of the security. This is a continuous cyclical adjustment process which starts over every time the dealer's exposure changes.

17. Figure: Cycle of market maker's price setting



Source: author's own edition

Based on Treynor's (1987) model, a new bid and ask price setting strategy was considered. The net position of the dealer determines the market risk of market maker, which simultaneously determines the ask and bid price.

We can argue that bid price is a declining function of long risk and its higher price is the economic price of the security. As bid price is a concave function of balance sheet risk it helps the market maker to adjust its balance sheet. Ask price is a declining, convex function of balance sheet risk its lowest value is the economic price of the security. The set price is also impacted by risk tolerance of market maker, economic value of the security and market specification factors (i.e. competition).

We can infer from the spread equation that the applied spread is basically independent of the economic value of the security but maximum level of risk tolerance; risk exposure in balance sheet; and market specifications significantly influence the spread. The thightest spread is applied around the mid-price if the mid-price is equal with the economic value.

In this model the parameters included into the profit equations are exogen variables so the market maker cannot modify them, except its risk tolerance and risk sensitivity. Therefore, the security dealer is able to maximize its profit throughout changing the tolerated level of short and long risk.

The core of the model is the risk as the market risk in the market maker's balance sheet determines the price and therefore the spread between the bid and ask price. However, the dealer's sensitivity on its exposure is based on various factors but one of the emphasized is the uncertainty. If the uncertainty is high, the more intense reaction can be expected from the dealer in order to convince traders to adjust the market maker's balance sheet.

In this model, a single security is considered on the market. In our model the market maker is price-setter so the dealer sets the ask and also the bid prices, therefore it possesses a monopoly on trading. The market maker's position can be negative or positive depending on the executed trades. If the dealer is a net buyer the trades would increase the dealer's long risk (or decrease its short risk) in the dealer's balance sheet and if the dealer is a net seller the trades would increase its short risk (or decrease its long risk). The dealer passively accepts all orders to purchase or sell securities at a given price and the strategy of the market maker is to set the bid and ask price therefore it sets the spread simultaneously between two of them.

The aim of the market maker is to maximize its profit which has three attributes. The first profit component is the difference between the bid and ask price on the traded volumes. The second profit component comes from the held position at the end of periods. The long position means interest rate income for the dealer as the dealer is a net owner of the security, while net short in the dealer's balance sheet represents cost for the market maker because it has to fund the short position. We do not calculate with other financing costs in the model thereby disregarding the carry cost. The final component is the management cost.

$$\max E\left[\sum_1^i(\pi_i)\right] \tag{13}$$

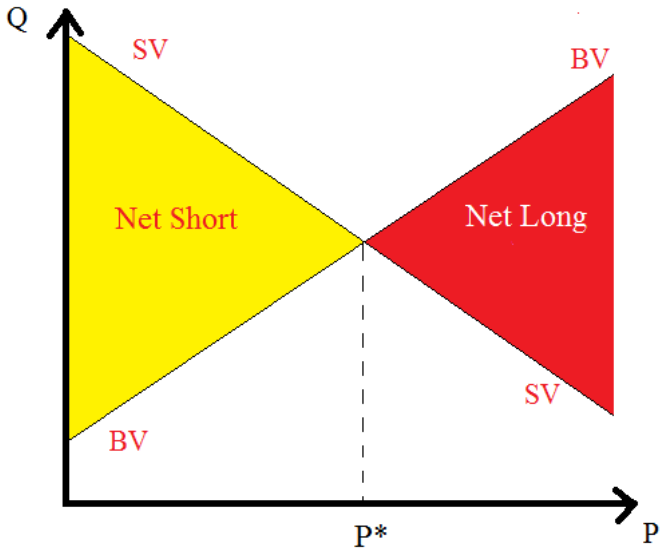
$$\pi_i = SV_i * a_i - BV_i * b_i + c_i * \sum_1^i(SV_i - BV_i) - MC_i \tag{14}$$

$$where\ c = \begin{cases} +c\ if\ V_t < 0 \\ -c\ if\ V_t > 0 \end{cases}$$

where π_i is the dealer's profit at i period, SV_i is the selling volume, a_i is the ask price at i period, BV_i is the buying volume and b_i is the bid price, c_i is the revenue or cost on the net position at the end of the i period and MC_i is the management cost.

In this model, the market demand and supply functions are considered as a simple linear function of price. The market maker sets the selling price which determines the selling volume and in parallel sets the buying price which determines the buying volume. From the market's point of view the security demand is a linear negative function of price and the security supply is a linear positive function of price. From the dealer's view the buying volume is the increasing function of the security price and the selling volume is the decreasing function of the price as the market maker satisfies the market demand and supply as it is illustrated in Figure 18. Demand or buying from the market maker's perspective is selling from the market maker's perspective.

18. Figure: Traded volume in the function of price from the dealer's view of view



Source: author's own edition

From the dealer's point of view, net short position is generated for the market maker if the selling volume exceeds the buying volume and vice versa. The amount of profit is the exceeded selling volume times price, but the dealer sets two different prices and the net position from trading activity also impacts the profit; therefore optimization process of the market maker is a complex method.

The security's demand and supply, i.e. the buying and selling volume of the dealer can therefore be described by the following functions.

$$S = BV_i = \beta * b_i + \Omega \qquad (15)$$

$$D = SV_i = -\alpha * a_i + \mu \qquad (16)$$

,where α and β are parameters which show the price sensitivity of the demand (selling volume) and the supply (buying volume) while μ and **Ω** are autonomous demand and supply for the security, therefore these are the expected buying and selling volumes at zero price.

Applying (15) and (16) into the profit equation we have the following profit function.

$$\pi_i = (-\alpha * a_i + \mu) * a_i - (\beta * b_i + \Omega) * b_i + c_i * \sum_1^i (SV_i - BV_i) - MC_i \ \ where\ c = \begin{cases} +c\ if\ V_t < 0 \\ -c\ if\ V_t > 0 \end{cases} \qquad (17)$$

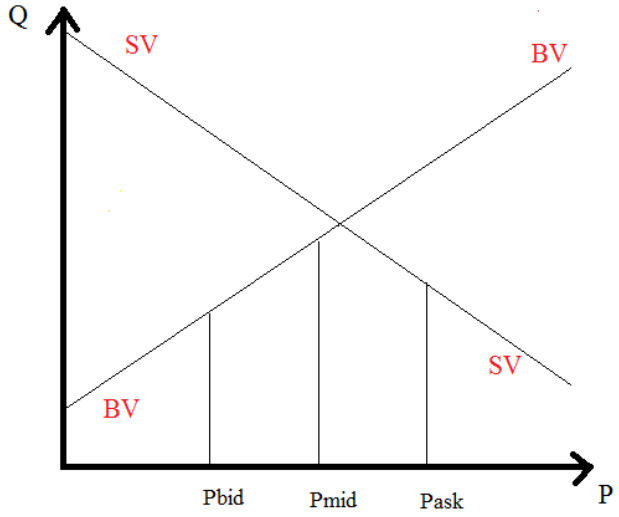
The market maker's strategic action is to set ask and bid prices. We can implement it as a symmetric spread around a price, known as the mid-price. This way we can apply (18) and (19) functions into the profit equation (17) as ask and bid prices.

$$a = p + s \tag{18}$$

$$b = p - s \tag{19}$$

In this case we can illustrate the demand (selling volume) and supply (buying volume) in the following graph. The trading profit is the difference between selling value (volume time price) and buying value (volume time price) which means that both of them are parabolistic functions of price and significantly depend on the slope of demand and supply and the autonomous demand and supply. It is illustrated in Figure 19.

19. Figure: Bid and ask prices and traded volume from a dealer's point of view



Source: author's own edition

$$\pi_i = [-\alpha * (p_i + s_i) + \mu] * (p_i + s_i) - [\beta * (p_i - s_i) + \Omega] * (p_i - s_i) + c_i * \sum_1^i (SV_i - BV_i) - MC_i \tag{20}$$

$$where\ c = \begin{cases} +c\ if\ V_t < 0 \\ -c\ if\ V_t > 0 \end{cases}$$

In order to optimize the pricing of the market maker we need to analyse the first-order derivative of the profit function (20). As the dealer is price setter we need to derive by price and spread because they can be adjusted by the dealer for profit maximization.

$$\frac{\partial \pi}{\partial p} = -2\alpha p - 2\alpha s + \mu - 2\beta p + 2\beta s + \Omega + c\beta + c\alpha - \frac{\partial MC}{\partial p} \tag{21}$$

In order to maximize profit the first order derivatives must be equal with zero therefore equation (21) implies that the profit impact of price changes merely depend on the slope of demand and supply curves. To make it simple, we can assume the same slope for demand and

supply curve. The rising price decreases the profit because in this case the selling volume (revenue) decreases while buying volume (cost) increases. If we assume that management cost is not impacted by the price, we can say that the profit is maximized if the marginal trading profit from price increase is equal with marginal coupon income increase from price rising.

$$\frac{\partial \pi}{\partial s} = -2\alpha p - 2\alpha s + \mu + 2\beta p - 2\beta s + \Omega - c\beta + c\alpha - \frac{\partial MC}{\partial p} \qquad (22)$$

The market maker is also able to adjust spread symmetrically around the mid-price as a strategic decision. The profit impact of the marginal spread change is significantly impacted by the slope of demand and supply curve but for simplicity we assume they are equal in this case as well. As we increase the spread we increase profitability but it also impacts the trading volume. Both selling and buying volume are decreasing as a result of raising spread around the mid price.

5.1. The price setting in the model

Throughout the pricing process the dealer has to analyze the future trading opportunities. „*The dealer's current price should relate in a rational way to what the price is expected to be in the future. Otherwise, his current price will create profit opportunities across time for those who trade with him. At positions between his layoff positions, the dealer should set price according to the price he expects to be setting one trade later. The next trade will, of course, move his position up or down with equal probability. If the price the dealer would set in those positions is known, then the price he sets in his current position must be the probability-weighted average of those two prices; otherwise he will create easy profits for those trading against him*" (Treynor, 1987, p. 30).

According to Treynor's (1987) theory, the market maker is not able to choose the price on its own without any limitations. The dealer can adjust price both bid and ask within the so called outside spread. The outside spread is set by the value based traders and it can be said they determine the price of the security as they set the price zone within which the market maker can adjust its price and its spread.

According to Treynor (1987), the market maker can adjust the price based on its balance sheet risk. If it has more long risk, the price is lower while the price is higher in case the dealer is net short. Longer risk means lower price the shorter risk means higher price. The idea behind this assumption is that if the price is lower, growing demand can be expected for the security,

hence the market maker can adjust its balance sheet to decrease its long exposure and the opposite for the short side.

The price mechanism of the market maker is based on the inventory risk. The size of the balance sheet does not necessarily mean the risk however it can be a good proxy. The inventory risk means the market exposure of the dealer. For example, if a dealer possesses large amount of Hungarian government bonds, the dealer is exposed to the market movement of the bond market. The dealer can make off balance sheet deals to hedge this exposure therefore the net risk of this position is minimized however the balance sheet is increased. This market exposure or called market risk is illustrated on the horizontal axes of Figure 20 and Figure 21.

I assume that market maker is not just able to adjust price but spread as well based on its risk position. It is based on the keystone of finance as more risk means more return expectation. We can also assume that short and long risks are symmetric which means an applied spread on a net short risk is the same applied spread for an equal net long risk. So larger risk means larger spread in an absolute way. We can assume the dealer knows the fundamental value of the security and the market maker is not willing to sell the security below this price and not willing to purchase the security above that awarded price.

In this model, I also assume the market maker is aiming to convince the traders to adjust the dealer's balance sheet so encourage the traders to sell if the dealer is net short and encourage the traders to buy if the dealer is net long.

As demand and supply was introduced in this model we need to apply concave function for bid and convex function for ask price. Illustrated in Figure 18, if both the bid and ask prices are lower than the price for trade equilibrium (P* on Figure 18) the market maker will trade net short position, therefore it should be applied that if the dealer's current position is net long. The same can be said about the opposite side, if the dealer has had short risk in its balance sheet, the price would be higher than P* for both bid and ask in order to adjust the dealer's balance sheet. If the slope of demand and supply are the same P* as a mid price is a special price as symmetric spread around P* would have no effect on the dealer's risk position.

For simplicity we can apply simple exponential function for the two cases as it satisfies the assumptions above while it is continuous and can be strictly convex or strictly concave upon our request.

$$a = n(x - k)^2 + u \tag{23}$$

$$\text{b} = -n(x + k)^2 + u \tag{24}$$

,where x is the risk in the market maker's balance sheet; k is the maximum long/short risk the market maker is willing to tolerate in its balance sheet; u is the economic value of the security; n is a component including market specifications.

The n parameter (risk sensitivity) reflects the market competition, market concentration, clients access to the dealers, credit risk, counterparty credit risk and so on which is merely a technical parameter. It is the parameter which also reflects the uncertainty in the dealer's decision. The higher the uncertainty the dealer can adjust its balance sheet exposure, the more sensitive the price setting mechanism on the exposure is. According to the model, the higher uncertainty means more intense incentive to traders to adjust the market maker's balance sheet. This is because the market maker is not willing to tolerate too much risk if uncertainty is higher.

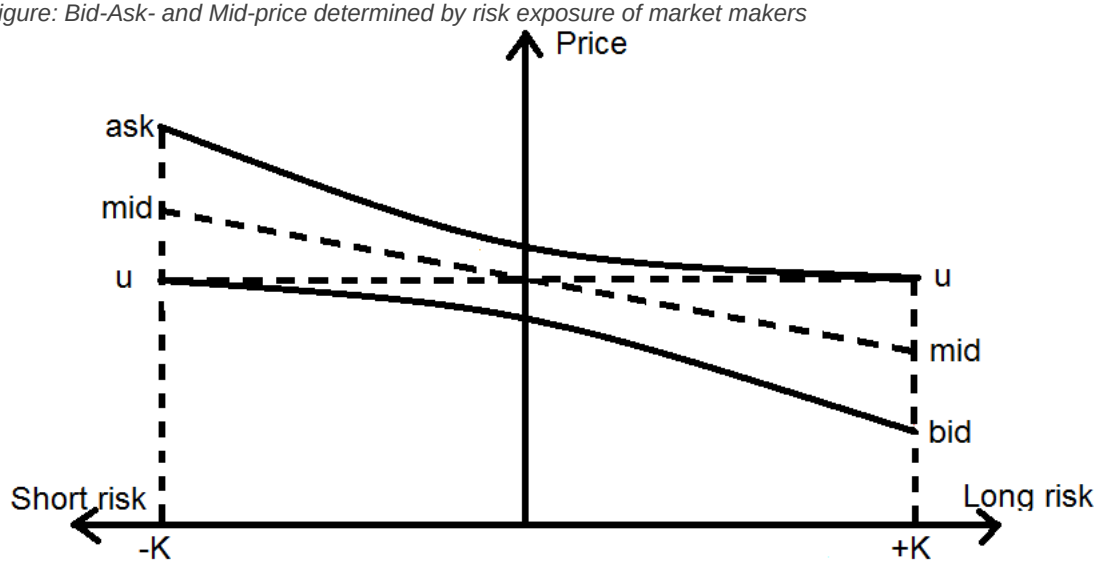
As we can see (23) is a declining function on $]-k; +k[$ and at +k its value is u. As it is a convex function we can satisfy the assumption thus, the valuation of the security can help the market maker to adjust its balance sheet if it has large long or short risk. Similar features can be said about (24) as it is also declining on $]-k; +k[$ and at -k its value is u but bid price function is a concave function in order to help the market maker to adjust its balance sheet.

As a consequence of (23) and (24) we can imply the mid price function which is described as (25).

$$mid = \frac{a+b}{2} = \frac{[n(x-k)^2+u]+[-n(x+k)^2+u]}{2} = -4\,nkx + u \qquad (25)$$

The mid price is equal with the economic value only if the market maker has net zero risk exposure in its balance sheet. Therefore, the thightest spread is applied around the mid price if the mid price is equal with the economic value.

20. Figure: Bid-Ask- and Mid-price determined by risk exposure of market makers



Source: author's own edition

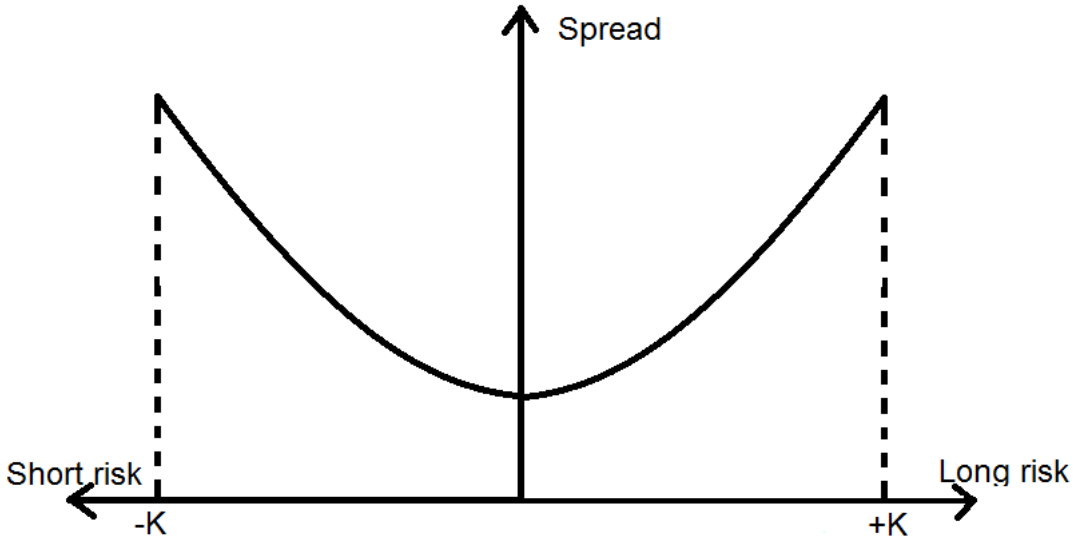
Therefore, the applied spread is also determined by the risk exposure in the market maker's balance sheet as the actual short/long position simultaneously determines both ask and bid prices.

$$spread = a - b = 2n\,(x^2 + k^2) \qquad (26)$$

We can infer from the spread equation that the applied spread is basically independent from the economic value of the security but maximum level of risk tolerance; risk exposure in balance sheet; and market specifications. At zero risk exposure the spread is $2nk^2$ but the realized profit depends on demand and supply curve. Ideally p_{mid} is p* at net zero risk so traded volumes are roughly equal. Yet this is the expected return at risk-free position.

Therefore, the spread is a parabolistic function of balance sheet risk exposure on $]-k; +k[$ which has minimum point at zero. This is illustrated below on Figure 21.

21. Figure: Bid-Ask- and Mid-price determined by risk exposure of market makers



Source: author's own edition

5.2. Parameters

The market maker simultaneously determines the bid and ask prices based on its balance sheet risk but the set price depends on other parameters as well, i.e. risk tolerance (k), market features (n) and the economic value of the security (u).

We can argue the endogenity of the two as market structure can impact one dealer's risk tolerance but we ignore this in this case for the sake of simplicity. We assume that we can distuingish the impact of risk tolerance and market features meaning that risk tolerance is independent of market features.

The market specification parameter (n) includes market competition between market makers besides the strict assumptions the dissertation considered above. The larger the competition in the market the smaller the parameter is. If the market makers stand up groups like cartel the spread can stay or even go up in order to manage the issue coming from the sink demand hence increasing profit but in this case cartel is not allowed.

The risk tolerance (k) shows how much unhedged market risk is tolerated in the market maker's balance sheet. As we assumed previously this is based on the risk appetite of the dealer which is independent from the market conditions and features. Basically, risk tolerance is the only factor influencing the set prices the market maker can adjust by itself.

We can use the ask (23) and bid (24) equation within the profit equation (17) to get a detailed profit function of the market maker including its risk tolerance, market competition,

balance sheet risk, economic value of the security and the revenue or cost of carry and management costs.

$$\pi = \{-\alpha[n(x-k)^2+u]+\mu\}[n(x-k)^2+u] - \{\beta[(-n)(x+k)^2+u]+\Omega\}[(-n)(x+k)^2+u] + \frac{c}{p}x - MC \quad (27)$$

$$where\ c = \begin{cases} +c\ if\ x<0 \\ -c\ if\ x>0 \end{cases}\ and\ \ p = \begin{cases} a\ if\ x<0 \\ b\ if\ x>0 \end{cases}$$

As we discussed in this model the parameters included within the profit equations are exogen variables so the market maker cannot modify them except its risk tolerance. The first order derivative of profit equation by risk tolerance shows how the profit reacts for the marginal change of its risk tolerance as it is shown in equation (28) and equation (29).

If the market maker has long position and changes its maximum level of tolerated risk we get (28) as a marginal impact of risk level changes on profit and (29) in the case of net short position.

$$\frac{\partial \pi}{\partial k} = 2\alpha n[n(x-k)^2+u](x-k) - 2n\{\mu - \alpha[n(x-k)^2+u]\}(x-k) + 2n(x+k)[\beta(u-n(x+k)^2+\Omega] + 2\beta n(x+k)[u-n(x+k)^2] + \frac{2cnx(x+k)}{[-n(x+k)^2+u]^2} \quad (28)$$

$$\frac{\partial \pi}{\partial k} = 2\alpha n[n(x-k)^2+u](x-k) - 2n\{\mu - \alpha[n(x-k)^2+u]\}(x-k) + 2n(x+k)[\beta(u-n(x+k)^2+\Omega] + 2\beta n(x+k)[u-n(x+k)^2] + \frac{2cnx(x-k)}{[n(x-k)^2+u]^2} \quad (29)$$

5.3. Chapter summary

In this chapter a new concept of market maker's behaviour was introduced. The dealer passively accepts all orders to purchase or sell securities at a given price and the strategy of the market maker is to set the bid and ask price therefore it sets the spread simultaneously between two of them. The market maker is able to adjust the market price around the economic value of the security within a range called outside spread. The net short or long market risk of the dealer determines the price of the security. This is a continuous cyclical adjustment process which starts over every time the dealer's exposure changes. We can also assume that short and long risks are symmetric which means an applied spread on a net short risk is the same applied spread for an equal net long risk. So larger risk means larger spread. Market maker is aiming to

convince the traders to adjust the dealer's balance sheet so encourage the traders to sell if the dealer is net short and encourage the traders to buy if the dealer is net long. The core of the model is the risk as the market risk in the market maker's balance sheet determines the price and therefore the spread between the bid and ask price. However, the dealer's sensitivity on its exposure is based on various factors but one of the emphasized is the uncertainty. If the uncertainty is high, the more intense reaction can be expected from the dealer in order to convince traders to adjust the market maker's balance sheet. The profit of the market maker is determined by the market maker's unhedged market risk, the market maker's risk tolerance, the market maker's risk sensitivity including market competition, concentration and also credit risk, price sensitivity of demand and supply (slope), autonomous demand and supply, the fundamental value of the security, the carry costs and the management costs.

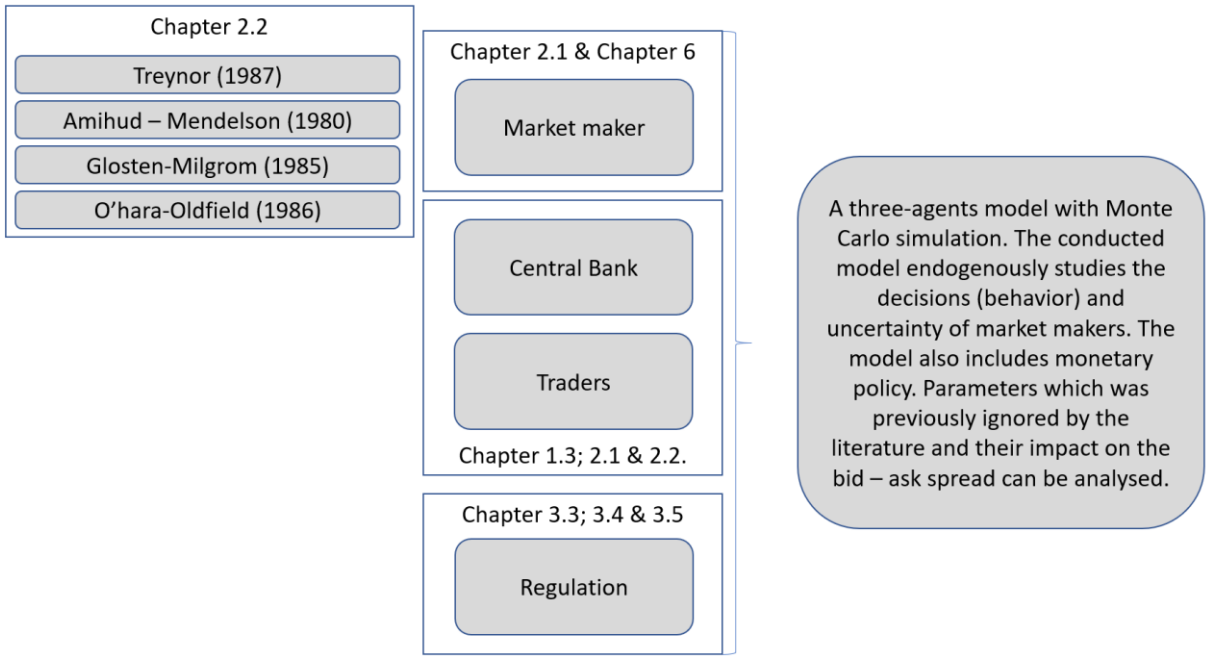
6. Microstructure of market liquidity: Monte-Carlo Simulation

A new model was introduced in chapter 5 for analysing the determinants of the bid-ask spread and the price setting methodology. The earlier microstructure models in the literature examine either the inventory risks' role in price setting or information asymmetry's impact on the market. An analytical microstructure model introduced in chapter 5 analyses the role of inventory risk in price and spread setting. In order to make it more reliable and veritable we need to add information asymmetry, monetary policy and unlock assumptions we identified in chapter 5. After the modification, the interactions between actors are not able to be solved by analyticial methods therefore a multi-agent model with Monte Carlo simulation is regarded as the best method to investigate. Contrary to the earlier models in the literature a microstructure model with inventory risk, information asymmetry and monetary policy is introduced to get better understanding about price and spread setting mechanisms of financial markets.

We can distinguish market makers or so called dealers, uninformed traders and informed traders who are traders with fundamental information about the true value of the security. This method allows for a wider variety of scenarios therefore a sophisticated model will help us to understand the market.

This method is considered as a computational method of economic processes modelled as a dynamic system of interacting agents. The system of financial agents is complex as the system includes interactions between the units and emergent properties (i.e. properties arising from the interactions of units) which helps us to understand the nature of bid-ask spread so do the liquidity of financial markets. The agents are market maker, informed trader, uninformed trader and central bank appears as exogenous actor. The background of the model introduced in this chapter is visualised in Figure 22.

22. Figure: The background of the model introduced in this chapter



Source: The author's own edition

6.1.Market maker

In the model, market makers set the price, thus the dealer provides both the ask and the bid prices allowing it to maintain a monopoly over the trading. The market-provider's position is twofold: positive or negative.

Should the dealer be a net buyer, trading would grow its overall long risk (or decrease its short risk) in the balance sheet. However, should the dealer take up a position of net vendor, the trades would increase its short risk (or decrease its long risk). The dealer inertly consents to all orders of purchase and sale of securities at a given price while the market makers' tactic is to provide both the bid and the ask price, thus it is responsible for arranging the spread at the same time between them. According to Treynor (1987), the market maker does not have the ability to pick the price by itself beyond any restrictions. The dealer is capable of modifying both the bid and the ask prices within what is referred to as the outside spread.

The outside spread is determined by value based traders and they set a security's price as they set the price zone, where the market maker can modify its price and its spread according to its needs. In Teynor's (1987) theory, market makers are able to adjust prices along the balance sheet risk. Should the risk be long, the price is lower, however it increases, when the dealer is net short. Higher long risk entails a lower price whereas a higher short risk indicates a higher

price. The core of this idea originates from the insight that when price is lower an increase in demand may be expected for a given security, thus the market supplier can modify its balance sheet to diminish its long exposure, while doing the reverse for the short side. The basic assumption of the model is that the market dealer is not only capable of adjusting the price but the spread as well on its risk position. This approach is based on perhaps the most basic concept of finance: more risk means a greater expectation on returns. It is also assumed that short and long risks are symmetric. In other words, an applied spread on a net short risk is the same as an applied spread for an equal net long risk. The greater the risk the greater the spread is in absolute terms. We also built on the assumption that the dealer is aware of the basic value of the security, while the market provider is determined not to sell the security under that given price as well as not to buy the security above the awarded price[1]. Finally, it is equally assumed that the market maker's goal is to persuade the traders to modify the dealer's balance sheet in order to push the traders to sell should the dealer be net short and vice-versa. In our analysis, we utilize a concave function for bid and convex function for ask price. Should the bid and ask prices be simultaneously lower than the price for trade equilibrium, the market maker will trade from a net short position, this should imply that the dealer's current position is net long. This is also true of the other side, if the dealer had a short risk in its balance sheet, the price would be higher than P* (price in equilibrium[2]) in the case of bid and ask so the dealer's balance sheet is allowed to adjust.

For the sake of simplicity, we can apply quadratic functions for the two cases because it adheres to the assumptions that were laid out above. While because it is continuous it can be strictly convex or strictly concave, depending on our preference.

$$a = N[n(x-k)^2 + u - \frac{1}{2}h\,, historical\ standard\ deviation] \qquad (30)$$

$$\text{b}= N[-n(x+k)^2 + u + \frac{1}{2}h\,, historical\ standard\ deviation] \qquad (31)$$

,where *x* is the risk in the market maker's balance sheet; *k* is the maximum long/short risk the market maker is willing to tolerate in its balance sheet; *u* is the economic value of the security; *n* is a risk sensitivity factor. The h parameter is delivered by equation (32) as it is considered to determine the expected return of the market maker on trading a single security with no risk in the balance sheet. This factor is affected by the market maker risk sensitivity, market maker

[1] This assumption is changed when the level of information assymetry is discussed
[2] Set price by the market maker if the market maker has no risk in its balance sheet

risk tolerance and the risk-free return. The h parameter also determines the exposure when the market maker starts aggressively adjust its balance sheet i.e. set offer price lower than the fundamental and set bid price higher than the fundamental price.

$$\mathrm{h}= 2n * k^2 - \frac{risk.free.rate}{\frac{std}{n}} \tag{32}$$

Based on the formula (30) is a downward sloping function on $]-k;+k[$ and at $+k$ its value is *u*. The fundamental value of the security follows a random motion (as it was assumed), so changes on bid and ask prices are considered to have a distribution really close to geometric Brownian motion.

Since it is a convex function we can accept the assumption, that the valuation of a security can aid the market provider in its goal of adjusting its balance sheet which is as large long or short risk. Similar statements can be made about (31) as it is equally downward sloping on $]-k;+k[$ and at $-k$ its value is *u* but bid price function is a concave function allowing the market provider to modify its balance sheet.

Based on (30) and (31) we can denote the mid-price function, which is determined as (33).

$$mid = \frac{a+b}{2} \tag{33}$$

The mid-price is the same as the economic value solely in case the market provider has net zero risk. This means that the tightest spread is applied around the mid-price if the mid-price is the same as the economic value.

The spread used is thus also determined by the market maker's balance sheet exposure, due to the fact that the actual short/long position simultaneously determines the ask and the bid prices.

$$spread = a - b \tag{34}$$

Based on the spread equation we can conclude that the utilized spread is independent of the economic value of the security. In case there is no risk of exposure the spread is $2nk^2$ yet the profit acquired depends on the supply and demand curve (in an ideal case p_{mid} is p^* at net zero risk so traded volumes are 1, more of less equal).

6.2. Traders

From the literature, we can distinguish informed and uninformed traders in the model (Wang, 2014; Glosten - Milgrom, 1985 and many others). In the model, α is assumed as the proportion of informed traders and β as a proportion of uninformed traders. α and β add up to 1 and the net position of traders (informed and uninformed) is offset the net position of the market maker so traders are only allowed to deal with the market maker. Short position is only ruled out for the traders and not for the market maker. The model does not include taxes and other transaction costs for any agents.

The informed traders are able to properly evaluate the arising information hence they have knowledge about the value of the underlying asset. Thus, informed traders who are assumed to know *Vt*, will place a buy order if the fundamental value is higher than the ask price (*Vt* > *At*) or a sell if the fundamental value is lower than the bid price (*Vt* < *Bt*) or no trade at all otherwise. Whenever the informed trader is satisfied with the trading condition at time t, the trading volume is generated by a normally distributed stochastic process with mean 1 and variance σ^2 but both parameters are also input parameters of the simulation. So the probability of informed trades are described by equation (35) and trading volume of informed traders are described by equation (36).

$$Probability\ of\ informed\ trade_t = \int_{-\infty}^{B_t}[f_t(v)]\,dv + \int_{-\infty}^{A_t}[f_t(v)]\,dv \qquad (35)$$

, where B_t the bid price, A_t is the ask price at t and $f_t(v)$ is the normal density of the fundamental value.

$$Informed\ trade\ quantity_t = \alpha \int_{-\infty}^{\infty} f_t(f)\,df \qquad (36)$$

, where α is the proportion of informed traders and $f_t(f)$ is the normal density of the trading process distribution.

The non-informed or ordinary traders do not know the real value of the securities therefore their decision does not depend on the changes in the fundamental value. Non-informed traders will place a buy or a sell with an equal probability of γ or keep their position with probability of $1\text{-}2\gamma$. In the case of trading, uninformed actors trade (buy or sell) a random number determined by normal distribution in which the parameters are also parts of the

simulation independently from the stochastic process which generates the trade size for informed trades. The probability of uninformed trades is described by equation (37) and trading volume of uninformed traders is described by equation (38).

$$Probability\ of\ uninformed\ trade_t = 2\gamma \quad (37)$$

$$Uninformed\ trade\ quantity_t = (1-\alpha) \int_{-\infty}^{\infty} f_t(f)\, df \quad (38)$$

The uninformed traders' probability for buy or sell was adjusted for analysing the over heat or fire sales in the model in order to help us to understand the liquidity impact resulting from behavioural changes. In that case the probability of buying is μ while the probability of sell is *1-* μ therefore this scenario does not include the possibility of non-acting. The uninformed traders either buy or sale the security in each of the 50 periods.

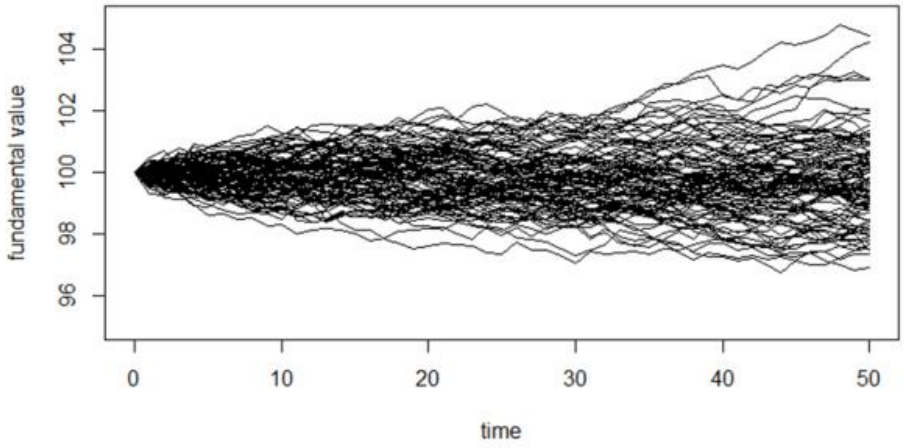
Considering that in the model we distinguish between different types of traders, the price in the market can significantly differ from the fundamental price whenever the uninformed traders are active and they continuously trade on one side (either buy or sell). However, the model deals with such scenarios these are rare events, just as asset bubbles thus their impact on the simulation results are moderate. The market correction will depend on the market maker's risk tolerance and how intense the market maker prefers adjusting its balance sheet. Overconfidence, bounded rationality and other characteristics described by behavioural finance mentioned in Chapter 3.1. are not simulated in the dissertation. In a future research, the impact of behavioural characteristics may be analysed on the market. This would however require adjustments to the current model (i.e. expectations and budget).

6.3. Model parameters

The simulation program was written in *R* software package (*R Core Team, 2016*). 50 periods (sequences) of pricing and trading were modelled and simulated a thousand times. Dealers and traders enter the market sequentially in every period, dealers set the price while traders can buy the security at ask price (A_t) and sell the security at bid price (B_t). Information arises about the security in every period which determines the fundamental value (V_t) of the security at time *t* but only the market makers and the informed traders know the proper value of the security. The true underlying value of the security (V_t) at time $t=0,1,\ldots,50$ follows a random walk therefore $V_t=V_{t-1} + \varepsilon_t$, where the ε_t are following normal distribution, which

parameters are integrated part of the simulation. Simulating the fundamental value hundred times with using the assumptions of random motion generate the following price path with the initial price (price at *t0*) 100.

23. Figure: Price simulation a hundred times



Source: author's own calculation

The agent computational models need to specify the initial state of the system by specifying agents' initial data and behavior. In this model, 12 parameters are supposed to be given at time 0 then the dynamic interactions between the agents are managed automatically.
The dealer's risk sensitivity parameter determines how the market maker reacts to additional risk and also important parameter for determining the expected rate of return. It is merely a technical parameter with the standard value of 1.

Risk taking willingness of the dealer relative to the issued security is also an input parameter of the model. This parameter shows the total risk tolerated in the market maker's balance sheet in the proportion of total issued security so 1,2 means the market maker would be able to add 20% more than the total market risk. Based on fact that the market makers are the participants of the primary market on dealer driven markets so the newly issued securities are going through their balance sheet the standard value of the parameters is 1.2.

Proportion of the informed traders is an important initial parameter which is also analysed by the literature. This parameter shows the proportion of informed traders within all traders. The standard value of the parameters is 0.05 which mean 5% of total traders are informed so 95% of the traders are uninformed.

We also have to set the initial value of the security as starting fundamental value. Fundamental value, ask and bid price together determine if the informed traders deal with the market maker. The standard initial value of the security is 100.

The path of fundamental value during the simulation sequences can be set by parameters of the fundamental value's distribution: Mean and Std. Dev. The parameters of fundamental value's distribution determine the path of the fundamental value during the 50 periods. The standard applied distribution is standard normal distribution (0.1) as we assume to have random motion.

Risk – free interest rate is being constant during the simulation steps but it has to be set at the initial period. Risk-free interest rate has impact on the market makers' expected rate of return. The standard initial value of risk-free interest rate is 1%.

The non-informed traders' behaviour can be determined by the probability of keeping (non-trading) for the uninformed traders. Non-informed traders will place a buy or a sell with an equal probability of γ or keep their position with probability of $1\text{-}2\gamma$. The standard initial value of trading is 66.6%.

Next to trading probability, the traded values are very important for set the traders' behaviour. As this is described as a stochastic process the parameters of the distribution can be set for both the informed and non-informed traders. These parameters are the mean and standard deviation. Fundamental value, ask and bid price together determine if the informed traders take place a trade with the market maker. The initial parameters of the distribution for informed traders are 30% of the total issued security as a mean with 15% standard deviation. The initial parameters of the distribution for non-informed traders are 15% of the total issued security as a mean with 15% standard deviation and weighted by the proportion of uninformed traders. We assume that the informed traders execute 2-times larger trades in volume than the uninformed traders because of two reasons. (1) We assume informed traders are institutional traders and (2) we also assume actors with fundamental information even though they are not institutional investors are willing to allocate more funds on trading.

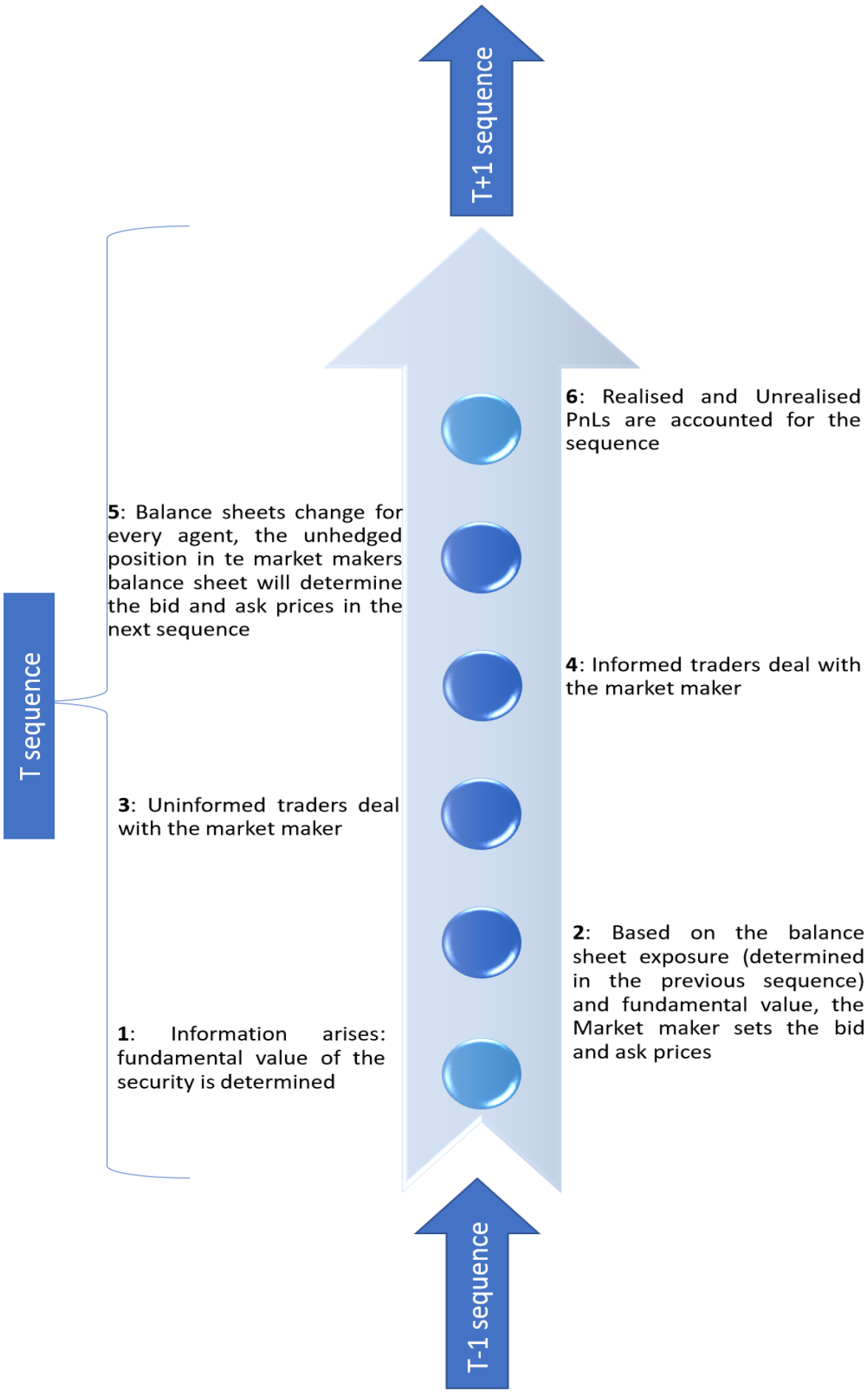
The traded value is generated by a random number following a normal distribution but the traded quantity is weighted by the proportion of uninformed traders.

These parameters and the behaviour of the agents are described in the following chapters in detail. One of the aims and contributions of this dissertation is to determine how the changes in the above listed factors, behaviours and rules affect the bid ask spread. In the simulation method we apply various values for the parameters and simulate every value a thousand times. The average of bid-ask spread for 50 periods is analysed so the average of the thousand simulation provides a reasonably accurate mean regarding the spread. Therefore, whenever the value of any parameter is changed, we can detect its impact on the spread ceteris paribus. As

all of the parameters are interpreted as a dealer behaviour, trader behaviour or market feature we can detect how these factors can vary the bid-ask spread and thus the market liquidity.

The model works in steps in every sequence. The order of the steps remains throughout the 50 sequences, which is shown in the following graph.

24. Figure: The model steps within a sequence in the multi-agent Monte Carlo simulation



Source: author's own edition

7. Determinants of Bid-Ask Spread

The determinanst of Bid-Ask Spread were derived from the Monte-Carlo simulation on our agent-based model (discussed in Chapter 6) which is based on the microstructure model (introduced in chapter 5).

We can distinguish various types of impact on the bid-ask spread. These are the following:

- Effects from the dealer market,
- Effects from the security's market,
- Effects from the trader
- Information asymmetry.

A contribution of this chapter is the applied innovative way to analyse the impact of the factors with various assumptions and initial parameters. The impact of the factors are analysed in various scenarios. Due to the complexity of the model, multidimensional results are shown and therefore multiplier effects and interrelations are able to be captured. Therefore, in the benchmark scenario we assume a unit risk sensitivity from the dealer, the risk-taking willingness is 20% larger than the issued securities, all of the issued securities are sold to the market maker at issuance, the proportion of informed traders are 30% and the uninformed traders has equal probability for buying, selling and holding in every period.

Various scenarios were used to capture the interconnected effects which is summed up in table 2. However, table 2 includes the scenarios which were analysed for every parameter other scenarios were also used at some points where it was relevant.

2. Table: Basic scenarios for analysing the parameters' impact on spread

	Price Path	***Trading Activity of uninformed***	***Volatility***	***Risk-Free Return***
Benchmark	Random walk - N(0,1)	Equal probability for buy, sell and hold	1	0,01
Bull market	Stochastic process for the market is N(1,1)	Equal probability for buy, sell and hold	1	0,01
Bear market	Stochastic process for the market is N(-1,1)	Equal probability for buy, sell and hold	1	0,01
Active traders	Random walk - N(0,1)	44.5% for both buy and sell and 1% for hold	1	0,01
Passive traders	Random walk - N(0,1)	25% for both buy and sell and 50% for hold	1	0,01
high volatility	Random walk - N(0,1)	Equal probability for buy, sell and hold	3	0,01
low volatility	Random walk - N(0,1)	Equal probability for buy, sell and hold	0,5	0,01
low return	Random walk - N(0,1)	Equal probability for buy, sell and hold	1	0,001
high return	Random walk - N(0,1)	Equal probability for buy, sell and hold	1	0,1

Source: author's own calculation

The results show the average bid-ask spread for 50 periods at different values and on different initial assumptions therefore we are able to detect the spread impact of the factors. As it has been shown, bid-ask spread is a valid and popular proxy for market liquidity therefore we can infer that those effects impact on liquidity which is inversely proportional with the spread effects thus whenever the spread increases, the liquidity decreases and vice-versa.

7.1.Results of the Monte-Carlo simulations

7.1.1. Dealer market effects

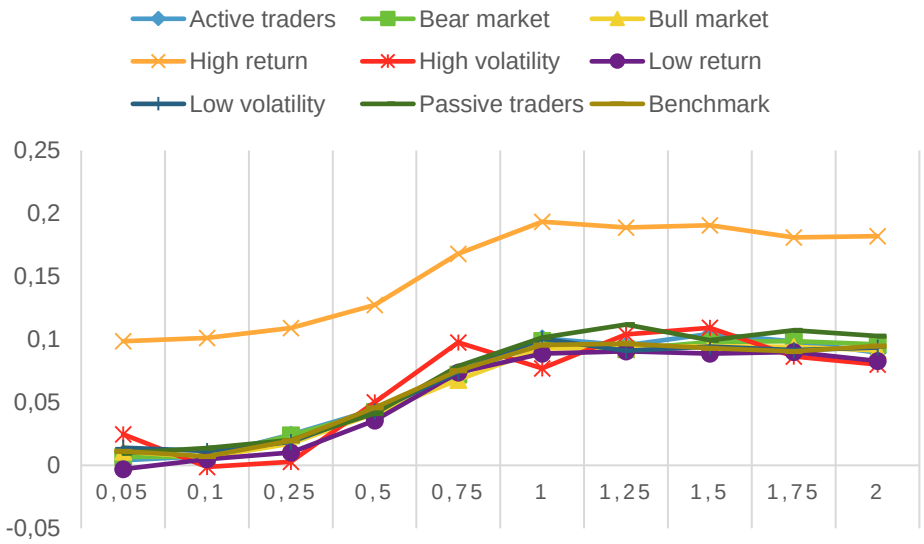
As previously deduced, dealers set the price of the security which is determined by the risk sensitivity of dealers, dealer's unhedged risk in its balance sheet and its risk-taking willingness.

The risk appetite in this case represents the maximum unhedged risk in the balance sheet that the market maker is willing to take both in long and short symmetrically. In general, we can say that the larger the risk-taking willingness of market makers the larger the spreads are. This is caused by the main financial principle which says the larger the return, the larger the risk is. The larger risk-taking willingness the wider the spreads will get. This is caused because the market maker stands as they are ready to satisfy large trader demands at any time. We can

say the depth of the market is represented in a way in this model throughout the risk-taking willingness parameter.

Regarding the scenarios, there are not major differences between the basic scenarios except when high return is assumed as the dealers would set wider spreads in this case. The rest of the scenarios are moving together however in the case of passive traders the spreads are wider. Of course, market is less liquid when the traders are not keen on trading. According to further simulations, it seems that the reaction of bid-ask spread on different level of risk-taking willingness depends on the size of the market. Based on the simulation, the larger the market the larger the impact of the risk-taking willingness so a unit of change in the risk taking willingness results in wider/tighter bid-ask spread if the size of the market is larger/smaller. This is caused by the assumption made on investors' behaviour so the traders have the same trading activity in both cases (same stochastic process describe the trading activity) which actually does not seem to be a very unrealistic assumption.

25. Figure: The impact of risk taking willingness on the bid-ask spread with various scenarios

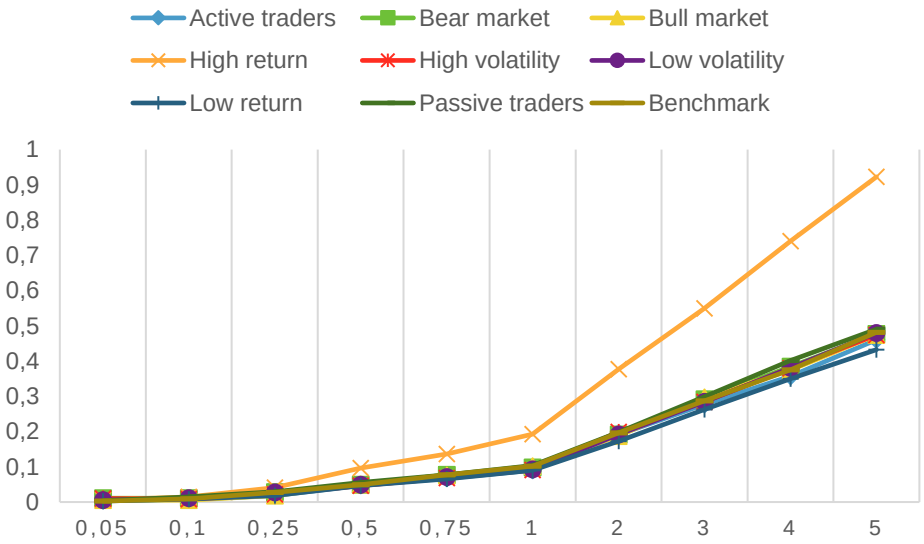


Source: author's own calculation

The risk sensitivity of the dealer also determines the bid-ask spread. To contain these effects a merely technical parameter is considered as it is supposed to reflect the market competition, market concentration, client's access to the dealers, credit risk, counterparty credit risk and so on. The results confirm that larger risk sensitivity results in wider spread. It is important to emphasize that it is strictly assumed that the risk taking willingness and risk sensitivity of the dealer are independent from one other.

Every factor affects the spread impact of the risk sensitivity. Further simulation results confirm that risk taking willingness has outstanding multiplier effect on the spread impact of risk sensitivity which are two very close concepts but in this model are assumed and handled as independent features.

26. Figure: The impact of risk sensitivity on the bid-ask spread with various scenarios



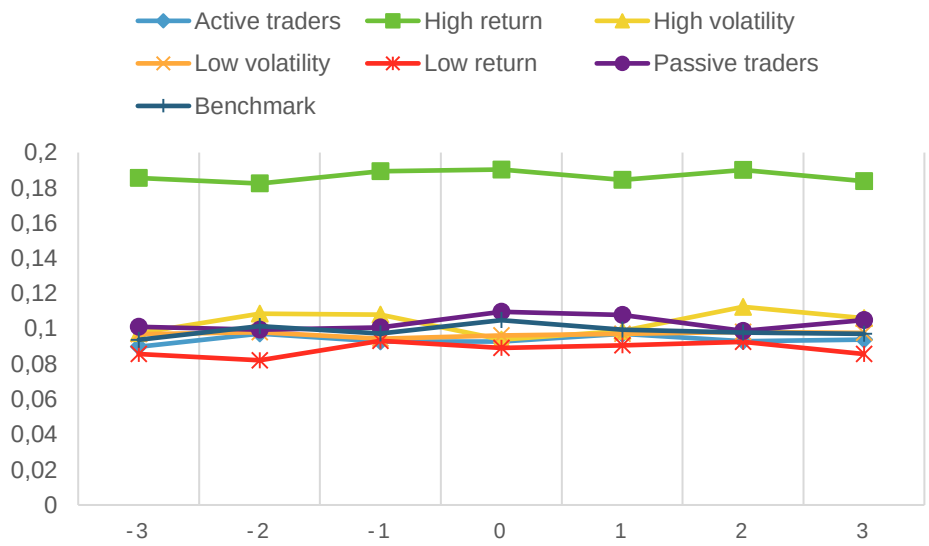
Source: author's own calculation

7.1.2. Market effects

Other market elements can also affect the spread example given: the path of the fundamental value of the security, its volatility and the risk-free interest rate. The prior means the direction of development in the fundamental price, in other words, whether the price goes up or down. In the simulation, the path of the value is determined by a stochastic process, i.e. the changes in the value is a random number from a normal distribution (standard normal distribution in the benchmark scenario). In the simulation, we applied different numbers for the mean of the distribution therefore we could determine the path of the value.

According to our simulation, path of the fundamental value has no significant impact on the liquidity impact. However different impact has been detected on different scenarios.

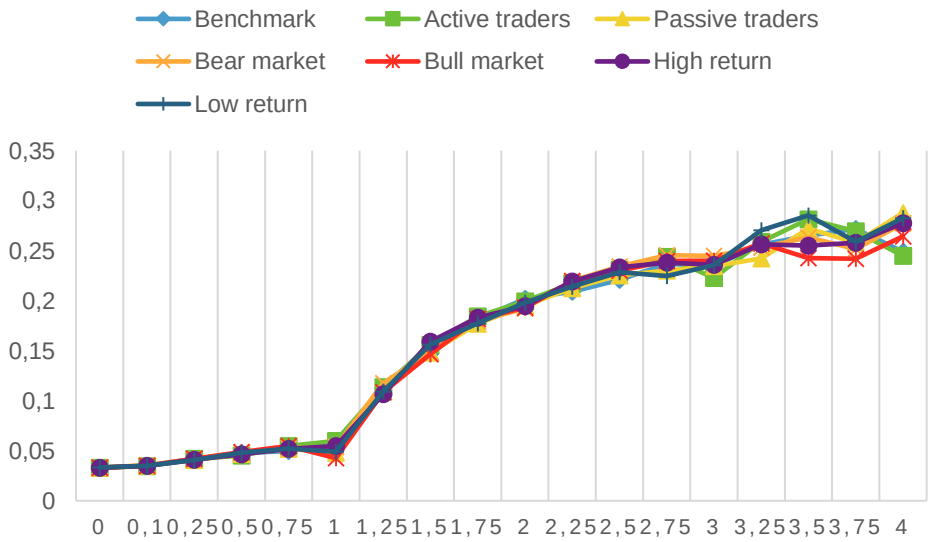
27. Figure: The impact of value's path on the bid-ask spread with various scenarios



Source: author's own calculation

The volatility of the security also important element for the liquidity of the market. The more volatile the market the wider the spread is. Volatility is a great proxy for the riskiness of a security therefore we can imply that the riskier the security the higher the spread is. In practice the volatility determines the applied haircut on the security, which can impact upon the liquidity of the security. The higher the volatility, the higher the resulting applied haircut is. This reduces the security's desirability as collateral and thus decreases the liquidity. EMIR, as it was discussed in Chapter 3.3.2., has impact on collateral valuation and haircut calculation, therefore infrastructure regulation in the EU can multiply the liquidity effect of volatility on liquidity.

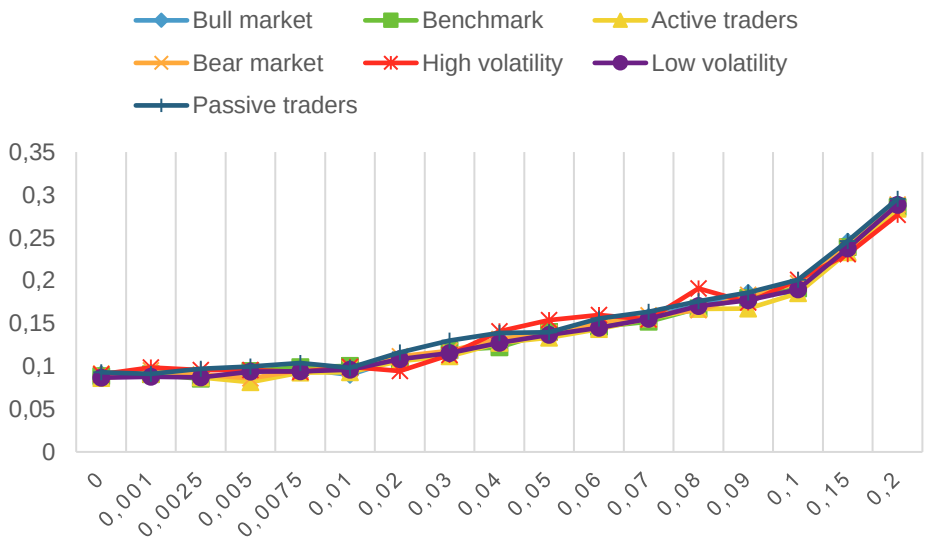
28. Figure: The impact of security's volatility on the bid-ask spread with various scenarios



Source: author's own calculation

The risk-free interest rate affects the expected rate of return for the market maker. As the model confirms our expectations higher risk-free interest rate results wider spread in the market therefore we can conclude that the market liquidity is lower. An increase in the risk-free interest rate increases the financing cost of the market maker and throughout the yield searching the market maker will look for other investment opportunities. This is why we can say one of the most important roles of the risk-free interest rate is the benchmark role which is getting more emphasized in contemporary times for monetary transmission mechanism. Monetary policy can influence the risk-free interest rate which can determine the liquidity of the markets therefore maintain stability for interbank collateral securities markets.

29. Figure: The impact of risk-free interest rate on the bid-ask spread with various scenarios



Source: author's own calculation

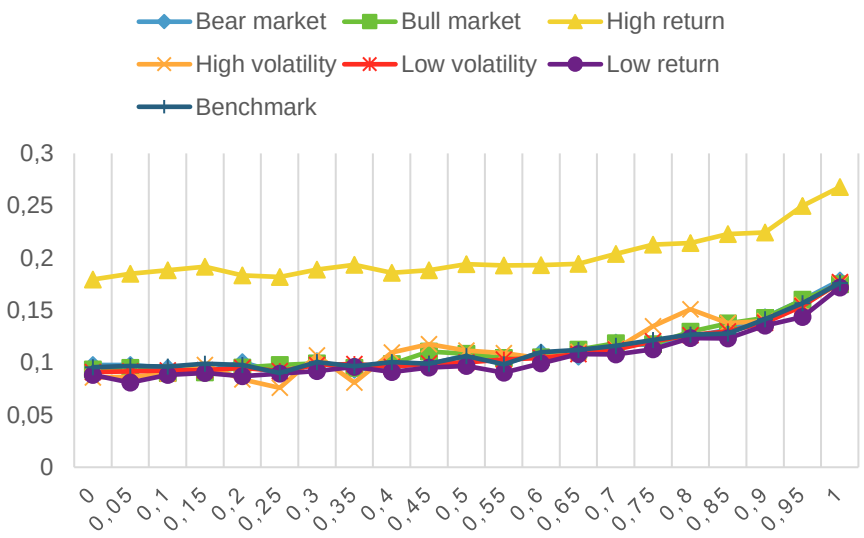
7.1.3. Traders' activity

Traded volume is considered as a measurement of liquidity by itself. The trading activity affects the bid-ask spread thus the liquidity of the market. Trading activity means the trading probability of uninformed traders in each sequence which remains stable throughout all the sequences. Generally, activity significantly increases the liquidity by decreasing the spreads. This result can be easily interpreted because if traders make deals with higher probability, it will be easier to find someone else who also wants to trade.

The impact of trading activity on the spread seems to be not affected by the path of the fundamental value. However, the proportion of informed traders can have impact on the effect of activity. The decisions of informed investors are determined by the price therefore the more

uninformed the traders are the higher the impact is on the spread. But it is true for high activity and there is no difference when the uninformed traders are passive. In the case of passive traders, they would hold their position which would result in the same activity in any scenarios as the only trades are done by informed investors. Figure 30 shows how the spread is influenced when the probability of holding increases.

30. Figure: The impact of trading activity on the bid-ask spread with various scenarios

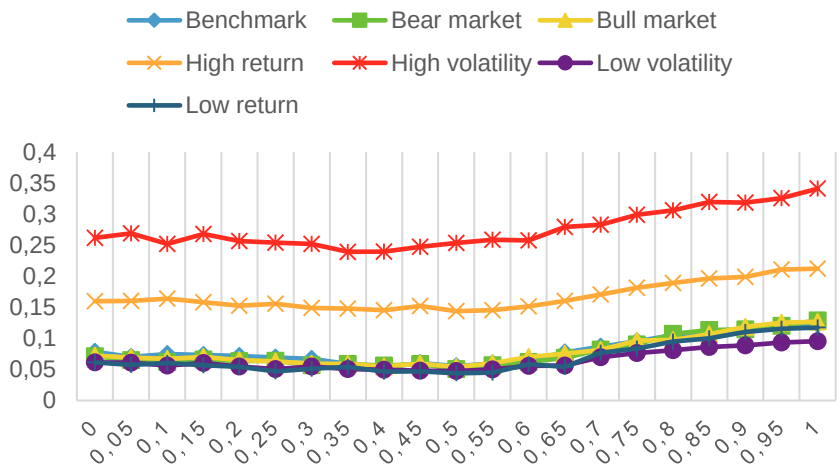


Source: author's own calculation

The adjusted model was able to help us understand how herd behaviour would affect the spread. In this case, probability of buying is different from the probability of selling and for technical simplicity keeping a position is not allowed for uninformed traders. The probability of buying is ζ while the probability of selling is (1- ζ). In general, the increasing probability of buying reduces the spread until the probability is 55-60%. For the first sight, it might be interesting that the lowest spread is not at equal chances for buying and selling but the result is determined by the assumption made about the dealer market. The dealer holds while unable to hedge the issued securities in the initial period so the dealer starting position is net long therefore equal chances would on average keep this exposure in its balance sheet. A little bit higher probability of buying helps the market maker to close its net long position. The too large probability of buying means that the market maker has to maintain an even higher short position therefore the spread is wider when the selling probabilities are higher. The impact of selling and buying probabilities are asymmetric because short position of the investors is not allowed in the model.

The proportion of informed dealers would influence the spread impact of the trading activity because only uninformed investors' deal is described by as a stochastic process while informed traders act with information in hand.

31. Figure: The impact of trading activity with no possibility of position keeping on the bid-ask spread with various scenarios



Source: author's own calculation

7.1.4. Information asymmetry

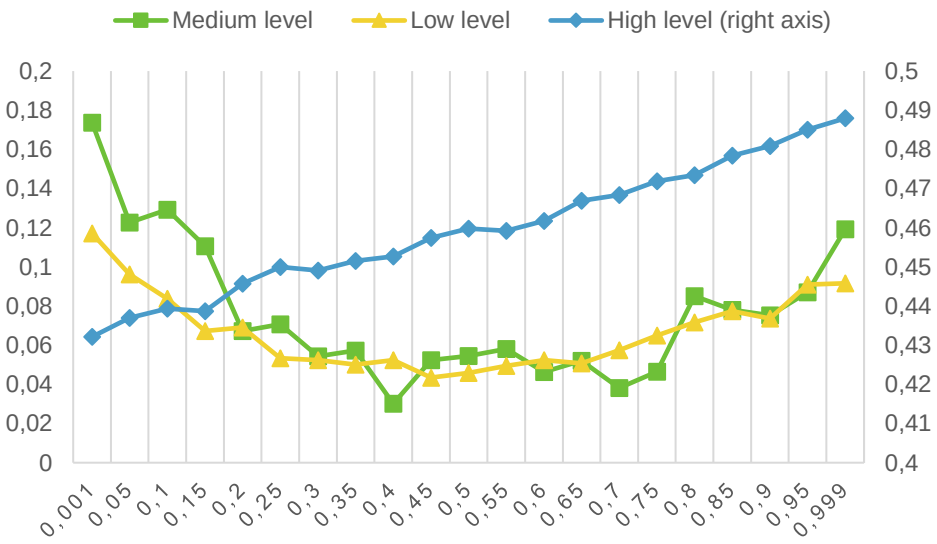
Information asymmetry arises because the market maker is not aware if it makes deal with informed or uninformed trader. By adjusting the model we can analyse how the different degree of information asymmetry can determine the spread. Therefore we can distinguish three types of scenarios for different degree of information asymmetry.

1. High level of information asymmetry: Market maker is not aware of the true fundamental value of the security while the informed traders know the proper value of the security. This is assumed in various papers (Glosten - Milgrom 1985; Kyle 1985; Easley - O'Hare 1987 and etc.).
2. Medium level of information asymmetry: Market makers know the density function for fundamental value of the security. So this stochastic process is a normal distribution where the mean is the fundamental value and the standard deviation is the half of the securities standard deviation. The informed traders know the proper value of the security.
3. Low level of information asymmetry: Market makers and informed traders know the fundamental value as a density function. This scenario seems to be the most realistic.

Informed traders can cause information asymmetry induces adverse selection costs that make the dealer to set wider bid and ask prices. The simulation results confirm that a larger proportion of informed traders results in wider spreads. Therefore, one of the spread's composition is a premium that the market maker demands for trading with informed traders. The trading activity of uninformed investors can change the spread impact of information asymmetry. In the case of passive or non-trading uninformed traders, the increasing proportion of informed traders does not increase the average width of the spread as it appears from the graph below. It is caused by the trading structure, as the trading book of the dealer lists only informed traders because the uninformed traders are inactive. So in spite of the low proportion of informed traders, all of the deals managed by the market maker are done with informed traders and most probably it is lower in quantity.

At medium and low degree of information asymmetry, the proportion of informed traders decreases the spread until a point, then it increases. It is due to the fact informed traders help the market maker to adjust its balance sheet whenever its needed therefore they help to maintain the fair price of the market. According to the results, we can infer that less information asymmetry between informed traders and market makers bolster the market's capability to avoid asset bubbles. It is because, market makers with more accurate information regarding the fundamental value are more keen on adjusting their balance sheets and amend the price on market. This result is closely related to Cornell - Sirri (1992) and Collin-Dufresne - Fos (2015), who empirically analysed the relationship of adverse selection and liquidity. The papers surprisingly find that liquidity increases when there is more active informed trading.

32. Figure: The impact of informed traders' proportion on the bid-ask spread with various scenarios



Source: author's own calculation

7.2.Robustness check, model validity

To check robustness of the results, confidence intervals were calculated for every simulated case based on the characteristics and features of the simulations. A confidence interval is a parameter estimation of a population calculated from empirical data. Should the related known or observed value for the simuland be within the confidence interval the model is accepted as true for the parameter in question. Of course, provided that it was calculated from the model executions, or within some acceptable tolerance of the confidence interval's endpoints. (for further details see: Petty, 2012)

The confidence interval for the population is calculated in equation (39)

$$\left[\bar{X} - t_{N,\alpha}\frac{\sigma}{\sqrt{n}}, \bar{X} + t_{N,\alpha}\frac{\sigma}{\sqrt{n}}\right], \tag{39}$$

where $\bar{X}$ is the sample mean, σ is the sample standard deviation, n is the sample size and $t_{N,\alpha}$ is a parameter that is derived from Student's t distribution at N-1 degrees of freedom at α confidence level.

The confidence interval was calculated on 95% confidence level. Therefore, the calculated confidence intervals are constructed to contain 95% of the population parameter.

The confidence intervals are measured to be stable over different parameters and different parameters' values expect for high and low standard deviation scenarios. The confidence intervals' range was calculated for 0.009 which is less than 10% of the outputs average. It is more than doubled for the high volatility scenarios and the half of it was measured for the low volatility scenarios. Therefore, the outputs of the model are robust and significant. We cannot confirm the robustness and significance of the volatility scenarios however, we need to be permissive for these cases as volatility is the key essence of this variation, which will endogenously result in higher confidence intervals by increasing the volatility of the output.

7.3.Summary of the results and economic implicatons

In this chapter a new microeconomic model for market makers has been introduced with realistic assumptions. The basic assumption of the model is that the market dealer is not only capable of adjusting the price but the spread as well on its risk position. This approach is based on perhaps the most basic concept of finance: more risk means a greater expectation on returns.

It is also assumed that short and long risks are symmetric. In other words, the greater the risk the greater the spread is in absolute terms. We also built on the assumption that the dealer is aware of the basic value of the security, while the market provider is determined not to sell the security under that given price as well as not to buy the security above the awarded price. Finally, it is equally assumed that the market maker's goal is to persuade the traders to modify the dealer's balance sheet in order to push the traders to sell should the dealer be net short and vice-versa. In our analysis, we utilize a concave function for bid and convex function for ask price.

As the output of the multi-agent Monte Carlo simulation showed, the liquidity of financial markets can be considered as a rather complex phenomenon. The liquidity impact of the factors may differ from the initial positions and the applied assumptions (e.g. regulation). Generally, increase in risk taking willingness, risk sensitivity and market size would make the spread wider but these impact on liquidity are not joint and numerous for every scenario. In the model we can also distinguish low, medium and high level of information asymmetry. The simulation results confirm that the larger proportion of informed traders results in wider spreads at high level of information asymmetry while at medium and low degree of information asymmetry the proportion of informed traders increases the liquidity until a point then it decreases. This result can describe the theoretical background of some empirical works which surprisingly find that liquidity increases when there is more active informed trading.

Initial position, trading activity, trading volume and path of fundamental value do not have such a clear way to affect. The impact can be smaller, larger, convex or concave depending on the underlying initial assumptions which is summed up in table 3.

3. Table: Factors' affects on the bid-ask spread

Increase of	***Bid-Ask spread***	***Liquidity impact***
Market movement	No significant change	Different on different scenarios
Market volatility	Increase by decreasing magnitude	Moderate
Trading activity	Decrease dynamically	Moderate
Risk taking willingness	Increase by decreasing magnitude	Slight
Risk sensitivity	Increase exponentially	High
Risk-free interes rate	Increase dynamically	Moderate
Information asymmetry	Depending on the degree of information asymmetry its a U graph or dynamic increase	Moderate

Source: author's own calculation

The theoretical and empirical models utilized in the dissertation provides special insights to the market liquidity determinants and methods. Therefore, we can take important economic implications. These are related to the efficiency of the regulation, the limitations of microprudential and macroprudential regulation, central bank policy and the commonality in liquidity.

Hypothesis 2: Bid-ask spread is not just determined by exogenous factors as the behaviour of market maker also have impact on the bid-ask spread.

A new microstructure model was constructed with asymmetric information, inventory risk and monetary policy for analysing the determinants of the bid-ask spread and the price setting methodology in financial markets. The earlier microstructure models in the literature examine either the inventory risks' role in price setting or information asymmetry's impact on the market. In order to examine the price setting and liquidity in a more reliable and veritable way, the microstructure model introduced in this dissertation tried to capture various effects in the same time. Due to this, interactions between actors are not able to be solved by analyticial methods therefore a multi-agent model with Monte Carlo simulation was considered as best method to investigate. Contrary to the earlier models in the literature a microstructure model with inventory risk, information asymmetry and monetary policy is introduced to get better understanding about price and spread setting mechanisms of financial markets.

As the output of the multi-agent Monte Carlo simulation showed, the liquidity of financial markets can be considered as a rather complex phenomenon. The liquidity impact of the factors may differ from the initial positions and the applied assumptions (e.g. regulation). Generally, increase in risk taking willingness, risk sensitivity and market size (quantity of issued securities) would make the spread wider but these impact on liquidity are not joint and numerous for every scenario. Initial position, trading activity, trading volume and path of fundamental value do not have such a clear way to affect. The impact can be smaller, larger, convex or concave depending on the underlying initial assumptions. **As a result of the analysis, significant evidences were found to accept Hypothesis 2.**

Hypothesis 3: Monetary policy plays a more significant role from market liquidity point of view than it is considered by the literature as monetary conditions have direct and indirect effects on market liquidity.

The risk-free interest rate affects the expected rate of return for the market maker. As the model confirms our expectations higher risk-free interest rate results wider spread in the market. Therefore we can conclude that the market liquidity is lower. An increase in the risk-

free interest rate increases the financing cost of the market maker and throughout the yield searching the market maker would look for other investment opportunities. This is why we can say one of the most important roles of the risk-free interest rate is the benchmark role which is getting more emphasized in contemporary times for monetary transmission mechanism. Monetary policy can influence the risk-free interest rate which can determine the liquidity of the markets therefore maintain stability for interbank collateral securities markets. The model results provide essential take aways regarding central bank policy as well. Risk-free interest rate has direct effect on market liquidity because of the profitability of the market makers. This is because yield searching market makers can turn their attention to risk-free assets instead of providing liquidity. However, monetary policy can also affect the risk sensitivity of the market makers if the central bank communicates that it is ready to step in as a dealer of last resort whenever the market needs it. In this case, dealers become less risk sensitive, so it results in tighter spreads. If the market knows that the central bank is ready to act as a dealer of last resort, the market makers would also increase the maximum risk they are willing to take because they are aware of the further possibilities to adjust their risk position via the central bank's asset purchasing program.

As a consequence of hypothesis 1 we already infered that central banks can indirectly increase the asset's liquidity by boosting the funding of dealers. **As a result of the analysis, significant evidences were found to accept Hypothesis 3.**

Hypothesis 4: Information asymmetry is directly affecting the spread however an increase in the information asymmetry between traders may decrease the spread.

Informed traders can cause information asymmetry induces adverse selection costs that make the dealer to set wider bid and ask prices. The simulation results confirm that the larger proportion of informed traders' results in wider spreads when the market maker has no information at all about the proper value of the underlying security. At medium and low degree of information asymmetry, the proportion of informed traders decreases the spread until a point, then it increases. It is due to the fact that informed traders help the market maker to adjust its balance sheet whenever it is needed therefore they help to maintain the fair price of the market. As a result of the microstructure model simulation, the results are consistent with the empirical literature, bid-ask spread may decrease when information asymmetry is higher. In the medium and low information asymmetry case, we can infer market maker with higher market power and thus more information which is significant qualitative difference from those assume in the existing theoretical literature. However, it is important to note that information asymmetry may

have impact on the spread and on the depth as well. The relationship between market depth and information asymmetry is not well documented in the literature neither in theory nor in empirical literature. **As a result of the analysis, significant evidences were found to accept Hypothesis 4.**

Hypothesis 5: The purpose of regulation is to prevent financial institutions from causing extreme fluctuations within the markets, however due to direct and indirect effects on market makers' behaviour it influences the spread as well.

Regulation of financial institutions aims to maintain financial stability and therefore economic stability. The regulatory authorities apply different rules to make a substantial contribution towards achieving their target. These rules are mainly about the maximum risk financial institutions can take but these rules are not just limiting their operations but also changing the banks' behaviour.

Regulation directly affects the taken risk by financial institutions which has significant and direct impact on the price and even on the spread. Regulation also have indirect impact risk taking willingness which have important role in price and spread setting method. Even consumer protection has various effects on the market liquidity. There is one clear effect is throughout the stability of dealers' funding liquidity but preventing market abuse and ensuring that consumers are in safe and get fairly prices services from financial institutions. Consumer protection has a clear effect on promoting effective competition for services provided by financial firms which clearly have impact on risk sensitivity of market makers therefore on the market liquidity.

The term 'macroprudential' was coined in the 1970s, when it denoted the systematic supervision of the macroeconomy. However macroprudential regulation only came to receive a substantial amount of academic attention in the past decade. It was, however, the 2008 financial crisis that highlighted the necessity of macroprudential regulation for all countries. Microprudential policies had helped safeguard the interests of individual economic actors, but that was not enough; regulation needed to be implemented to safeguard the financial system as a whole. The model described provides evidence that microprudential regulation can help us maintain the stability on the level of institutions and the market. However, intensifying regulation would result in more stable financial institutions but due to the institutions' declining risk-taking willingness and increasing risk sensitivity, the regulation might have a negative influence on market liquidity.

The results regarding the degree of information asymmetry can help us to understand one of the reasons why the regulations have different impact on different assets' markets.

As per the above-mentioned factors, we can conclude that there is an optimum level of regulation because too liberal rules would lead instability on both institutional and market level, while too rigorous regulation would no doubt be beneficial for continued institutional stability, yet, on the other hand, it would have a negative impact on the level of the market. The goal of macroprudential regulation is to find the optimum for the application of microprudential rules on the right institutions and right timing. It is also important to emphasize that macroprudential policy has to eliminate the so called regulatory relaxation from Minsky super-cycle which is about not to closely follow the systemic practice on risk taking however the financial institutions' operation change quickly and willing to take on more risk due to financialization and short termism. **As a result of the analysis, significant evidences were found to accept Hypothesis 5.**

IV. Summary and Conclusions

There are many definitions of liquidity in the financial literature and different market participants have different definitions as well. However, all of them are related to each other. In corporate finance liquidity means if the company or the portfolio can meet its cash outflow. The liquidity of a market means that the purchase or the sale of an asset can be accomplished in quantities typical to the market in a very short time with low transaction costs without causing significant changes in the price of the asset. The dissertation aims to understand the sources and determinants of market liquidity. Liquid financial markets are desirable for financial economists for many reasons. Higher liquidity means higher efficiency in source and information allocation. Therefore, central banks can intervene in the market in a more efficient way and central banks can even use indirect monetary policy instruments as the transmission channel is stable and the effects of central banks' operations are predictable. Liquidity has significant role to determine financial institutions' behaviour as liquid markets allow banks to take larger maturity mismatch and also currency mismatch between assets and liabilities. Liquidity also has an impact on crisis management as financial and non-financial companies can fund their operation more easily, therefore reducing the risk on central banks to act as a lender of last resort during a recession.

Due to financialization, financial markets play an ever increasing role not only in acquiring funds, but the instruments' liquidity has an effect on the smooth working of the financial network and has impact on investments, the balance sheets of the businesses, moreover through the balance sheets they also influence the capacity and demand of credit or even the households' wealth.

Financialization, the rising prominence of financial markets and the financial sector, is a natural part of the development of capitalism. Several factors supported and aided this process. In my opinion, the market fundamentalist economic policies of the 1970s were one to the most influential of these. The securitisation of risks and thus the reduction in the intermediary system's role led to the increased prominence of short-term views through a reduction in investor loyalty and a rising risk appetite. Financialization and the consequent short-term views propelled globalisation and integration processes, increased income inequality and caused that business cycles became shorter and more intensive, which peaked during the financial crisis of 2008/2009. The crisis acted as a catalyst and brought about phenomena like the globally low interest rate environment and the risk-aversion trap. These developments called for new monetary policy instruments, as traditional approaches proved to be ineffective in

dealing with new challenges. The topics addressed in this article were subject of research in recent years, but they have mostly been treated as separate factors. They, however, are closely linked phenomena whose roots can be traced back to financialization.

However, the emergence of new monetary policy instruments was necessary not only due to financing constraints and the need for rapid intervention, but also because of the change in monetary transmission and the emergence of new channels. One of the consequences of financialization presented earlier is that financial markets play an increasing role in fundraising, as well as saving. The line between the behaviour of financial and non-financial businesses is becoming thinner as many non-financial firms offer loans, manage portfolios and finance their activities by issuing bonds instead of bank loans. As a result, the importance of financial market liquidity has become more visible, which caused that central banks moved away from their position as 'lenders of last resort' towards a new position of 'dealers of last resort'. This implies that the central bank fulfils the role of a market maker in cases when no other economic agent does or is capable of doing so. In times of crisis, this essentially means purchasing bonds in order to help economic agents in the process of balance sheet adjustment. This is important especially in the markets for goods which serve as collateral for financial transactions.

Maintaining the liquidity of financial markets is a key element of the current regulation system. The findings confirm that maintaining or even boosting the liquidity of the dealers can have positive effect on the financial market's liquidity. The results infer that central banks can indirectly increase the asset's liquidity by boosting the funding of dealers.

In the 4th chapter, the source of liquidity was empirically tested in small, open economies. However, we faced a few contradictionary results, overall we can infer the followings. Market liquidity can be positively affected for economic growth and inflation while negatively affected to an increase in cost of funding. This is because the source of market liquidity is the balance sheet of financial intermediaries. The results are clear, significant and robust and supported by the theoretical models. However many researchers studied the topic just a few focused on the emerging markets. The results can be seen as strong evidence for the important role of trader's funding liquidity for the liquidity of financial assets' markets in small, open economies as well. Therefore, the first hypothesis, which says funding liquidity of market makers determines the market liquidity in the CEE region**,** was proved.

For testing hypothesis 2-5, a new microstructure model was developed in chapter 5. The theoretical model was augmented and simulated as a monte-carlo simulation in chapter 6. This method is considered as a computational method of economic processes modelled as a dynamic system of interacting agents. The system of financial agents is complex as the system includes

interactions between the units and emergent properties which helps us to understand the nature of bid-ask spread so do the liquidity of financial markets. The agents are market maker, informed trader, uninformed trader and central bank is considered as exogenous actor in the model. The basic assumption of the model is that the market dealer is not only capable of adjusting the price but the spread as well on its risk position. This approach is based on perhaps the most basic concept of finance: more risk means a greater expectation on returns. It is also assumed that short- and long-term risks are symmetric. As the output of the multi-agent Monte Carlo simulation showed, the liquidity of financial markets can be considered as a rather complex phenomenon. The liquidity impact of the factors may differ from the initial positions and the applied assumptions (like regulation). Generally, increase in risk taking willingness, risk sensitivity and market size (quantity of issued securities) would make the spread wider but these impact on liquidity are not joint and numerous for every scenario. Low, medium and high level of information asymmetry were distinguished. The simulation results confirm that the larger proportion of informed traders results in wider spreads at high level of information asymmetry while at medium and low degree of information asymmetry the proportion of informed traders increases the liquidity until a point then it decreases. This result can describe the theoretical background of some empirical works which surprisingly find that liquidity increases when there is more active informed trading.

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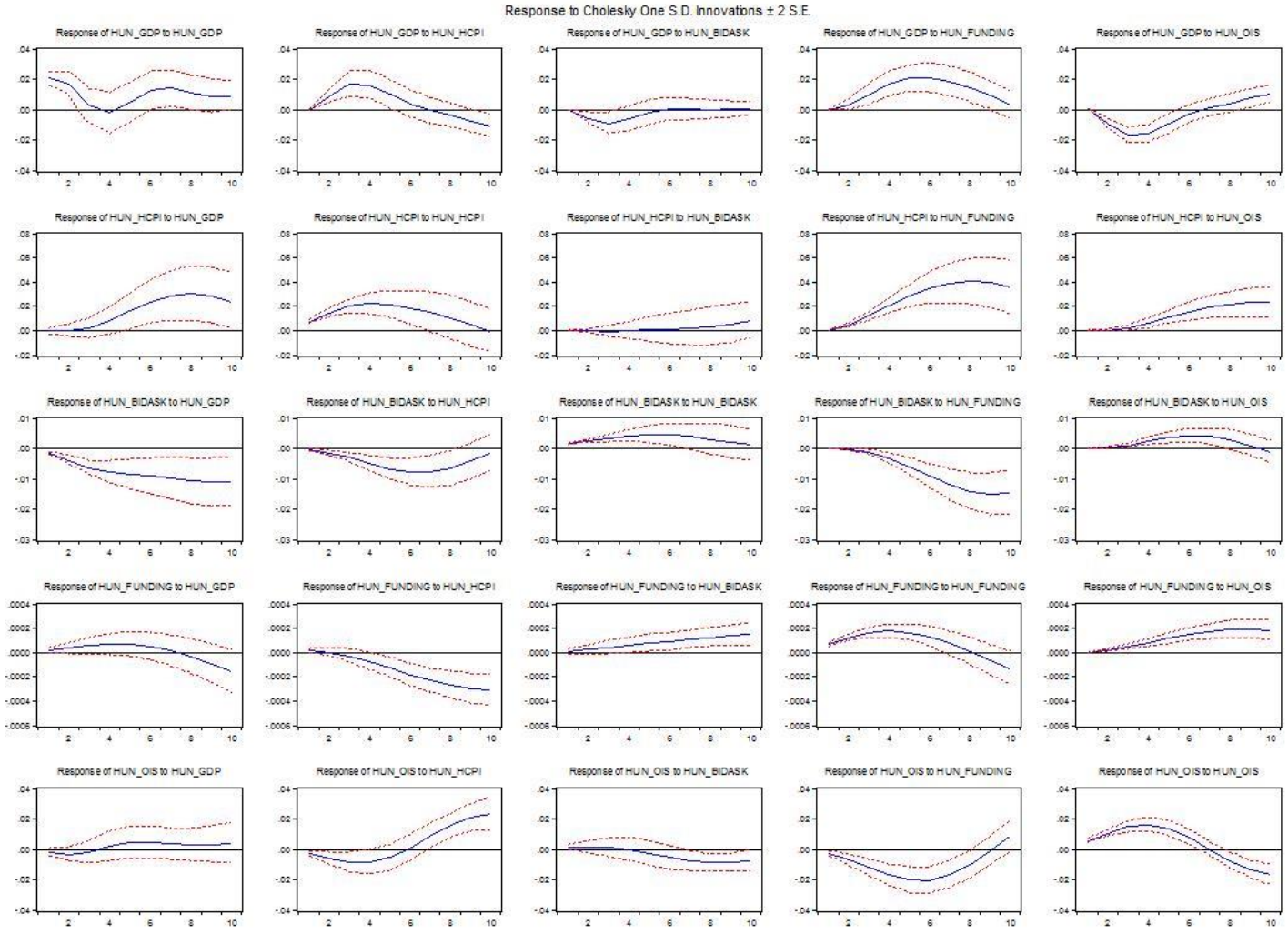
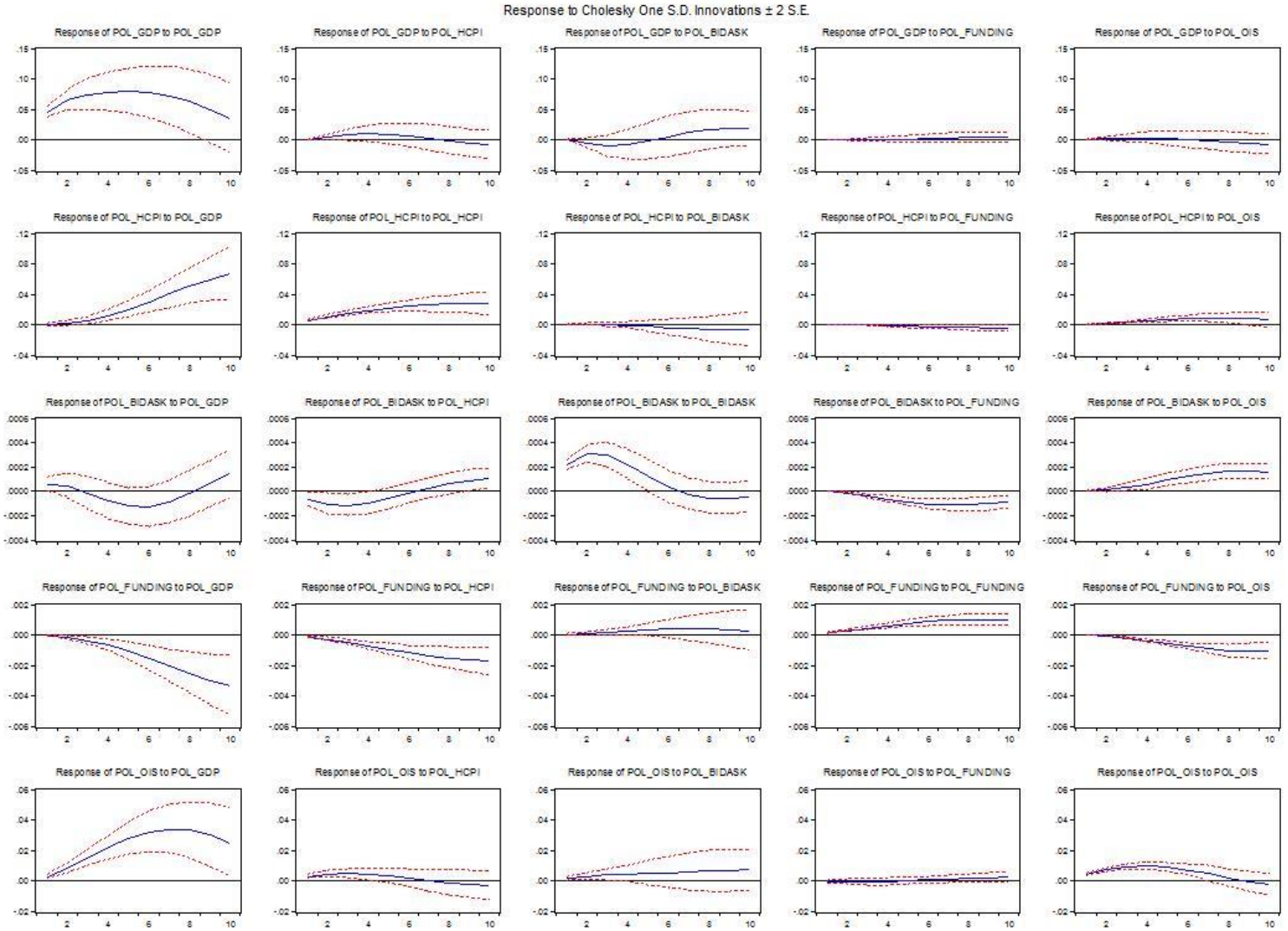
Appendix: Impulse functions of recursive VAR models

4. Table: Results of VAR model based on Hungarian data



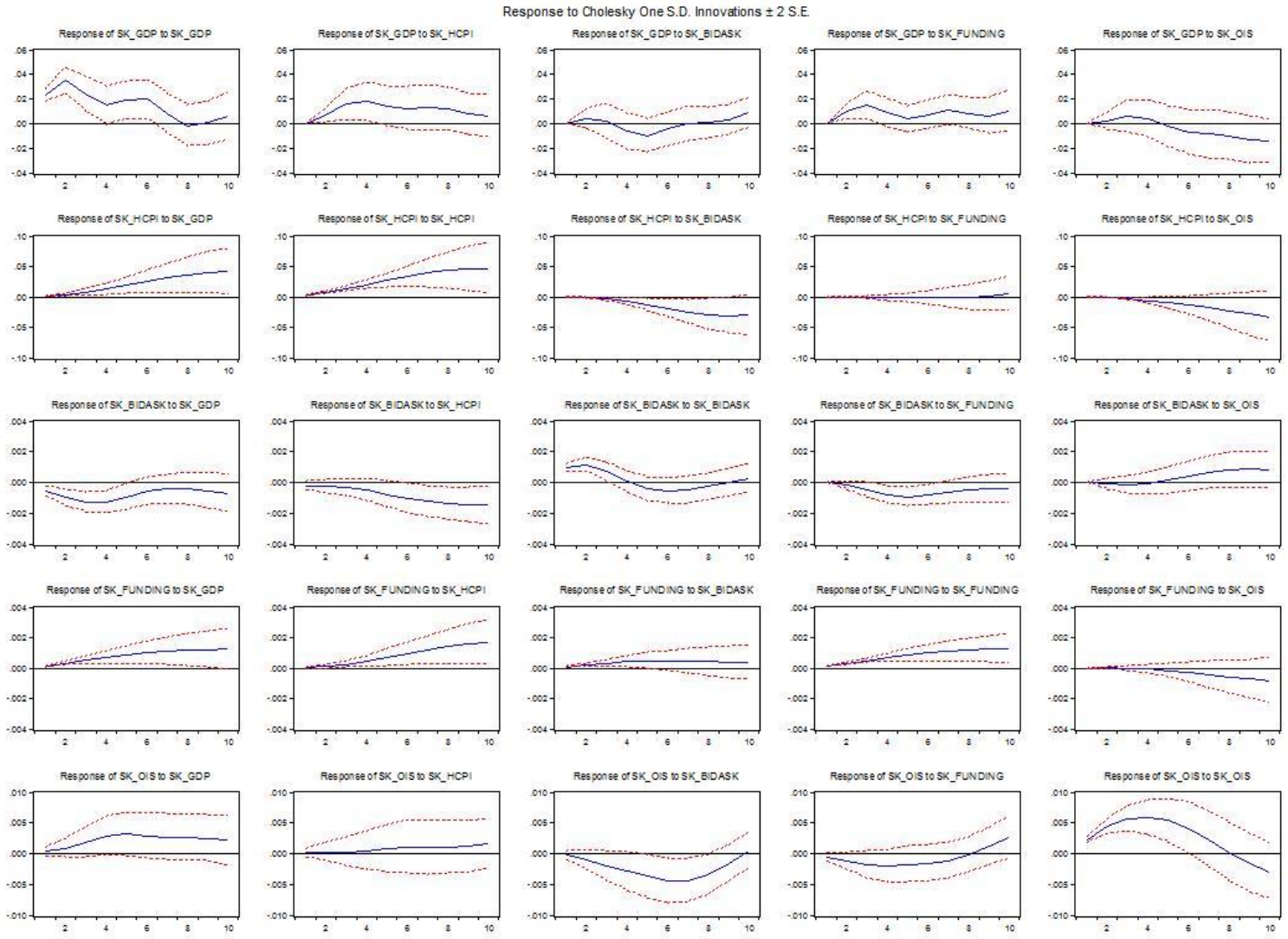
Source: The author's own calculation

5. Table: Results of VAR model based on Poland data



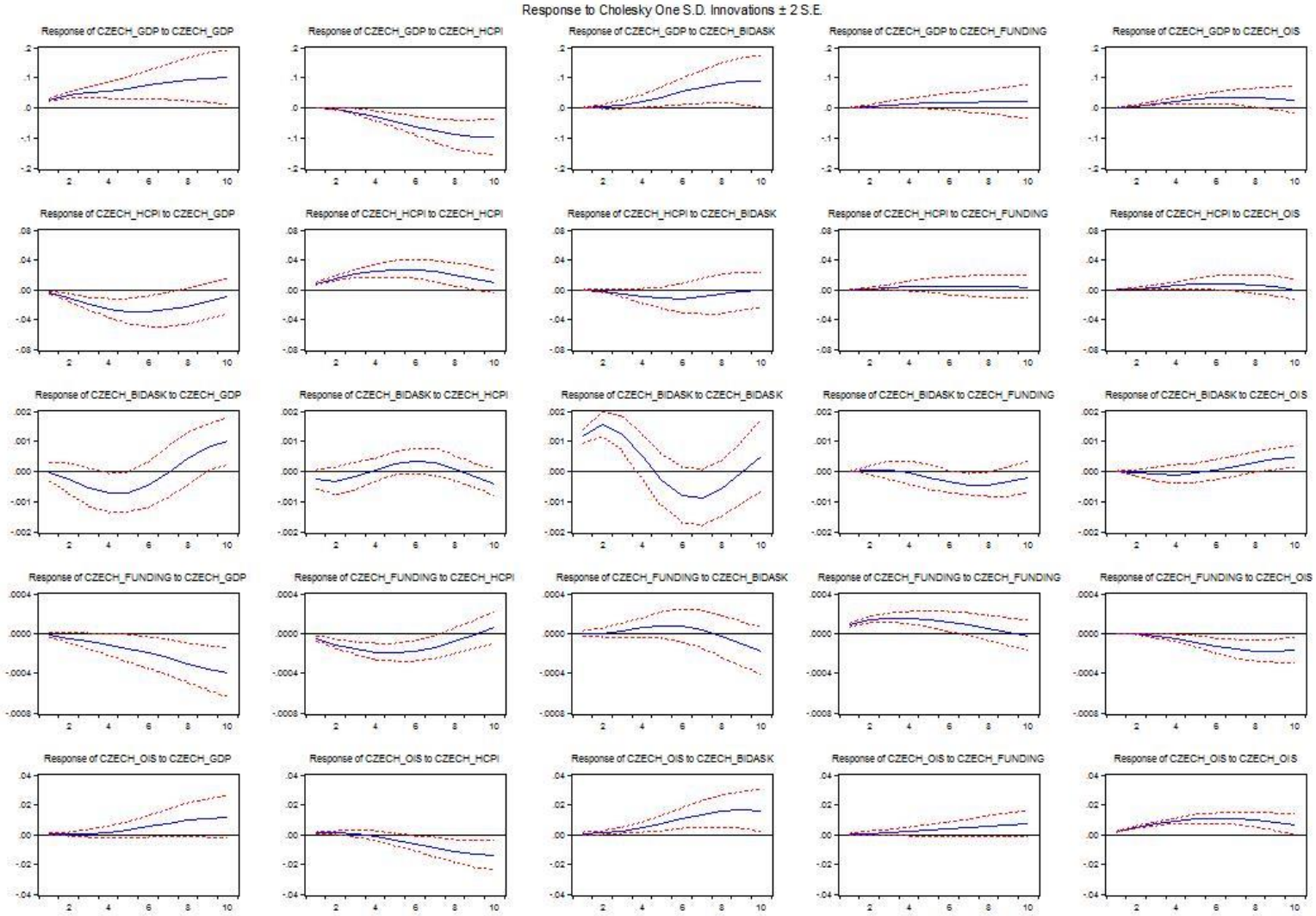
Source: The author's own calculation

6. Table: Results of VAR model based on Slovakian data



Source: The author's own calculation

7. Table: Results of VAR model based on Czech data



Source: The author's own calculation