TALLINN UNIVERSITY OF TECHNOLOGY

Tallinn School of Economics and Business Administration

Department of Finance and Economics

Chair of Finance and Banking

Erik Aru

BANKING BALANCE SHEETS AND FINANCIAL CYCLES

Master's Thesis

Supervisor: professor Karsten Staehr

Tallinn 2014

Olen koostanud töö iseseisvalt.

Töö koostamisel kasutatud kõikidele teiste autorite töödele,

olulistele seisukohtadele ja andmetele on viidatud.

Erik Aru ……

(allkiri, kuupäev)

Üliõpilase kood: 960104

Üliõpilase e-posti aadress: erikaru@ymail.com

Juhendaja professor Karsten Staehr:

Töö vastab magistritööle esitatud nõuetele

……

(allkiri, kuupäev)

Kaitsmiskomisjoni esimees:

Lubatud kaitsmisele

……

(ametikoht, nimi, allkiri, kuupäev)

CONTENTS

ABSTRACT

The concept of a financial cycle that was almost forgotten for half a century has risen like its ideological forebear the phoenix from the ashes after the crisis of 2007. This thesis gives an overview of the theoretical concept of a financial cycle, and a short summary of theoretical and empirical literature in the field.

As the interest for financial study in economics has increased rather lately, study of the financial cycle in Baltic States has been pretty much neglected. The empirical part lays a few tiles for the groundwork for the analysis of the financial cycle in this region. The leverage of banking sector in the Baltics turns out to have been largely acyclical during the last decade. That is good news for local policy makers, as in the US, for example, banking leverage has been pro-cyclical, amplifying fluctuations of the real economy. GDP growth and ECB's monetary policy together accounted for 43 percent of the variation in yearly changes of financial assets of the Estonian banking sector.

Keywords: Business fluctuations, Cycles, Monetary Policy, Banks

JEL Classification Number: E32, E52, G21

INTRODUCTION

Financial crisis has been for obvious reasons an extremely popular term in economics for the good part of a decade now. Reinhart and Rogoff (2009, p xxvi) divide financial crises into four: sovereign defaults, banking crises, exchange rate crises, and bouts of high inflation. Of, course, any kind of division is arbitrary to at least some degree, as all these different kinds of crises tend to happen in clusters. This thesis focuses on what constitutes for Reinhart and Rogoff (2009) a banking crisis: situations, where a notable part of a nation's banking sector turns out to be insolvent because of investment losses, a banking panic, or both.

As there are many different schools in economics, it is by no means surprising that views about the reasons of the crisis of 2007 also differ quite a lot, ranging from people explaining it from rational expectations perspective like to ones calling for discarding all previous macroeconomics and building the discipline anew like Colander et al. (2009).

One of the more prominent choir of voices in the discussion calls for the return into standard macroeconomic theory of the financial cycle that was banished from there in the second half of the 20th century. Instrumental in this were the views of Modigliani and Miller (1958) where real economic decisions became independent of financial structure altogether.

A return of financial cycle would mean including a banking sector into macroeconomic models. Obviously, for modelling purposes, a thorough understanding of the interdependencies of banking sector indicators is of crucial importance. While there have been developments going on in this field since 1980s, attempts at that have now started with a new urgency.

For Baltics, the study of financial cycles has been pretty much neglected until now. The aim of this thesis is to take a few tentative steps on the road of building the groundwork for the analysis of financial cycle in the region. To do that, a more thorough understanding of local banking sector and its driving forces is needed.

This thesis analyses the dynamics of changes in liabilities and assets of Baltic banks. The goal is to gain an understanding about the cyclicality of the banking sector leverage in the Baltics to better understand the money creation process during the financial cycle and also

learn how banking sector assets change – basically, how money created by banks changes – dependent on the monetary policy conditions. The hypothesis is that banking sector balance sheets increase when monetary policy is expansionary and decrease when monetary policy is contractionary.

To study the cyclicality of banking leverage, the yearly changes of total liabilities and financial assets of Baltic banks, calculated based on aggregate balance sheets of local monetary financial institutions, are plotted graphically. After that, correlation and regression analysis is used to find out the relationship between changes in Estonian banks' financial assets and the monetary policy of the European Central Bank (ECB).

The thesis is organised as follows. First there is a short overview of theoretical interpretations of the financial cycle starting with the interwar period through to contemporary formal models. As the amount of literature covering this topic is huge, there are bound to be omissions. Starting from 1980s there have been quite many attempts to include the financial sector into formal models, mostly through different forms of financial accelerator. That brings us to conflicting ideas about the role of finance in crises. As the term "accelerator" implies, most economists consider finance a factor that amplifies the real business cycle and shocks to the real economy. Some, most prominently the economists working for the Bank for International Settlements (BIS) think that finance should be seen – and modelled – as the root cause of crises. As they are in a minority, there are only a few examples of such models. Still others use the theory of complex networks to model the effects of patterns of banks' interconnectedness on the spread of the crisis.

Theoretical overview is followed by a summary of empirical studies on the topic. There is a pair of long term studies like Schularick and Taylor (2009) and Reinhart and Rogoff (2009), but most of the literature used focuses on the American and world experience during the crisis of 2007. The main topic is the role of leverage in crisis. It seems the relation is not always quite straightforward but depends also on other factors, like institutions, regulations etc. Mostly, though, the evidence seems clear – the more leverage you have the harder you fall. The topics considered are the severity of crisis experience of US households and counties, and nations, depending on the leverage ratio; the changes in leverage of different institutional sectors during financial cycle; the dependence of capital market funding on changes in banking balance sheets.

The empirical part of the thesis is divided into two. First, yearly changes in total liabilities and financial assets of Baltic banks are calculated and plotted graphically. Second, correlation and regression analysis is performed on changes in Estonian banks' financial assets and ECB's monetary policy.

1. FINANCIAL CYCLE IN ECONOMIC THEORY

With the financial crisis of 2007 the financial cycle, a concept known for over a century has regained a prominence it last had before World War II. The roots of the financial cycle lay in the nature of financial intermediary sector, more specifically in one of its characteristics called maturity mismatch – it borrows short (be it deposits for commercial banks or repos for investment banks and hedge funds) and it lends long, to businesses buying durables and building infrastructure, and individuals acquiring housing. That makes the intermediaries vulnerable on occasions when credit dries up. As the world witnessed a financial crisis of a magnitude last seen over three quarters of a century ago, the concept of a financial boom and bust cycle suddenly regained credibility in the eyes of many.

This chapter gives an overview of the financial cycle in economic theory. The chapter is organised as follows. First there is an overview of the concept of financial cycle and its different theoretical explanations. That is followed by a glimpse on various approaches to formal modelling of financial cycles, from early banking panic models, through many different forms of financial accelerator models, to models that look at the banking system as a complex network. (See Appendix 1 for a full table of models discussed.)

1.1. The concept of a financial cycle

Stories of cycles have played a part in many different cultures for many centuries, the story of the phoenix being reborn from ashes being one of the most well-known examples. So it is not very surprising that a theory of cycles was applied to economic fluctuations. Of course, there is a significant part of mainstream economists who deny the relevance or in some cases even the existence of business cycles. To find an example one needs to look no further than a popular introductory economics textbook that states that business cycle is a misleading term because economic fluctuations are completely irregular, and almost impossible to predict accurately Mankiw (2009, p 703).

First theories of business cycle began to arise in the first quarter of 19th century. A classic overview of different early cycle theories, first published in 1954, calls it one of the few truly original achievements of economists of that period (Schumpeter (2006, p 707)).

According to Borio (2012) the average length of the financial cycle in a sample of seven industrialised countries since the 1960s has been around 16 years.

That would be in line with the theoretical concept known as the Kuznets swing or Kuznets wave that has been interpreted as lasting anywhere between 13 to 25 years by different scholars. Kuznets himself called these waves "demographic" or "building" cycles/swings, connecting them with demographic processes – immigrant inflows and outflows that caused changes in construction intensity. Other interpretations describe Kuznets swings as waves of major investments in fixed capital and as infrastructural investment cycles. (Korotayev and Tsirel (2010, pp 11-12))

In modern literature the idea of a financial (or credit or leverage) cycle as we understand it is usually traced back to the debt deflation theory laid out in Fisher (1933) whose approach expands on the monetary theory of cycles created by Ralph George Hawtrey a couple of decades earlier. More recent non-technical interpretations of financial cycle include Hyman Minsky's (a compact overview can be found in Minsky (1992)), and Kindleberger and Aliber (2005) (first edition published in 1978) who theoretically in large parts draw on Minsky but illustrate it with many historical examples. There are at least three views on the role of money and credit in theoretical literature.

Most prominent in the last half a century has been the "irrelevance view" based in large part on Modigliani and Miller (1958) where money plays the role of a veil and real economic decisions are completely independent of financial structure altogether. According to this view money and banking can be left out of macroeconomic models completely.

Another view that is gaining traction among mainstream economists might be called "credit view" (and which will be called "the mainstream view" for the remainder of this thesis as the "irrelevance view" is for our purposes, well, irrelevant). It sees financial crises as a characteristic part of the business cycle. With an economic downturn the value of bank assets will fall, so the probability will increase that banks will have problems satisfying the clients' withdrawal requests.

Most economic modellers in this field have accepted this description and used the value of assets as the mechanism that ignites the cycle. Geneakoplos (2009), preferring to use

the term “leverage cycle”, points out that the laws of supply and demand can determine both the interest rate and leverage of the loan. The larger the demand (as borrowers get more impatient), the higher the interest rate; the more nervous the lenders become, or the higher the volatility becomes, the higher the collateral they demand. Standard economic theory has problems with this, as a single supply-equals-demand equation for a loan should determine two variables, both the interest rate and the leverage. So the usual solution in economic theory is to say that supply and demand determine only the interest rate.

But as variation in leverage impacts the price of assets, it also contributes to economic bubbles and busts. In boom times the leverage rises, becoming too high at some point. With higher leverage come higher asset prices, so when leverage gets too high, so do the asset prices. Conversely, during a bust leverage becomes too low. And, too low leverage during crisis periods means that asset prices will also fall by “too much”.

Geanakoplos (2010, p 2) lists three components that signal the end of a leverage cycle:

1) bad news that creates uncertainty and disagreement,
2) sharply increasing collateral rates, and
3) losses and bankruptcies among the leveraged optimists.

These factors reinforce each other, creating a feedback loop as uncertainty about exogenous events will give rise to uncertainty about endogenous events. Uncertainty about when prices will bottom out or who will survive the crisis leads to a tightening in lending that will further depress prices, etc. The aftermath of a crisis will bring depressed asset prices, reduced economic activity, and a subgroup of agents hovering near insolvency. The length of the aftermath depends on the depth of a crisis and on the actions government has taken to relieve it.

Geanakoplos (2010, p 4) lists the reasons leverage is important:

1) At the macro (sic!) level, it makes possible for a small group of people with little cash to own and control a large collection of assets.
2) At the single investor level, it makes possible to reap larger profits as an investor who buys his assets with a leverage of x times gets an x% return on his cash every time as the asset price rises by 1%; of course, he also loses x% of the cash he put down every time the asset price falls by 1%.

3) When taking hold of the collateral offers a possibility for the lender to salvage his money in case of a default, the borrower can walk away if the value of collateral falls below the debt, having an effective "put" option.

Geanakoplos (2009, 2010) represents the standard mainstream view of a financial crisis as a result of some shock to the real economy – although, a result that through a feedback mechanism will trigger a downward spiral that will bring an escalation of the crisis.

The widely spead opinion is that severe financial crises usually don't happen in isolation. Usually financial crises don't trigger recessions but act as an amplification mechanism. As the real output growth of an economy stumbles, some entrepreneurs and households will default on their bank loans, so banks start to lend more selectively, causing the output to fall even more, so more agents will have debt servicing difficulties, etc. According to this view finance acts as only the amplifier of a crisis of real economy. (Reinhart and Rogoff (2009, p 145))

But Reinhart and Rogoff (2009) also give a hint that financial crises might be a trigger to a recession. Now we arrive to the third view, the one that might be called "the money view" as it stresses the monetary nature of economy and considers the financial cycle as a culprit of real fluctuations.

As this view has been long forgotten for most mainstream economists, it causes some misunderstandings. One example can be seen in Allen and Gale (1998, 2000), according to whom Kindleberger and Aliber (2005) propagate the idea that financial crises are random events that are not related to changes in real economy but result mostly from mob psychology that causes bouts of mass hysteria. That view will basically relegate the financial crisis to a bank run or a stampede on the stock market that is brought about by "sunspots". Especially for followers of "irrelevance view" for whom money and credit are only a veil in the real economy classifying financial cycles and sunspots into the same bracket would come completely naturally, of course.

More true to the spirit of Minsky and therefore also of Kindleberger and Aliber than the idea of a stand-alone random financial crisis ascribed to the latter by Allen and Gale (1998, 2000) might be an explanation that "money view" sees the business cycle as a characteristic part of the financial cycle, not vice versa. Probably the most extreme version of this notion is Ralph George Hawtrey's theory of cycles as a purely monetary phenomenon as described in Schumpeter (2006, p 1087).

A completely different approach to modelling financial systems has arisen mainly in the last decade with the development of network theory. That will help to account for not only the probability of contagion but also its spread. As Allen and Gale (2000) explain, it is difficult to model contagion in banking during a crisis if there are no real connections between different regions – in that case, any pattern of correlations becomes possible.

1.2. Formal models of bank runs

After World War II the financial cycle was largely forgotten as credit was abstracted out of economic models. Although then only a few noticed it missing, Borio (2012) compares macroeconomics without the financial cycle to Hamlet without the Prince.

As one of the first signs of a comeback, Diamond and Dybvig (1983) formalise the idea of a financial crisis as brought about by mass hysteria, describing bank runs as self-fulfilling prophecies. There are banks that have a comparative advantage in investing in illiquid long-term assets. As individuals want to take advantage of that, they deposit their funds on the first period. Depending on their consumption preferences they withdraw the deposits either on the second or on the third period.

There are two equilibria, one where every depositor believes a bank run is coming, and another where no one awaits a bank run. In the case of the first equilibrium, in a first-come, first-served world it is rational for everyone to withdraw their deposits at once, as the earliest get most of the money. In the latter equilibrium only those that have immediate needs for liquidity will withdraw their deposits, so in this case there will be no banking panic provided the banks have enough cash on hand. Which equilibrium occurs, will be determined exogenously.

For a model of bank runs in case of a single equilibrium, see Postlewaite and Vives (1987) who demonstrate that even when there are no exogenous shocks there is a positive possibility for a bank run. There are four periods, 0, 1, 2, 3, and two agents, each having one unit of endowment, who will live for one, two or three periods. On period 1 they will get a signal which indicates their lifespan. Each agent deposits an amount to a bank that plants the seeds. On periods 1 and 2 they can draw the deposit without interest, on period 3 they will also get a share of the profits. If demands for withdrawal exceed assets, all assets will be distributed proportionally to the demands. That will create a Prisoner's Dilemma situation

when an agent learns that both will live for two periods – both will withdraw on period 1 as it is the best they can do.

A further development of Diamond and Dybvig (1983) model is put forward in Allen and Gale (1998) as follows. The illiquid assets that banks invest in are risky and information about the returns earned on those investments becomes available a period before the returns are realized. Obviously, bad information can cause a run on the banks as "late" depositors who in other circumstances would be happy to hold their funds in banks until the third period also want to withdraw their funds.

Gorton (2010), Gorton and Metrick (2012), and Mehrling (2011) have drawn analogies between classic bank runs and modern runs on capital market intermediaries that are caused not by depositors cueing behind bank doors but increases in collateral requirements and decreases in borrowing capacity as permitted leverage falls. So it cannot be said that a bank run would be an obsolete model for current capital markets.

Diamond and Dybvig (1983) remains an often-cited paper as it is the first formalising the relationship between banking crises and asymmetrical information (banks having the comparative advantage in investing). However, as a bank run is normally considered by economists just one of the symptoms of financial distress – although one that can aggravate its consequences – most models have tried to reach a more generalized level.

1.3. Models with a financial accelerator

The 1990s brought a new wave of formal models with financial expansion and contraction. Bernanke, Gertler and Gilchrist (1996) introduced the term "financial accelerator", while the idea behind it is known for at least hundred years. The concept is also used by Fisher (1933) when analysing debt-deflation, for example.

The financial accelerator is referring to the fact that relatively small impulses can cause large fluctuations in aggregate economic activity as worsening credit-market conditions create a downward spiral in the real economy, amplifying the initial shock. This could be witnessed once again during the financial crisis of 2007 as while the size of the estimated losses from subprime loans and securities was about 250 billion dollars as of October 2007, the expected cumulative loss of world output was 4,700 billion dollars, based on the forecasts

of IMF, and the decline of world stock markets from July 2007 to November 2008 was 26,400 billion dollars (Blanchard (2009, pp 2-3)).

One early attempt to include financial intermediation as an essential part of an equilibrium business cycle model was Williamson (1987), another Bernanke and Gertler (1989). The latter might be considered the first widely published financial accelerator model, predating the exact term by seven years – although the article does make a few references to "accelerator".

In Williamson (1987) financial intermediation is the main conduit for borrowing and lending because of asymmetric information and costly monitoring. As entrepreneurs have more information about their prospects than the households who have the funds to finance their investments, the households need to invest through intermediaries (banks) who have an advantage in monitoring the entrepreneurs. A credit supply effect ("rationing") contributes to real output fluctuations as a fall in new loans by intermediaries reduces the output in the next period.

Bernanke and Gertler (1989) also lay out the principal-agent problem in credit-markets. Their focus is on borrowers' balance sheets. They use a stochastic neoclassical growth model with overlapping generations. Each generation of individuals lives for two periods and can earn wages only on the first period, so they must save for the second. There are two classes of agents, entrepreneurs and lenders. Realised outcome of an investment project is costlessly observable only to the entrepreneur concerned. Others must use auditing technologies.

In the model the strength of borrowers' balance sheets is the driver of output dynamics. Strengthened balance sheets expand investment demand, amplifying the upturn; during a downturn, the opposite happens. Agency costs fall during the upturn, and rise during a downturn (this could be interpreted as costs of bankruptcies and liquidations). Real fluctuations are triggered by shocks to borrower net worth independent of aggregate output. Basically, agency costs that fall during an upturn and rise during a downturn are sufficient to introduce investment fluctuations and cyclical persistence into an economy that would have neither of these without agency costs.

The financial accelerator can be interpreted theoretically as a result of endogenous changes in the agency costs of lending over the business cycle as in the good times agency costs fall, in bad times agency costs rise.

Bernanke, Gertler and Gilchrist (1996) develop the concept further and tie it with empirical evidence. They interpret the relatively lower share of credit received by borrowers that face higher agency costs as flight to quality. Consequently it also means that borrowers with high agency costs account for a proportionally bigger slice of the fall in economic activity. The rise in agency costs for highly indebted borrowers can be interpreted as bankruptcy and liquidation costs.

Bernanke, Gertler and Gilchrist (1999) is a synthesis of previous models, additionally bringing in money and price stickiness to simulate monetary policy in an economy with credit-market frictions. They also include decision lags in investment. That allows the model to generate a delayed, hump-shaped response of output dynamics that is consistent with data. Also a lead-lag relation between asset prices and investment appears. A third addition to previous models is heterogeneity among firms allowing to take into account that not all borrowers have the same access to capital markets.

Another seminal paper is Kiyotaki and Moore (1997) who find a similar dynamic in an intertemporal model where lenders cannot force borrowers to repay their debts unless the debts are secured. In this framework durable assets play a dual role: as factors of production, and as collateral for loans. The only durable asset in this model is land, so all loans are secured with land.

There are two types of agents, impatient ones ("farmers") who wish to borrow to finance their investment plans, and patient ones ("gatherers") who wish to save (of course, more conventional would be to call the former "entrepreneurs" and the latter "households"). Farmers have to put up land as collateral when they wish to borrow. If the value of land falls, so does the amount they can borrow. This creates a feedback effect – a fall in borrowing and investment further depresses the land price that in turn creates another pullback in borrowing and investment and so on. In this way small, temporary shocks to technology or income distribution can be amplified into large economic fluctuations.

Schleifer and Vishny (1997) took an approach more focused on asset markets. Their model shows how during times of distress asset prices can get more misallocated than warranted by fundamentals. Basically, almost all arbitrage requires capital, and is typically risky. Professional arbitrage is a fief of a relatively small number of specialized investors, who use other people's capital.

Here an agency problem comes into play. As these other people do not know or understand what the arbitrageur is doing, they judge his performance based on past returns. During market distress, they might get worried and pull their capital out. That would imply that such arbitrage is particularly ineffective in times when prices are significantly out of line and arbitrageurs are fully invested. If owners of capital get scared and pull out, the arbitrageurs also will have to sell their assets in the worst possible time when they actually should be buying. A noteworthy difference with both Bernanke and Gertler (1989) and Kiyotaki and Moore (1997) is that Schleifer and Vishny (1997) deal with balance sheets of intermediaries, not borrowers.

A large part of research has focused on finding out which sectors will be worst hit by a credit crunch. The typical and intuitive answer is that small, capital-constrained firms.

In Holmstrom and Tirole (1997) a firm's creditworthiness is determined by its net worth. Firms with low net worth cannot get direct financing from uninformed investors but have to find an intermediary. Intermediaries use tighter monitoring as partial substitute for collateral – and therefore their loans are also more expensive. The article deals with effects that reductions in different types of capital have on investment, interest rates and forms of financing. As the model includes both demand factors (changes in collateral) and supply factors (changes in intermediary capital), it is possible to identify separate "balance sheet channel" and "lending channel" – a first for a formal model.

Firms with high net worth can get cheaper asset-backed loans. Firms with low net worth have to pay a premium for monitored loans. When monitoring capital contracts, the spread between the loans will rise, and more highly leveraged firms will get squeezed. If both asset-backed lending and monitored lending contracts, the sign of the change of the spread will be determined by the relative change in the amounts of capital.

Lorenzoni (2008) aims to create a theoretical explanation based on Holmstrom and Tirole (1997) why a financial boom might be inefficient from *ex ante* perspective and what could and should be done to avoid it. If risk perceptions of agents are correct, the risk of a negative shock should be taken into consideration in their optimal decisions. If they conclude that expected benefits of current consumption outweigh the expected costs of future financial problems, they decide to borrow heavily which may lead to socially inefficient decisions that may call for government intervention.

In case of a negative shock, entrepreneurs will have to sell assets that will affect aggregate asset prices – an effect an atomistic entrepreneur will not consider. The main conclusion of Lorenzoni (2008) is that excessive borrowing *ex ante* can result in an excessive contraction in investment and asset prices *ex post.* Reducing aggregate investment *ex ante* will bring a smaller need for asset sales after a negative shock.

One of the criticisms for both Bernanke and Gertler (1989), and Kiyotaki and Moore (1997) was that their amplification mechanism can be undone if we introduce a possibility to insure or hedge against price swings. Krishnamurthy (2003) shows that by including insurance into a simplified form of Kiyotaki and Moore (1997) the collateral values and output will remain correlated as collateral is also used as a productive input. But the mechanism where changes in collateral values feed back into output values will disappear because the borrowing agent does not have to bear the full burden of declining collateral values. He addresses that problem for by proposing incomplete hedging that is constrained by the aggregate value of collateral so the amplification mechanism will become functional again.

Some, like Gromb and Vayanos (2002) and Brunnermeier and Pedersen (2009) focus on modelling the interaction of funding liquidity (the ease of borrowing) with market liquidity (the price impact of sales). They bring in the "margin spiral" with models that connect an asset's market liquidity with traders' funding liquidity. Market liquidity is provided by traders who depend on availability of funding. But as traders' funding also depends on assets' market liquidity, margin calls can be destabilising and can cause a liquidity spiral because in illiquid markets market liquidity is very sensitive to further changes in funding conditions.

Christiano, Motto and Rostagno (2005) use Bernanke, Gertler, and Gilchrist (1999) model as a basis for a counter-factual policy analysis with an aim to evaluate the Friedman-Schwartz hypothesis that with a looser monetary policy by the Federal Reserve the Great Depression of 1930s could have turned out much milder. Their conclusion is that the hypothesis holds.

Carlstrom and Fuerst (2007) build on the Bernanke and Gertler (1989) model where entrepreneurs only live for one period, extending it to allow for long-lived entrepreneurs. Again we have entrepreneurs and households as their lenders. The model shows that endogenous agency costs can alter business cycle dynamics because after a shock households

wait for agency costs to fall to their lowest point – that will come several periods after the shock – before taking investment decisions.

All models described so far focus on the net worth of assets. The leverage ratio stays constant, financial tightening is brought about by a change in collateral prices. Another possibility is to look at changes in leverage. Geanakoplos (2009, 2010) introduces the leverage ratio as a variable. He defines leverage as the ratio of collateral values to the downpayment that has to be made to buy them (Geanakoplos (2009, p 6)). He believes that endogenous leverage does not have to be based on asymmetric information – for example, he does not think that asymmetric information played a critical role in determining margins during the crisis of 2007 (Geanakoplos (2009, p 5)).

A two-period model shows that when two assets are identical, but only one can be leveraged then efficient markets pricing and even the law of one price will fail. The reason is that it takes fewer optimists to buy all of the asset shares and drive up the price if an asset can be leveraged.

In a three-period model the asset pays in the third period, in the second period news arrives about the pay-off. News is divided into bad news that lowers expectations and scary news that also increases volatility. Scary news will drop the price of an asset more than any agent thinks it should, as leverage collapses and most optimistic agents go bankrupt. This leads to a suggestion that central banks might consider monitoring and regulating not only the interest rate but also leverage. In this model, under certain circumstances a crash happens anyway, even if all agents are acting perfectly rationally.

As banks in real life use value-at-risk (VaR) models to determine the risks they are facing, some models make use of VaR as a constraint on financial intermediaries. An early version of a model with VaR-constrained traders is Danielson, Shin and Zigrand (2004) who using a general equilibrium model focus on the effects of risk regulations. The impact of a binding VaR constraint is similar to a rise in the underlying risk aversion of traders. They concluded that risk regulations perversely lower prices and liquidity, while increase volatility, making the financial system less stable.

Adrian and Shin (2008c) build on Holmstrom and Tirole (1997) for the analysis of a contracting model of leverage. Both leverage and balance sheet increase when risks decrease. In case of an exponential distribution of losses intermediaries act according to the VaR rule so

that equity always matches total VaR, maintaining a constant probability of default and adjusting their exposure accordingly.

The model has two periods, one agent, an intermediary (bank) that finances itself through collateralised borrowing (repurchasing agreements), and one principal, the creditor of the bank. The bank invests in assets at 0, and reaps rewards and repays its' creditor at 1. A fall in permitted leverage can lead to a funding crisis for banks which are unable to decrease their balance sheets according to the amount of funding withdrawn. That can lead to a run on an institution. A further development can be found in Adrian and Shin (2013).

Angeloni and Faia (2009) introduce banks with endogenous capital structure that provide liquidity to both depositors and entrepreneurs into a standard DSGE model. Banks that have skills for redeploying capital when a project gets liquidated early have two kinds of financing – deposits and capital – and are exposed to runs. There are two kinds of incentives to discipline the agents: depositors can run the bank and bank can withhold its skills for capital redeployment. Desired capital ratio is a trade-off between balance sheet risk and higher returns for investors in "good" states.

The model offers a possibility to study the interplay of monetary policy and bank regulation – the effects of capital requirements – for crisis prevention. Expansive monetary policy or a positive productivity shock increase bank leverage and risk, while pro-cyclical capital requirements (like Basel II) amplify the cycle. Angeloni and Faia (2009) conclude that the best policy mix combines mildly anti-cyclical capital ratios (so banks accumulate capital in good times) with a monetary policy that responds to inflation and asset prices or leverage.

Adrian and Boyarchenko (2012) develop a DSGE model with an endogenous solvency risk of the financial sector. The leverage cycle of the financial sector propagates fundamental risks in the model. In the model financial intermediaries have access to better capital creation technology than households. Intermediaries also provide risk bearing capacity as they accumulate inside equity. If negative shocks to intermediaries' balance sheets are large enough and their net worth falls lower than a threshold, systemic solvency risk and a need to restructure will arise. Deleveraging will occur by debt writedowns, so households will experience losses.

Adrian and Boyarchenko (2013) build on the same model, but bring in another type of financial intermediaries as empirical studies have shown that the cyclical behaviour of leverage differs by financial subsectors (see section 2.5). In this model bank and fund sectors

compete for households' savings. Households can invest into risk-free debt, risky debt of the bank sector and equity contracts with funds. The conclusions are that while the leverage of the whole intermediary sector is pro-cyclical, the leverage of banking sector is also pro-cyclical as their funding is risk-constrained but the leverage of fund sector is acyclical as households are unwilling to reduce their holdings of fund equity during downturns.

Brunnermeier and Sannikov (2012) build a model to study full equilibrium dynamics, not just near the steady state, of an economy with financial frictions. There are two types of agents, experts and households that are less productive. Both can own capital, but experts' ability to do so depends on their net worth, determining also the asset prices.

Around the steady state the system is characterised by relative stability, low volatility and reasonable growth. Away from the steady state a very different picture emerges. The amplification effects are highly non-linear, so the system can fall much below the stochastic steady state and stay there for a significant amount of time (without government intervention). Below the steady state volatility shoots up and system becomes more unstable. So the fat tails of asset prices are caused mainly by endogenous risk, not some rare exogenous events. In the case of low exogenous risk, experts take on more leverage causing systemic volatility spikes. Hedging of risks in financial system brings lower exogenous risks, but increases endogenous risks.

He and Krishnamurthy (2012) build a model that describes the consequences of limited intermediary capital on asset prices, the goal being an equilibrium model of intermediation that is dynamic, parsimonious, and can be realistically calibrated. There is a risky asset and two groups of agents, households and specialists. Households cannot directly invest into the risky asset, so they need specialists to do it for them. The only other option for households is to invest into a risk-free short-term bond (as such a solution simplifies the analysis). Specialists are constrained by equity capital. When the constraint binds, i.e. intermediary capital gets low, risk premia rise, as capital gets scarce. Another feature considered is the pattern of recovery of spreads.

He and Krishnamurthy (2012) also evaluate the effects of three government crisis resolution policies: reducing intermediaries borrowing costs, injecting equity capital, and purchasing distressed assets. Injecting equity turns out to be most effective as it directly deals with equity capital constraint that caused the crisis in the first place.

1.4. Models for emerging market crises

Occupying the middle ground between models where the financial sector's role is to amplify real shocks and models where the financial sector is the culprit of crises are models of emerging market economies. In these models the spark for a crisis that hits the real economy can come also from the financial sector. But as the financial sector in question is the global capital market, the shock in this case is also often largely exogenous by nature. These models might in some cases have relevant also for developed countries as there have, for example, been comparisons between the Eurozone crisis and financial trouble in emerging markets (see De Grauwe (2011)).

While the models described so far in this thesis have dealt with financial constraints in developed economies, modelling emerging economies means that external financing complete with an external financing constraint has to be brought in. In parallel with the development of financial accelerator models for advanced economies, another strand of studies focused on constraints that come with international borrowing. Bulow and Rogoff (1989) show that under relatively general conditions a small country's reputation for repayment is not enough and international lenders will demand direct sanctions made available to them for the event of a default. Atkeson and Rios-Rull (1996) construct a model where a small country is hit by a current account crisis as international borrowing constraint kicks in. Calvo (2000) demonstrates that while large current account deficits make it more difficult to mitigate the effects of self-fulfilling crises with domestic policy, a currency crisis can occur without a deficit. The paper mostly focused on how large capital inflows magnify financial vulnerability.

So it would be only natural that before long somebody would try to combine these two types of models. Caballero and Krishnamurthy (2001) build a model showing how sudden stops in credit flows can spark a crisis. They take a model like the ones described in section 1.3 where microeconomic constraints limit a country's ability to reallocate resources, creating so a financial amplifier (the model discussed is based mostly on Holmstrom and Tirole (1998)), and combine it with emerging markets models, where a constraint on aggregate borrowing brings distress to the real economy.

Firms have limited international collateral (for example, export revenues), so there is a limit on foreign financing they can get. They also have domestic collateral (for example, real

estate) limiting the amount they can borrow from other domestic firms. These two constraints interact in two different ways.

If the banking sector's ability to reallocate resources is hampered by falling asset prices, a binding international constraint will make matters worse. The international constraint brings sharply rising interest rates and a fire sale of domestic assets leading to a contraction in real activities.

The other form of interaction is a dynamic effect as limited domestic collateral can lead to wasted international collateral. Companies tend to undervalue international collateral and overborrow at date 0. At date 1 they will have less international collateral than the efficient outcome would be, so a negative shock will be amplified by the lack of enough international collateral, and the effect of the shock on investment and output will be amplified on date 1.

Fostel and Geanakoplos (2008) bring the leverage cycle to the emerging markets. The aim is to provide a theory for asset pricing for emerging markets that are not mature enough to be attractive for the general investor. They use a general equilibrium model that has heterogeneous agents, incomplete markets, endogenous collateral, and an extension that encompasses adverse selection. They argue that crises hitting emergent markets are not always due to fundamental problems but can be caused by what they call the "anxious economy". Anxious economy is defined as a state between a normal economy and a crisis or panicked economy where there is a large liquidity wedge (the spread between the interest rate optimists are willing to pay and the interest rate pessimists are willing to take) for assets, leverage is limited and pessimists (the anxious general public) are selling risky assets, but there are still optimists on the market who are more confident. Anxious economy is a state that is ten to 20 times more frequent than a crisis, occurring about twice in a year.

Geanakoplos and Fostel (2008, p. 3-4) pose three questions:

1) Why does bad news concerning one sector affect other sectors with independent payoffs? (The background being that the spreads of emerging market and high yield bonds are 33 percent correlated although their payoffs are not correlated.)
2) Why do the prices of bonds with independent payoffs not fall uniformly? (Spreads of high-rated bonds increase less than spreads of low-rated bonds.)

3) Why does the issuance of bonds with independent payoffs not fall uniformly? (The drop in issuance of high-rated emerging market bonds drops more, although the spreads change less.)

The first question can be answered by portfolio and consumption effects. The portfolio effect appears as anxious investors abandon high-yield bonds. Optimists, sensing a bargain, buy these bonds, but in order to do so they have to unload some other assets, like emerging market bonds, an alternative being refraining from consumption. The consumption effect comes into play as today's consumption falls, dragging along the relative marginal utility of assets that promise payoffs enabling to consume in the future.

Flight to collateral might be an answer to the second question as investors prefer assets that have a higher collateral value. The third problem comes from information asymmetry as investors are not able to differentiate between good and bad countries, so paradoxically the good ones suffer more.

Mendoza (2010) uses a DSGE model with an endogenous collateral constraint that limits total debt to explain why after sudden stops in emerging economies financial crashes are followed by deep slumps. During expansions leverage will rise, until it releases the constraint. The constraint will act in line with debt deflation mechanism of Fisher (1933) amplifying macroeconomic fluctuations and turning them asymmetric. This tightens the constraint further, causing a spiral as credit, asset prices, investment and consumption collapse, and net exports increase.

1.5. Models with the financial sector as the cause of a crisis

There is a difference between two approaches to finance – ones who see it as only the amplifier of a crisis of real economy, and others who see is as the cause. The mainstream approach is that severe financial crises are rarely a *ceteris paribus* event. Usually the financial crisis is not the one that triggers the recession, rather it acts as an amplifying mechanism. As output growth decreases, there will be defaults by borrowers, causing a fall in bank lending that depresses output even more, so there will be more problems with debt repayment, etc. (Reinhart and Rogoff (2009, p 145))

The other approach is described in Borio (2012). He is pretty dismissive of modelling where the only role for the financial cycle in this is to enhance the persistence of economic

shocks that hit the economy, so the return to long-term equilibrium will be slightly delayed – as an example he brings Bernanke, Gertler, and Gilchrist (1999). (Borio (2012, p. 1))

He has a list of three essential features that require modelling (Borio 2012, pp. 8-9):

1) A financial boom should cause the bust, not just precede it.
2) There should be debt and capital stock overhangs (disequilibrium excess stocks).
3) The model should distinguish between potential output as non-inflationary output and as sustainable output. (Sustainable output is defined in Borio, Disyatat and Juselius (2012) as output that when reached, can be maintained indefinitely. Equalling it with non-inflationary output is deemed too restrictive as it is possible that inflation stays low and stable, while output grows on an unsustainable path because of increasing financial imbalances.)

Borio (2012, pp 10-11) also has a list of three steps how models that fit to his requirements should be constructed:

1) Moving away from model-consistent ("rational") expectations. He considers it artificial to model the build-up and unwinding of financial imbalances while assuming that agents have a full understanding of the economy.
2) Allowing for attitudes towards risk to vary with the state of the economy, wealth and balance sheets.
3) As a more fundamental issue he considers capturing more deeply the monetary nature of the economy. He thinks models should deal with true monetary economies, not with real economies treated as monetary ones.

A formal model in this vein, focusing on financial intermediation, noted with approval by Borio (2012), is given in Gertler and Kiyotaki (2010). It has firms, each located on an island, producing according to an identical Cobb-Douglas production function with constant returns to scale, and labour and capital as inputs. Capital is not mobile, but labour is perfectly mobile. Some islands have investment opportunities, some do not. New capital can be acquired from households via financial intermediaries only by firms on islands with investment opportunities.

In each period, banks raise funds on the national market that is divided into retail market of deposits from households and wholesale market of interbank financing. As bank managers can divert funds to their families, a bank faces constraints in getting funds both from depositors and wholesale markets. These financial frictions impact through banks the

funds available to the real economy – and weakening bank balance sheets can also cause a crisis by depressing credit flows. For simplicity, there are no frictions in bank lending to firms. A fraction of banks on islands with low expected returns can move each period, selling their loans to nonfinancial firms to other banks on the island for interbank loans, bringing in arbitrage in the beginning of a period.

1.6. Models of complex networks

One of the problems that arise while modelling financial crises is how to account for the interconnectedness of the financial system. The models presented earlier in this thesis are extremely stylised. Gai and Kapadia (2010) conclude that existing literature (along the lines elaborated in previous sections of this chapter), while trying to give the probability of contagious default, has nothing to say about its potential spread. So they, along with some, mainly European economists have tried to correct this deficit by applying network theory that considers the financial crisis as an epidemic spreading through interlinkages between banks. This comparison is not far-fetched as complex networks theory has earlier been used to estimate the spread of epidemics, and one author of economics papers with the Bank of England, Dr. Nimalan Arinaminpathy, actually is an epidemiologist, while Lord May of Oxford is an ecologist.

The model presented in Allen and Gale (2000) that builds on Allen and Gale (1998) could be considered a forerunner. It uses a network of four banking regions to show how the contagion depends on the pattern of connections between banks. The model has three periods and a large number of consumers who have one unit of consumption good each. At period 1 they get to know whether they are early consumers who prefer to consume at period 1, or late consumers who prefer to consume at period 2.

Banks collect the units of consumption as deposits and invest these. There are two possible investments, short-term asset that pays one unit in return on period 1, and a long term asset that pays less than 1 on period 1 or more than 1 on period 2. Banks from different regions exchange deposits on period 0, so if a region has a more than average amount of early consumers, the banks there can withdraw their' deposits in other regions.

When all banks are connected to each other, all exposures are spread evenly, so in case of a shock each bank takes only a minor hit. But when banks have connections to fewer

counterparties the network gets more fragile. As neighbouring banks get hit, they have to liquidate their assets and the ensuing depression of asset prices has consequences to the whole of the financial sector.

Nier et al. (2008) likewise investigate how the risk of a systemic breakdown depends on the structure of the banking sector. They construct a banking system as a network of N nodes linked to each other. Then they vary the key parameters of the system – level of capital, the degree of interconnection, the size of interbank exposures, the degree of concentration of the banking system – while imposing shocks on it.

First, there is a positive non-linear relationship between capitalisation and resilience of the banking system. Second, the degree of connectivity has a non-monotonic effect creating an M-shaped chart, as a small increase in connectivity strengthens the contagion. However, above a certain threshold more connectivity brings a better resilience to shocks. Third, as the percentage of interbank liabilities in total assets gets larger, so does the risk of a contagious default. Fourth, when the banking system gets more concentrated – i.e. has a smaller number of banks with a given amount of assets – the systemic risk increases. That might be caused by two channels. The more concentrated a system gets the larger is the shock of a bank defaulting. Also, in a concentrated system interbank exposures play a more prominent role in contagion as the exposure to a single bank plays a more prominent role of total assets.

Cornand and Moysan (2009) question whether interconnections between banks weaken or strengthen the financial system. They analyse the contagion resulting from a small number of defaulting agents. The network has n number of homogenous agents (or dots) that fall into three types: healthy agents, contaminating agents and contaminated agents (the latter two are classified as toxic agents). The financial flows incoming and outgoing are about the size of the dot. The agents' actions depend on their capitalisation.

They conclude that above a certain number of links systemic risk is permanent as with each connection a toxic agent is tied to more healthy agents. Systemic risk falls as average level of capitalisation increases.

Gai and Kapadia (2010) were the first to present an analytical model of contagion in financial networks with arbitrary structure. It describes a system of n financial intermediaries (or banks), each of them a node in a random network, linked together by their claims on each other. Directed and weighted links between banks mimic interbank exposures. Incoming links are a bank's assets, outgoing links are its liabilities. Interbank liabilities of a bank correspond

to interbank assets of other banks. This joint degree distribution is taken as completely arbitrary. Each bank has a balance sheet of interbank assets, illiquid assets, interbank liabilities and deposits.

As this description shows, this model also has two channels of contagion. First, after the initial default the losses can spread through counterparty exposures. Second, as asset prices get depressed by the crisis other banks are forced to write down assets, so other defaults may follow.

As a result they conclude that financial systems show robust-yet-fragile tendencies, acting in some cases as a shock absorber and in others as a shock amplifier. Although interconnectedness allows to spread risk more widely and to absorb it better, a wave of defaults can spread much more widely through interlinkages. The model also shows how indistinguishable shocks can have very different consequences depending on the point in network that they hit. So it can be concluded that a system's resilience to fairly large shocks (as seen in the financial system prior to 2007) cannot be taken as a proof of its robustness in the future.

Amini et al. (2013) complain that discussion over contagion is dominated by either very stylised models or models that give heuristic results like Gai and Kapadia (2010). So they aim for a model that is analytically tractable and able to mimic the empirical features of real financial systems. One of the results they find are asymptotic limits for the size of contagion in financial networks that follow arbitrary shocks to the system. Another is a measure of a financial system's resilience to small shocks. For a large system where there are few defaults initially, the result depends on the structure of contagious links – exposures that are larger than the nodes' capital. As a third result they develop a probabilistic method for analysis of default cascades.

Georg (2010) compares contagion in different types of networks, using a network model of banks, firm and household sectors, and, notably, a central bank. The focus is on global properties of financial systems with the goal of assessing their inherent stability and analysing the transmission of monetary policy in three different network types – Barabási-Albert (scale-free), Watts-Strogatz (small-world), and random networks.

Intuitively, contagion is stronger in banking networks, where the average path is short and clustering is small – but this intuition turns out to be true only in the case when there is no active central bank. The inclusion of a central bank changes the network structure and the

flow of funds. Another conclusion is that large amounts of interbank liquidity will endogenously incur financial instability. The threshold level of liquidity depends on the structure of the network. The model does not show that a heterogeneous banking network would be more unstable than a homogeneous.

Georg (2011) demonstrates a dynamic multi-agent model of a banking system with a central bank. Banks that are linked by interbank loans hold a portfolio of risky investments and riskless reserves. Deposits are supplied stochastically.

One conclusion is that a liquidity injection by the central bank has more effect on the short term than on the long term. It turns out that network structures do not play a role in normal times, but are important to long-term stability during a crisis. Money-centre networks, where there are a few very interconnected banks, and many less interconnected banks can absorb risk better than random structures.

Systemic risk can be divided into two: contagion, when default of a bank hits others through interbank exposures, and common shocks that hit many banks simultaneously through common asset holdings. While the first type depresses mainly interbank liquidity, with the second banks with insufficient equity will become insolvent. While the number of insolvent banks may be small, many others will see deposit and asset return fluctuations, meaning there will be an endogenous problem with interbank liquidity. Therefore different types of shocks also require different policy responses. While interbank contagion can be cured with a liquidity injection, to overcome common shocks the banking system will need more capital.

Haldane and May (2011) and Arinaminpathy et al. (2012) basically describe the same model. They divide the channels of contagion into three. First, after a default lenders will lose at least a part of the loan. Second, a fall in market prices whether just because of general market conditions, because of an increase in expected defaults, or because of a fire sale of assets by a bank in distress will deplete the external assets of banks. Third, the availability of interbank lending will decrease.

The model can include banks of different sizes, including a few very large universal banks that are connected to many small ones. It is able to take into account the empirical fact that the networks tend to be disassociative rather than proportionately connected. Large institutions have disproportionately many connections to smaller ones and vice versa. Studies of epidemics have shown that this form of network will maximise the number of people

infected by an agent. But there is also a positive side to this form of network. It is expedient for cohabitation of a larger number of banks and will be more resilient to random losses.

1.7. Conclusion

With the financial system gaining new urgency for macroeconomic modelling, a strive for models closer to real life is notable. As modelling not only the net worth of banks but also the leverage they carry allows a truer portrayal of different channels for financial tightening, expect to see many more models in the vein of Geanakoplos (2009, 2010), Adrian and Boyarchenko (2012, 2013), etc. Another form of models we will probably see proportionally more of, are the ones based on complex networks as these open new perspectives for predicting contagion.

The jury is still out on the models where the banking system is considered to be the main culprit of the crisis of the real economy. As accepting such causation would demand a considerable change of view for most mainstream economists, these models will probably remain a minority in near future although they do have a prominent champion in the form of the Monetary and Economic Department of the Bank for International Settlements.

2. FINANCIAL CYCLE: EMPIRICAL EVIDENCE

As there are many different schools in economics, it is by no means surprising that views about the reasons of the crisis also differ quite a lot, ranging from people explaining it from rational expectations perspective to ones calling for discarding all previous macroeconomics and building the discipline anew like Colander et al. (2009).

So it is quite understandable that Lo (2012), trying to encompass 21 books written by academics and journalists, found that they proposed pretty different root causes for the economic calamity that fell on world economy starting in 2007. Lo (2012) also offered what seemed to many a debunking of one of the prevaling explanations for crisis – it had happened because the financial sector was overleveraged. He pointed out that according to General Accountability Office the leverage of all four largest US investment banks was lower before the onset of crisis of 2007 than prior to the implosion of dotcom bubble in 2000 Lo ((2012, p 36)). This does seem to be counterintuitive – if one thing causes another, why should its effective size be declining before the onset of this other? One could almost start to suspect that maybe these two are not related after all.

Of course, one should not throw away a whole lot of established literature about ties of leverage and crises because of something that might be just flips in statistics. Probably more reasonable would be to turn to empirical studies to find out.

Studies of empirics of the financial cycle are exactly what this chapter is supposed to give an overview about. The chapter is organised as follows. First it describes the empirical features of a financial cycle. The second subsection takes a look of two long-term studies of financial crises. The rest of this chapter is a summary of some of the academic papers concerning the crisis of 2007.

2.1. Features of a financial cycle

According to Borio (2012) there are at least five stylised empirical features of the financial cycle:

1) The financial cycle is best captured by the joint behaviour of credit and property prices.
2) It is much longer, and has a much larger amplitude, than the traditional business cycle.
3) It is closely associated with systemic banking crises, which tend to occur close to its peak.
4) It permits the identification of the risks of future financial crises in real time and with a good lead.
5) It is highly dependent of the financial, monetary and real-economy policy regimes in place.

Drehmann et al. (2012) took a look at short-term cycles, which last between 1 to 8 years and correspond to traditional business cycles with medium-term cycles, lasting between 8 and 30 years (admittedly unorthodox definitions for both short- and medium-terms). The average length of the financial cycle in a sample of seven industrialised countries since 1960 has been around 16 years. Although, when only cycles that peaked after 1998 are taken into account, the average length is 20 years; before that the average length of cycles was 11 years. They credit financial market liberalisation of 1980s as the probable reason that made financial cycles longer and their amplitudes larger.

The average length of 16 years would be largely in line with the theoretical concept known as the Kuznets swing or Kuznets wave of infrastructural investment that has been interpreted as lasting anywhere between 13 to 25 years by different scholars. Kuznets himself called these waves “demographic” or “building” cycles/swings, connecting them with demographic processes, namely immigrant inflows and outflows that caused changes in construction intensity. Other interpretations include ones that see Kuznets swings as waves of major investments in fixed capital, or as infrastructural investment cycles. (Korotayev and Tsirel (2010, pp 11-12))

2.2. Long-term studies of financial crises

Studies of leverage during historical credit crises include Schularick and Taylor (2009). They have created a dataset for 14 developed countries over the years 1870-2008 that they use to study movements of money, credit and macroeconomic indicators over the long run. Their aim, amongst others, is to answer the question whether right are those who think that credit only propagates shocks or those who see it as an independent source of shocks.

They differentiate between "two eras of finance capitalism" Schularick and Taylor (2009, p 2). During 1870 to 1939 money and credit were volatile but over the long run their relationship to each other and to the size of GDP was relatively stable, the only exception being the Great Depression when both money and credit collapsed. In this period, annual growth rates of broad money (3.65%), loans (4.16%), and assets (4.33%) were relatively proportional to each other (Schularick and Taylor (2009, p 4)).

The second era began after the World War 2 and is characterised by long post-war recoveries of money and credit that by 1970 surpassed their pre-war levels compared to GDP. Later credit decoupled from broad money and started growing faster, thanks to increasing leverage and after 1970s through new sources of funding, mainly debt securities, that created more nonmonetary liabilities of banks. Average broad money growth (8.57%) was much slower than loans (10.94%) and assets (10.48%). The loan-money ratios grew 20 times faster after the WW2 than before. This was a common phenomenon in many countries. (Schularick and Taylor (2009, p 4)) The world has entered an age of unprecedented financial risk and leverage (Schularick and Taylor (2009, p 2)).

They also conclude that this rise in leverage has increased the frequency of crises. During 1945–71 as leverage was low and liquidity was ample, this frequency was practically zero. After 1971, as the banks' hoards of liquidity evaporated and banks increased their leverage, annual probability of crises also rose to 4%. They build a probabilistic model that shows that a credit boom over the previous five years indicates a higher risk of a financial crisis, the five lags being jointly statistically significant at the 1% level.

Another long-term study considers numerous financial crises and concludes that unlike with serial default on sovereign debt or bouts of high inflation, there is no point where a country's economy becomes so advanced that it can outgrow from the recurrent plague of banking crises (Reinhart and Rogoff (2009, p. 141)).

2.3. Household leverage as a precursor of crises

The crisis of 2007 is not different from the historical examples considered by studies mentioned in the previous section, as shown by evidence on many layers of economy. Glick and Lansing (2010) establish that the US and many other developed countries saw a large increase in household leverage in the decade before 2007. During the same period house prices were rising the fastest in countries where household leverage increased the most. They also find a clear correlation between the rise in household leverage and decline in consumption after the crisis hit across countries.

The same applies also when comparing different regions of a country. A trio of studies by Mian and Sufi (2009, 2010, 2011) focused on the trends of US households' home equity based borrowing. Based on a random sample of nearly 70,000 homeowners living in every major metropolitan statistical area in the US, Mian and Sufi (2011) find that for every extra dollar the house prices appreciated, an average homeowner added 25 to 30 cents in home equity borrowing. They find no evidence that this borrowing was used to pay for new real estate or pay down credit card balances, so probably it was mostly used for consumption or home improvement. In just 5 years households' debt doubled. As according to their conservative lower-bound estimate home-equity based borrowing of existing home-owners was about 2.8 percent of GDP per year from 2002 to 2006, it must have been an important part of economic growth during these years. It also contributed to the recession that followed as it accounted for at least a third of new defaults from 2006 to 2008.

According Mian and Sufi (2009) the expansion of mortgage credit from 2002 to 2005 came hand in hand with a stronger house price rise in subprime zip codes compared to prime zip codes, although income growth was relatively (and sometimes absolutely) sharply declining in these areas. Actually, 2002 to 2005 was the only period in the last eighteen years of negative correlation between income and mortgage credit growth. And, the faster the rise, the sharper the fall – the increase in default rate in subprime neighbourhoods since 2006 was almost three times higher than in prime residential areas. This indicates the presence of a feedback loop straight out of Minsky (1992). As more and more new buyers gained access to easy credit, they bid up house prices. As house prices appreciated, lenders eased credit further as the value of assets to back mortgages was constantly rising. And, as at one point the access to credit dried up, many homeowners woke up to see that they had been living a Ponzi scheme that depended on an influx of easy money.

And, what is most interesting from the point of view of this thesis, Mian and Sufi (2010) show that household leverage is directly tied to the severity of crisis. Counties where the rise in household leverage was largest, saw also a sharp relative fall in consumption of durable goods that started already in the third quarter of 2006, a year before the recession officially began in the fourth quarter of 2007. In the counties that relied the most on credit card borrowing, consumption of durable goods fell significantly more after the financial crisis in the fall of 2008. The link was not limited to consumption of durables but was to be seen in a wide array of economic indicators. All in all, household leverage in 2006 turned out to be an early and strong statistical predictor of cross-sectional county-level variation in household default, house price, unemployment, residential investment, and durable consumption from 2007 to 2009. This suggests that the severity of recession depends on the amount that the preceding boom was fuelled on unsustainable lending.

This is not unique to the crisis of 2007. According to Reinhart and Rogoff (2009) who besides their own research cite also some earlier studies, the emerging pattern is quite clear: a boom in real housing prices preceding a crisis is followed by a significant fall during the crisis and in the years after that. They list 18 financial crises that had hit an advanced economy after World War II and pick out five of these as systemic, severe ones: Spain in 1977, Norway in 1987, Sweden and Finland both in 1991, and Japan in 1992.

Bordo and Jeanne (2002) study 15 advanced economies during 1970-2001, finding that banking crises tend to occur either at the peak of a boom in real housing prices or right after the bust. Gerdrup (2003) looked at Norway's three banking crises from the 1890s to 1993 and linked these to the booms and busts of the real estate sector. The latest banking crisis in Nordics during late 1980s and early 1990s followed a large capital inflow and real estate boom. The most severe post-World War II crisis in an advanced economy started as Japan's real estate bubble burst in 1992, followed by a decade long banking crisis.

It is also noteworthy that according to Reinhart and Rogoff (2009) the length and amplitude of real estate price cycles around banking crises are similar for both developed and developing countries. This is surprising as almost all other macroeconomic and financial time series are more volatile in developing economies.

What was unique to the crisis of 2007 were the dimensions of the boom that preceded it. Since 1891 when the Case-Shiller house price index's dataset begins, there has been no house price boom in the United States comparable in magnitude and duration. The United

States real house prices increased cumulatively in the period from 1996 to 2006 by about 92 percent – while from 1890 to 1996 the cumulative real price increase was a paltry 27 percent. (Reinhart and Rogoff (2009, p 207))

And all this holds true in a comparison across countries as well. Berkmen et al. (2009) try to find an explanation for differences in crisis experience across emerging economies (that's how they call middle-income countries). They conclude that for countries, where the financial system was more leveraged and credit growth was faster, the revisions in GDP growth forecasts were also larger. (They use outlook changes to sidestep problems with controlling for factors unrelated to the impact of crisis that would ensue when real GDP growth would have been used.) They find that leverage explains the whole growth revision for least affected countries, about two thirds of the revision for the average country, and over half of the revision for countries most affected by the crisis. Credit growth explains a significant share of the growth revision for the average country as well as those most affected. For most affected countries, exchange rate flexibility also had a large effect. None of the least affected countries had a pegged exchange rate.

When using a wider data set of developing economies (that set includes also low-income countries), trade linkages also played a role, with countries exporting more sophisticated goods experiencing a larger contraction than food-exporters. But trade channel does not seem to matter much for middle-income countries.

Berglöf et al. (2009) gives an overview of the crisis performance of emerging Europe. The conclusion is that the relative resilience of the region can be attributed to the benefits of European integration. One side of it is financial integration through international banking groups that dominate the domestic markets, the other political and institutional integration with Western Europe. The variance in GDP growth declines is best explained by pre-existing debt levels, and to a lesser extent to the structure of foreign liabilities. So to some degree it can be said that foreign ownership of banks is a mixed blessing.

2.4. Some empirical features of the financial sector

So, coming back to Lo (2012), we might ask, is it possible the leverage of household sector and countries is tied to the severity of crisis but the leverage of US investment banking is somehow de-coupled?

One explanation – which is in line with a traditional conception of banking as taught in Economics 101 classes all over the world – might be that household borrowing has not much to do with investment banks. The well-reported ubiquity of different asset-backed securities makes such an explanation feel flimsy. Also, modern banking has not much to do with banking of Economics 101 (also called Jimmy Stewart banking in Mehrling (2011) alluding to the movie *It's a Wonderful Life*) as best exemplified by a graph mapping the structure of contemporary financial sector in Poszar et al. (2010) (see Appendix 2)

Also, there is the additional problem that credit-to-GDP ratio actually rose in the US between 2001-7 as detailed in Drehmann et al. (2012).

Furthermore, leverage increased "dramatically" both in the US and globally from 1999 to 2006. If a bank in 2006 wanted to buy an AAA-rated security, it could pay only 1.6% in cash, borrowing 98.4% of the purchase price on the collateral of the bought security. That would be an equivalent of a leverage of 100 to 1.6, or about 60 to 1. So, "leverage got higher than ever before, and then margins got tighter than ever before." (Geanakoplos (2009, p. 2))

So why should have leverage fallen for investment banks?

An explanation might be that before the onset of the crisis a significant part of the actual leverage of investment banks was hidden in off-balance sheet vehicles as described in Mehrling (2011) and the full leverage ratio that hit the investment banks as the vehicles back-stopped by them got into trouble in the next year would not have been apparent in indicators used by Lo (2012).

D'Hulster (2008) also stresses the same point. She describes a financial sector, where banks funded more and more of their long-term assets with short-term liabilities in wholesale money markets, using off-balance sheet vehicles. As they provided facilities to these vehicles, effectively (and in the event of the crisis, actually) back-stopping these, they exposed themselves to credit and liquidity risk. Through structured credit instruments on their own balance sheets they also exposed themselves to leverage embedded into these instruments, increased their asset-liability mismatch and their funding liquidity risk. So D'Hulster (2008) concludes that balance sheet leverage ratio was not an adequate reflection of the trends in financial innovation.

Regarding the possibilities of accounting in financial sector, an important point was made by equity analyst Vincent Daniel who says that working as an accountant for Arthur Andersen auditing the books of Salomon Brothers he "concluded that there was effectively no

way for an accountant assigned to audit a giant Wall Street firm to figure out whether it was making money or losing money." (Lewis (2010, p ??)) And that was in the middle 1990s, before the Wall Street really started using many of the innovations that characterise the international financial markets in this century.

Of course, as The Economist (2014) highlighted that the banking sector seemed quite solid before the crash of 1929, one possibility might be that the severity of the crisis does not have to be proportional to leverage ratio but in large part also depends on other factors like institutional setup etc.

This is in line with Borio and Disyatat (2011) according to whom the financial crisis was not caused by "excess saving" but the "excess elasticity" of the international monetary and financial system. They draw the distinction between excess saving and excess credit: to have an effect on the equity prices, savings have to be turned into credit. Credit can only become excessive if there is too much elasticity and not enough discipline in the financial system. If there is "excess elasticity" and at least some leverage, we could have a crisis even in conditions that ultimately look quite sustainable (when not taking into account the institutional setup).

So it is a relatively safe bet to say that understanding the financial cycle would give us a much better grasp of processes. states that in the sample of seven industrialised countries given in Drehmann et al. (2012), all financial crises that had domestic origin (i.e. were not caused by losses on crossborder exposures) occur at, or close to, the peak of the financial cycle. The financial crises that do not concur with peaks in domestic financial cycles are usually a consequence of foreign financial cycles. (Borio (2012, p 4))

2.5. Balance sheets of financial intermediaries during the credit cycle

As Mian and Sufi (2008, 2009, 2010) looked at household balance sheets, Adrian and Shin (2008a, 2008b, 2009, 2010) have studied the changes in balance sheets of different financial intermediaries during booms and downturns and the effects these changes have on the asset prices and market liquidity. Adrian and Shin (2008a) offers a close look on how the United States financial institutions – bank holding companies, and security brokers and dealers – manage their balance sheets during the financial cycle. The results show that intermediaries' leverage increases during booms and decreases during downturns, showing a

pro-cyclical tendency that amplifies the fluctuations of the financial cycle. They argue that the best way to measure liquidity in a market-based financial system is to look at the growth rate of aggregate balance sheets. Also they find a strong correlation between balance sheet growth of financial institutions and easing and tightening of monetary policy.

Adrian and Shin (2008b) shows that marked-to-market leverage is highly pro-cyclical as asset price changes are immediately carried over into changes in net worth. Financial institutions actively manage their value-at-risk and react to these changes by adjusting their balance sheets. These reactions on aggregate have market-wide consequences. Pro-cyclical leverage has a strong impact on liquidity and the price of risk. Changes in dealer repos – the main channel for adjustment of intermediaries' balance sheets – can be used to forecast innovations in financial market risk as measured by the Chicago Board Options Exchange Volatility Index (VIX). They suggest that financial liquidity can be seen as the rate of change of the aggregate balance sheet of the financial intermediaries.

That suggestion and its consequences are elaborated more in detail in Adrian and Shin (2009). According to their findings decreases in balance sheets of broker-dealers (historically, largely investment banks) have tended to precede falls in real economic growth, so they see balance sheet sizes of these financial intermediaries as important monetary policy variables that have been neglected until now.

They emphasise the differences between their view of the credit supply channel and the financial amplification mechanisms of Bernanke and Gertler (1989), and Kiyotaki and Moore (1997) who focused on financing frictions in the borrowing sector, while their focus is on financing frictions in the lending sector. They focus on balance sheet quantities, while another possibility is offered by Curdia and Woodford (2009), who look at credit spreads.

Adrian and Shin (2010) summarises this research and takes a broader look in the changes of the United States market-based financial system during the last decades.

The intermediary sector is not homogenous in its reaction to crisis. Some parts of it shed, others add leverage. Also, changes in leverage can depend on the methods how they are measured. Adrian and Shin (2010) use data from the Federal Reserve's flow of funds accounts that are measured in terms of book values for the result that broker-dealer sector acted pro-cyclically, increasing leverage during the boom and decreasing it during the crisis. Ang et al. (2011) use market value of equity in their calculations and show that according to this data leverage in broker-dealer sector actually fell during the crisis of 2007-9. Their paper also

shows, based on data from a large fund-of-hedge-funds, that leverage of hedge fund sector fell during the crisis.

He et al. (2010) imply that sectors that are able to get longer-term financing, like commercial banks, significantly increased their asset holdings during the period from the fourth quarter of 2007 to the first quarter of 2009. In the same period sectors that are most dependent on repo-financing, like hedge funds and broker-dealers, decreased their asset-holdings. Also, they found that the leverage of the top 19 commercial banks rose from 10 to between 20 and 32 during this period.

These results show that during a financial crisis the distribution of leverage across the intermediary sector changes. While parts of intermediary sector sell their assets and reduce leverage, other parts take on more leverage to purchase assets. As the broker-dealer and hedge fund sector shed assets for approximately $800 billion, commercial banking sector added assets for $550 billion. So the story of deleveraging in the intermediary sector is broadly true, but its details are more complicated.

As Adrian et al. (2013) studied empirically which matters more to asset pricing, net worth or leverage, they came to the conclusion that leverage is the key. To their surprise, as much as net worth actually had any relationship to asset pricing, it seemed to be inverse to the one predicted by theory. The other relationship they studied was whether leverage should be taken into account as the market value of the intermediary (an approach favoured by for example Brunnermeier and Sannikov (2012) and He and Krishnamurthy (2012) as it allows to neglect the relationship between the bank and the borrower) or the book value of the intermediary. So empirically matters the definition of leverage as the ratio of total assets to book equity, not the ratio of enterprise value (the sum of market capitalisation and market value of debt) to market capitalisation.

The important result is that credit supply conditions matter for asset pricing, implying that the common simplification where borrowers and intermediaries are consolidated as one sector, might miss some details that play a role in financing conditions.

2.6. Early warning indicators of banking crises

Reinhart and Rogoff (2009) stress repeatedly the mainstream view that financial crises usually do not happen in a vacuum. Usually real GDP growth gets slowed down by a shock already before a financial crisis hits. They point out that this was the case also with the crisis of 2007 that was going along the path of a milder recession before the financial turmoil broke loose that threatened with a contraction deeper than the average of "Big Five" advanced economy crises after the World War II. As the mainstream view obviously holds that banking crises are not caused by sunspots that brings us to the topic of early warning indicators (EWIs) of banking crises. Obviously, the main economic policy indicators like GDP and inflation will not suffice.

Reinhart and Rogoff (2009, pp. 216-7) list rising asset prices, increasing leverage, large sustained current account deficits, and slowing trajectory for economic growth as standard indicators that a country is near to a financial crisis.

Drehmann and Juselius (2013) use statistical evaluation criteria to evaluate EWIs on the basis of their performance relative to the macroprudential policy maker's decision problem. The EWIs must have solid statistical forecasting power, and they must also comply with many additional criteria – the signals must be early enough, and they must be stable so that a trend could be discerned for policy makers. The paper elaborates the criteria for evaluation of EWIs and analyses ten EWIs accordingly. As a result it turns out that the credit-to-GDP gap (measuring deviations of credit-to-GDP from a long run trend) and a new indicator, the debt service ratio (the proportion of interest payments and mandatory repayments of principal to income.) consistently outperform other measures, the first being the best EWI at longer horizons, the latter at shorter horizons.

Schularick and Taylor (2009) build a probabilistic model based on the experience of 14 developed countries over 140 years (1870-2008) that shows that a credit boom over the previous five years indicates a higher risk of a financial crisis, the five lags being jointly statistically significant at the 1% level.

Jordà, Schularick and Taylor (2011) use the same data set to see whether external imbalances increase the risk of a financial crisis. They conclude that credit growth is the single best predictor of a crisis, while external imbalances have played a role – but more so in the pre-WWII period.

Drehmann, Borio and Tsatsaronis (2012) illustrate the importance of keeping in sight the "medium-term" (as mentioned in section 2.1, in their definition the medium-term lasts 8 to 30 years) financial cycle and not overreacting to short-term developments on the example of the United States, although the phenomenon is more general. Both in the mid-1980s to early 1990s and in the period of 2001 to 2007 the Federal Reserve eased monetary policy sharply after equity price crashes of 1987 and 2001 respectively and the economic downturn that followed. In both times, the credit-to-GDP ratio and property prices continued to increase, and, after a short hiatus, GDP improved also.

A few years later, it was the turn of credit and property prices to collapse and drag the real economy with them, bringing much bigger financial and economic problems. During the second episode, policy rates were raised more gradually, in part because inflation remained relatively low. Also, when in the first episode the interval between peaks in equity prices and property prices was about two years, it was around five years in the second episode. So from the perspective of the "medium-term" financial and business cycles Drehmann, Borio and Tsatsaronis (2012) name the slowdowns of 1987 and 2001 "unfinished recessions".

2.6. Conclusion

As can be seen in the empiric studies cited in this chapter, there is strong evidence that ties the leverage before the crisis to the severity and length of the crisis. This evidence can be seen in the most recent episodes beginning in 2007 as well as in historic examples detailed in long-term studies. So understanding the patterns of leverage might bring us closer to more realistic modelling and forecasting of financial contagion.

As well as in the chapter dealing with modelling, two distinct approaches can be seen: some analysts prefer to deal with the balance sheets data of borrowers, the others are more interested in lenders.

3. METHODOLOGY

One of the more lively discussions that arose in economics with the crisis of 2007 has been concerning the financial cycle, a century-old concept, that was been all but forgotten for the most part of second half of the 20th century. Now voices are emerging that demand introducing it in some form into economic models.

A return of financial cycle would mean including a banking sector into macroeconomic models. Obviously, for modelling purposes, a thorough understanding of the interdependencies of banking sector indicators is of crucial importance. While there have been developments going on in this field since 1980s, attempts at that have now started with a new urgency.

For Baltics, the study of financial cycles has been pretty much neglected until now. The aim of this thesis is to take a few tentative steps on the road of building the groundwork for the analysis of financial cycle in the region. To do that, a more thorough understanding of local banking sector and its driving forces is needed.

This thesis analyses the dynamics of changes in liabilities and assets of Baltic banks. The goal is to gain an understanding about the cyclicality of the banking sector leverage in the Baltics to better understand the money creation process during the financial cycle and also learn how banking sector assets change dependent on the monetary policy conditions.

The chapter is organised as follows.

3.1. Calculation of yearly changes in balance sheets of Baltic banks

When trying to make sense of debt issues, it is always a good bet to look where the money is – to study the balance sheets of different sectors, i.e. for our purposes, banks, households and businesses. Mian and Sufi (2009, 2010, 2011) have studied balance sheets of the US households (see section 2.3), while Adrian and Shin (2008a, 2008b, 2009, 2010) have focused on balance sheets of the financial intermediary sector (see section 2.5). For this thesis the latter road was chosen.

For exposing cyclical changes in the leverage ratio of the US banking sector, Adrian and Shin (2008a) plotted graphically the yearly changes in total liabilities and financial assets of US banks. This thesis uses the same approach.

With this goal in mind, aggregate balance sheet data of Baltic monetary financial intermediaries (MFIs) from home pages of Estonian, Latvian, and Lithuanian central banks was used. Total liabilities is self-explaining, for financial assets all financial assets on balance sheets were added, excluding central banks' liabilities (cash and deposits at central bank) as these are part of base money and do not play a role in money creation by banks.

For Latvia, comparable data from July 2004 to December 2013 is available. The data series for Lithuania is longer, but as Lithuanian litas was only fixed to euro in the beginning of 2002, using earlier data would have created currency conversion issues. To avoid that, for Lithuania data since January 2002 is used. For Estonia, data since January 2000 is used.

For calculations and graphs Microsoft Excel was used.

3.2. Calculation of monetary policy accommodativeness

Another issue of interest is how money creation by banks depends on the central bank's monetary policy. For the US Adrian and Shin (2008a) found a strong positive relationship between changes in financial assets of US banks and the accommodativeness of the monetary policy of the Federal Reserve. The calculations in this section are mostly based on methodology of Adrian and Shin (2008a), except where noted.

Monetary policy accommodativeness is measured by the residual of the interest rate estimation with Taylor rule. The interest rate used is the quarterly average ECB's main refinancing operations rate. For comparison is taken an indicator that might also have an influence on the banks' balance sheets, quarterly year-on-year GDP growth. To convert the interest rate to quarterly frequency of GDP growth rate, a three month average was calculated. The residual is found as the difference between the three month average of the actual policy rate and an interest rate suggested by the Taylor rule.

In a formula for the estimation of a central bank policy rate, the ECB interest rate can be divided into two parts:

$$ECB\ interest\ rate = Taylor\ rule + Taylor\ rule\ residual, \quad (1)$$

where

Taylor rule is calculated as (the formula used is one that Nechio (2011) suggested for the Eurozone):

$$Taylor\ rule = 1\% + 1.5 * HICP\ inflation + 1 * unemployment\ gap, \quad (2)$$

where

HICP inflation is the quarterly average of Eurostat's monthly year-on-year change of HICP, and
Unemployment gap is calculated as

$$Unemployment\ gap = NAWRU - unemployment\ rate, \quad (3)$$

where

NAWRU is non-accelerating wage rate of unemployment from the European Commission AMECO database, converted into a quarterly frequency through linear interpolation, and
Unemployment rate is Eurostat's seasonally adjusted quarterly average year-on-year unemployment rate.

If the Taylor rule residual in formula (1) is positive, the monetary policy is contractive for Estonia, as ECB's interest rate is higher than the interest rate suggested by the Taylor rule. Conversely, if the Taylor rule residual is negative, the monetary policy is expansive, as ECB's interest rate is lower than the interest rate laid out by the Taylor rule.

Data from 1st quarter of 2000 to 4th quarter of 2008 was used, as after the outbreak of the crisis of 2007 the monetary transmission channel has noticeably changed (see Čihák, Harjes and Stavrev (2009)). As time series for Latvian and Lithuanian banks would have been relatively short (20 and 28 data points, respectively) for analysis of the effects of monetary policy, the calculations were done only on Estonian data.

It might have been interesting to study whether ECB's or Swedish Riksbank's interest rate policy has more influence on financial assets of Estonian MFIs, but as the correlation between interest rates of ECB and Riksbank is nearly 1, it is not possible to tell with means of linear regressional analysis.

For calculating the Taylor rule and its components Microsoft Excel was used. For statistical analysis R was used.

4. RESULTS

This chapter is organised as follows. The first section plots the yearly changes in balance sheets of Baltic monetary financial institutions (MFIs) through the years. The second section studies the relationship between changes in financial assets of Estonian MFIs and ECB's key interest rate.

4.1. Yearly changes of Baltic banks' balance sheets

As Adrian and Shin (2008a) plotted the yearly changes in balance sheets for US financial intermediaries, they concluded that for banking holding companies the leverage was pro-cyclical, while for broker-dealers it was acyclical. They saw a larger volatility in liabilities than in assets of US bank holding companies (and of the US financial sector as a whole), with liabilities increasing faster than assets during upturns and decreasing faster than assets during downturns. That would mean a rising leverage during upturns and a falling leverage during downturns – a pro-cyclical leverage.

For the Baltic States the results differ noticeably. As can be seen on the graphs, while the financial assets (for our purposes, all financial assets of MFIs, except central banks' liabilities) and liabilities of local banks change pretty massively year-on-year, the changes in assets and liabilities tend to go hand in hand. As in the Baltics there is no noticeable difference between yearly changes in banking assets and liabilities, so the leverage of local banks seems to be largely acyclical. In Estonia, the leverage is basically acyclical (see chart 1). The same goes for Lithuania (see chart 3). Only in Latvia during the height of the boom years of the last decade it is possible to see banking liabilities changing noticeably faster than assets (see chart 2). That is of course good news for the policy makers as banks' leverage seems not to be amplifying cyclical fluctuations.

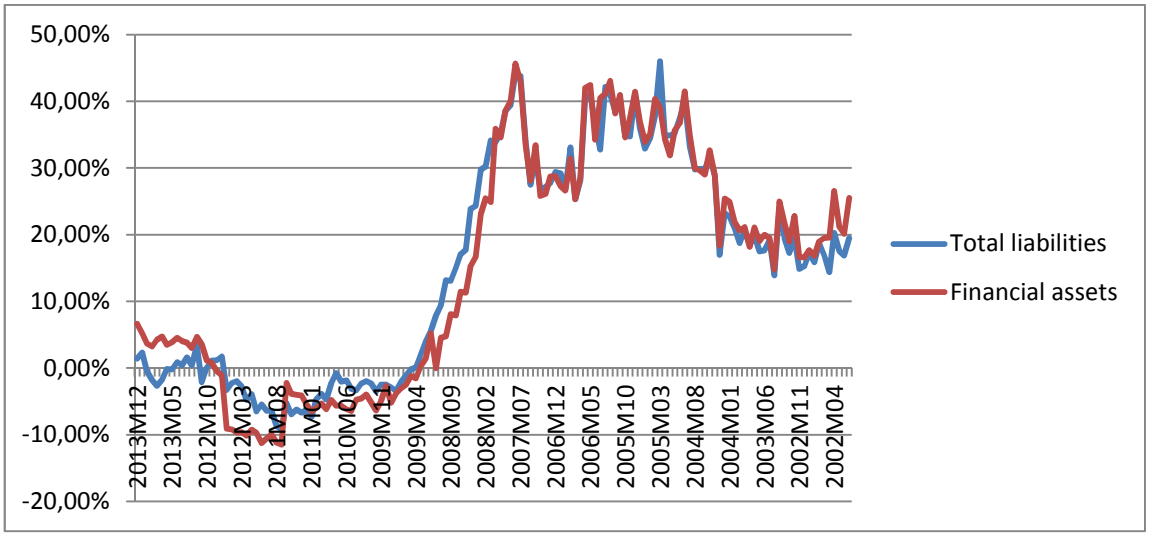

Chart 1. Estonian MFIs' aggregated balance sheets, yearly change, %

Source: Bank of Estonia, author's calculations

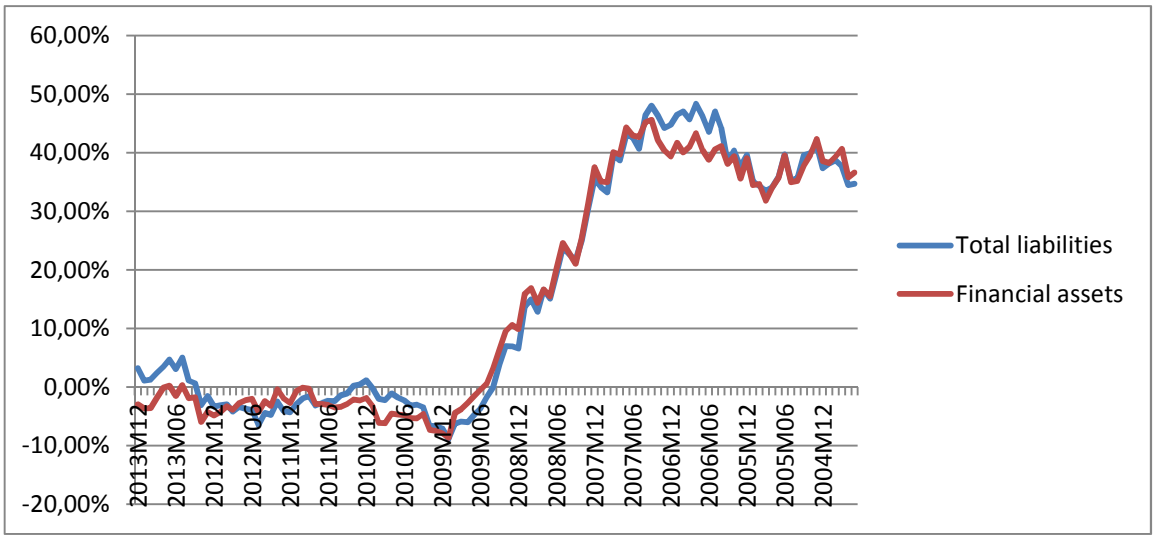

Chart 2. Latvian MFIs' aggregated balance sheets, yearly change, %

Source: Bank of Latvia, author's calculations

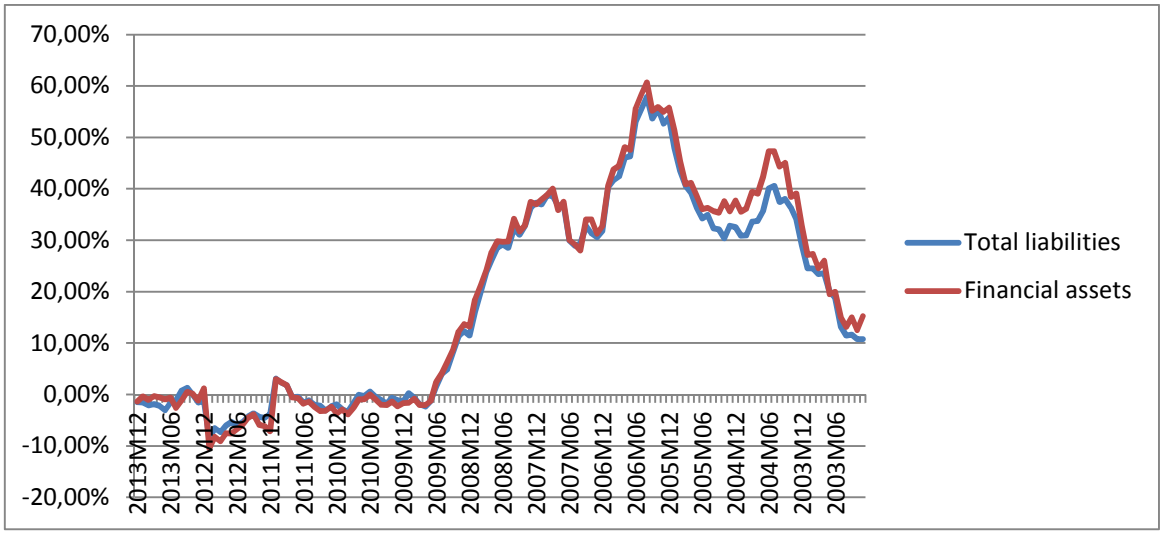

Chart 3. Lithuanian MFIs' aggregated balance sheets, yearly change, %

Source: Bank of Lithuania, author's calculations

4.2. Monetary accommodativeness and banks' balance sheets

Adrian and Shin (2008a) also found that changes in financial assets of US banks depended strongly on the main interest rate of the Federal Reserve. In the Estonian case, the results were quite different, again.

The accommodativeness of ECB's monetary policy is measured as the residual of Taylor rule for Estonia (see formula 1 in section 3.2). If the Taylor rule residual is positive, the monetary policy is contractive for Estonia, as ECB's interest rate is higher than the interest rate suggested by the Taylor rule. Conversely, if the Taylor rule residual is negative, the monetary policy is expansive, as ECB's interest rate is lower than the interest rate laid out by the Taylor rule.

From the correlation analysis the impact of ECB policy on banks' balance sheets seems minor, as the correlation between the change of financial assets and Taylor rule residual is a –4 percent. At least the sign is in the right direction for our hypothesis. For Taylor rule residual, we get a regression line:

$$Yearly\ changes\ in\ MFIs'\ financial\ assets = 0.26250 - 0.07490 * Taylor\ rule\ residual \quad (4)$$

This estimate of yearly changes in financial assets of Estonian MFIs is not statistically significant (p-value 0.8).

The correlation between changes of financial assets and GDP growth rate is a much stronger 51 percent. When we use the GDP growth rate as an estimator for yearly changes of financial assets of Estonian MFIs the regression results are also much better.

$$Yearly\ changes\ in\ MFIs'\ financial\ assets = 0.19558 + 1.07918 * GDP\ growth\ rate \quad (5)$$

R^2 is 0.26, meaning GDP growth rate explains 26 percent of the variation in yearly changes of Estonian MFIs financial assets, and the result is statistically significant at over 99 percent level with a p-value of 0.001.

Combining both the Taylor rule residual and the GDP growth rate into a regression model, we get the following estimation:

$$Yearly\ changes\ in\ MFIs'\ financial\ assets = 0.10968 - 0.88019 * Taylor\ rule\ residual + 1.67523 * GDP\ growth\ rate \quad (6)$$

For this estimation, R^2 is 0.43, meaning it explains 43 percent of the variation in yearly changes of Estonian MFIs financial assets. The estimate is statistically significant at over 99 percent level with a p-value of $9.2*10^{-5}$.

So Taylor rule residual together with the GDP growth rate does help to explain a large part of the variation in changes of Estonian MFIs' financial assets. However, as stand-alone predictor, it is not much of use. It does seem that banking is a completely different business in New York and in Estonia – although that may not come as a very big surprise.

CONCLUSIONS

After the analysis, the leverage of banking sector in the Baltics turns out to have been largely acyclical during the last decade. That is good news for local policy makers, as in the US, for example, banking leverage has been pro-cyclical, having a strong impact on liquidity and the price of risk. The effects here would probably be more subdued but real nonetheless.

Also the effects of monetary policy didn't turn out to be quite like in the US. The accommodativeness has a very weak correlation of 4 percent with the change of Estonian banking balance sheets. Not a very good result for the hypothesis that banks' balance sheets would increase when monetary policy loosens and decrease when it tightens. Nonetheless, the combination of GDP growth and ECB's monetary policy together accounted for 43 percent of the variation in yearly changes of financial assets of the Estonian banking sector.

So in the end, the main conclusion might be that Baltic and US banking sectors do differ. One should not be very surprised by that.

REFERENCES

Adrian, T., Boyarchenko, N. (2012) Intermediary leverage cycles and financial stability. Federal Reserve Bank of New York Staff Reports 567.

Adrian, T., Boyarchenko, N. (2013) Intermediary balance sheets. Federal Reserve Bank of New York Staff Reports 651.

Adrian, T., Moench, E., Shin, H.S. (2013) Leverage asset pricing. Federal Reserve Bank of New York Staff Reports 625.

Adrian, T., Shin, H.S. (2008a) Liquidity, Monetary Policy, and Financial Cycles. Federal Reserve Bank of New York, Current Issues in Economics and Finance, Volume 14, Number 1 January/February 2008

Adrian, T., Shin, H.S. (2008b) Liquidity and Leverage. Federal Reserve Bank of New York Staff Reports 328, May 2008.

Adrian, T., Shin, H.S. (2008c) Financial intermediary leverage and value-at-risk. Federal Reserve Bank of New York Staff Reports 338, July 2008

Adrian, T., Shin, H.S. (2009) Money, liquidity, and monetary policy. Federal Reserve Bank of New York Staff Reports 360, January 2009

Adrian, T., Shin, H.S. (2010) The Changing Nature of Financial Intermediation and the Financial Crisis of 2007-09. Federal Reserve Bank of New York Staff Reports. 439, March 2010

Allen, F., Gale, D. (1998) Optimal Financial Crises. The Journal of Finance, Vol. LIII, No. 4, August 1998

Allen, F., Gale, D. (2000) Financial Contagion. The Journal of Political Economy, Volume 108, Issue 1 (Feb. 2000), pp 1-33

Amini, H., Cont, R., Minca, A (2013). Resilience to Contagion in Financial Networks, Mathematical Finance.

Ang, A., Gorovyy, S., van Inwegen, G. (2011) Hedge fund leverage. Journal of Financial Economics, Elsevier, vol. 102(1), pp. 102-126, October 2011

Angeloni, I., Faia, E. (2009) A Tale of Two Policies: Prudential Regulation and Monetary Policy with Fragile Banks. Mimeo, European Central Bank.

Arinaminpathya, N., Kapadiab, S., R.M. (2012) Size and complexity in model financial systems. PNAS | November 6, 2012 | vol. 109 | no. 45

Atkeson, A., Rios-Rull, J.-V. (1996). The balance of payments and borrowing constraints: An alternative view of the Mexican crisis. Journal of International Economics 41 (1996) 331-349.

Berkmen, P., Gelos, G., Rennhack, R., .Walsh, J. P. (2009) The Global Financial Crisis: Explaining Cross-Country Differences in the Output Impact. IMF Working Paper WP/09/280 December 2009

Bernanke, B., Gertler, M. (1989) Agency Costs, Net Worth, and Business Fluctuations. The American Economic Review, Vol. 79, No. 1 (Mar., 1989), pp. 14-31

Bernanke, B., Gertler, M., Gilchrist, S. (1996) The Financial Accelerator and the Flight to Quality. The Review of Economics and Statistics, Vol. 78, No. 1. (Feb., 1996), pp. 1-15

Bernanke, B., Gertler, M., Gilchrist, S. (1999). The Financial Accelerator in a Quantitative Business Cycle Framework. Handbook of Macroeconomics, Volume 1, Edited by J..B. Taylor and M. Woodford, Chapter 21, Elsevier Science B.V, 1999

Blanchard, O. (2009) The Crisis: Basic Mechanisms and Appropriate Policies. CESifo Forum, 1/2009.

Bordo, M.D., Jeanne, O. (2002) Monetary Policy and Asset Prices: Does "Benign Neglect" Make Sense? IMF Working Paper WP/02/225

Borio, C. (2011) Rediscovering the macroeconomic roots of financial stability policy: journey, challenges and a way forward. BIS Working Papers No 354, September 2011.

Borio, C. (2012) The financial cycle and macroeconomics: What have we learnt? BIS Working Papers No 395, December 2012

Borio, C., Disyatat, P. (2011) Global imbalances and the financial crisis: Link or no link? BIS Working Papers No 346, May 2011

Brunnermeier, M., Pedersen, L. (2009) Market Liquidity and Funding Liquidity. Review of Financial Studies, vol 22,6,2201-2238

Brunnermeier, M., Sannikov, Y. (2009) A Macroeconomic Model with a Financial Sector. Mimeo, Princeton University.

Bulow, J., Rogoff, K. (1989) A Constant Recontracting Model of Sovereign Debt. Journal of Political Economy. 1989, vol. 97, no. 1.

Caballero, R., Krishnamurthy, A (2001) International and Domestic Collateral Constraints in a Model of Emerging Market Crises. Journal of Monetary Economics: 513-548.

Calvo, G. (2000) Balance of Payment Crises in Emerging Markets Large Capital Inflows and Sovereign Governments. From "Currency Crises", Paul Krugman (Ed.), University of Chicago Press, pp. 71-97.

Carlstrom, C., Fuerst, T (1997) Agency Costs, Net Worth and Business Fluctuations: A Computable General Equilibrium Analysis. American Economic Review 87 (5):893–910.

Christiano, L., Motto, R., Rostagno, M. (2005) The Great Depression and the Friedman Schwartz Hypothesis. Journal of Money Credit and Banking, Vol. 35, No.6 (December 2003, Part 2)

Colander, D., Goldberg, M., Haas, A., Juselius, K., Kirman, A., Lux, T., Sloth, B. (2009) The Financial Crisis and the Systemic Failure of the Economics Profession. Critical Review: A Journal of Politics and Society. Volume 21, Issue 2-3, 2009, pp 249-267

Cornand, C., Moysan, G. (2009) Unstable financial networks. Paris December 2009 Finance International Meeting AFFI – EUROFIDAI. December 16, 2009

Danielsson, J., Shin, H.S., Zigrand, J.-P. (2004) The impact of risk regulation on price dynamics. Journal of Banking & Finance, Elsevier, vol. 28(5), pages 1069-1087, May 2004

De Grauwe, P (2011) The Governance of a Fragile Eurozone. CEPS Working Document No. 346, May 2011.

D'Hulster, K. (2009) The Leverage Ratio. A New Binding Limit on Banks. The World Bank. December 2009

Diamond, D., Dybvig, P. (1983) Bank Runs, Deposit Insurance, and Liquidity. The Journal of Political Economy. Volume 91, Issue 3 (June 1983), 401-419.

Drehmann, M., Juselius, M. (2013) Evaluating early warning indicators of banking crises: Satisfying policy requirements. BIS Working Papers No 421, August 2013

Drehmann, M., Borio, C., Tsatsaronis, K. (2012) Characterising the financial cycle: Don't lose sight of the medium term! BIS Working Papers, no 380, June 2012

The Economist (2014) The Slumps that Shaped Modern Finance. The Economist, April 12th 2014

Fisher, I. (1933) Debt-Deflation Theory of Great Depressions, from A History of the Federal Reserve: Volume 1: 1913-1951.

Fostel, A., Geanakoplos, J. (2008) Leverage Cycles and the Anxious Economy. American Economic Review 2008, 98:4, 1211–1244.

Gai, P., Kapadia, S. (2010) Contagion in Financial Networks. Bank of England Working Paper No. 383 (March 23, 2010).

Geanakoplos, J. (2009) The Leverage Cycle. NBER Macroeconomics Annual, Vol. 24, No. 1 (2009), pp. 1-66.

Geanakoplos, J. (2010) Solving the Present Crisis and Managing the Leverage Cycle. Cowles Foundation Discussion Paper No. 1751, January 2010.

Georg, C.-P. (2010) The Effect of the Interbank Network Structure on Contagion and Financial Stability. Working Papers on Global Financial Markets No. 12.

Georg, C.-P. (2011) The effect of the interbank network structure on contagion and common shocks. Deutsche Bundesbank Discussion Paper Series 2: Banking and Financial Studies No 12/2011.

Gerdrup, K. (2003) Three episodes of financial fragility in Norway since the 1890s. BIS Working Papers No 142.

Gertler, M., Kiyotaki, N. (2010) Financial Intermediation and Credit Policy in Business Cycle Analysis. Gertler, in B Friedman and M Woodford (eds) Handbook of Monetary Economics, Vol 3, Amsterdam: North Holland, pp 547-599.

Glick, R., Lansing, K.J. (2010) Global Household Leverage, House Prices, and Consumption. FRBSF Economic Letter 2010-01. January 11, 2010.

Haldane, A.G., May, R.M. (2011) Systemic risk in banking ecosystems. Nature, Vol. 469, 20 January 2011.

He, Z., Krishnamurthy, A. (2013) Intermediary Asset Pricing. American Economic Review, 103(2): 732-70

He, Z., Khang, I.G., Krishnamurthy, A. (2010) Balance Sheet Adjustments in the 2008 Crisis. NBER Working Paper No. 15919, April 2010

Holmstrom, B., Tirole, J. (1997) Financial Intermediation, Loanable Funds, and the Real Sector. The Quarterly Journal of Economics, Vol. 112, No. 3. (Aug., 1997), pp. 663-691

Kindleberger, C., Aliber, R. (2005). Manias, Panics and Crashes. John Wiley and Sons, 316 pp.

Kiyotaki, N., Moore, J. (1997) Credit Cycles. Journal of Political Economy, 1997, vol. 105, no. 2.

Korotayev, A., Tsirel, S. (2010) A Spectral Analysis of World GDP Dynamics: Kondratieff Waves, Kuznets Swings, Juglar and Kitchin Cycles in Global Economic Development, and the 2008–2009 Economic Crisis. Structure and Dynamics, 4(1)

Krishnamurthy, A. (2003) Collateral Constraints and the Amplification Mechanism. Journal of Economic Theory 111 (2003) 277–292.

Lewis, M. (2010) The Big Short: Inside the Doomsday Machine. W.W.Norton & Co, 266 pp.

Lo, A.W. (2012) Reading About the Financial Crisis: A 21-Book Review. Journal of Economic Literature, 50(1): 151-78.

Lorenzoni, G. (2008) Inefficient Credit Booms. Review of Economic Studies: (2008) 75, 809-833.

Mankiw, N.G. (2009). Principles of economics. 5th Edition. South Western College, 904 pp.

Mehrling, P. (2011) The New Lombard Street: How the Fed Became the Dealer of Last Resort. Princeton University Press, 2011, 192 pp.

Mendoza, E.G. (2010) Sudden Stops, Financial Crises, and Leverage. American Economic Review 100 (December 2010): 1941–1966

Mian, A., Sufi, M. (2009) The Consequences of Mortgage Credit Expansion: Evidence from the U.S. Mortgage Default Crisis. The Quarterly Journal of Economics (2009) 124 (4): 1449-1496.

Mian, A., Sufi, M. (2010) Household Leverage and the Recession of 2007 to 2009. NBER Working Paper 15896, May 2010

Mian, A., Sufi, M. (2011) House Prices, Home Equity-Based Borrowing, and the U.S. Household Leverage Crisis. American Economic Review, 101(5): 2132-56

Minsky, H. (1992) The Financial Instability Hypothesis. The Jerome Levy Economics Institute of Bard College Working Paper No. 74, May 1992.

Modigliani, F., Miller, M. (1958) The Cost of Capital, Corporation Finance and the Theory of Investment. American Economic Review 48 (3): 261–297.

Nier, E., Yang, J., Yorulmazer, T, Alentorn, A (2008) Network models and financial stability. Bank of England Working Paper No. 346 April 2008

Postlewaite, A., Vives, X. (1987) Bank Runs as an Equilibrium Phenomenon. The Journal of Political Economy, Volume 95, Issue 3 (June 1987), 485-491.

Pozsar, Z., Adrian, T., Ashcraft, A., Boesky, H. (2010) Shadow Banking. Federal Reserve Bank of New York Staff Report no. 458, July 2010

Reinhart, C., Rogoff, K. (2009) This Time is Different: Eight Centuries of Financial Folly. Princeton University Press, 512 pp.

Shleifer, A., Vishny, R.W. (1997) The Limits of Arbitrage. The Journal of Finance, Vol. 52, No. 1. (Mar., 1997), pp. 35-55

Schularick, M., Taylor, A.M. (2009) Credit Booms Gone Bust: Monetary Policy, Leverage Cycles and Financial Crises, 1870–2008. NBER Working Paper 15512, November 2009.

Schumpeter, J.A. (2006) History of Economic Analysis. Routledge, 1320 pp.

Williamson, S. (1987) Financial Intermediation, Business Failures and Real Business Cycles. Journal of Political Economy. Journal of Political Economy 02/1987; 95(6):1196-1216.

RESÜMEE

PANGANDUSBILANSID JA FINANTSTSÜKLID

Erik Aru

Pärast 2007. aastal valla pääsenud majanduskriisi on üle poole sajandi taas tulnud moodi finantstsükkel. Umbes saja aasta eest välja töötatud kontseptsioon kadus majandusteaduse äärealadele pärast Teist maailmasõda. Olulist rolli mängis selles arengus kahe majandusteadlase artikkel, Modigliani and Miller (1958), mille tulemusel suur osa peavoolu majandusteadlastest hakkas uskuma, et makromudelitest saab raha ja panganduse välja abstraheerida ning reaalmajanduslikud otsused ei pea rahandusstruktuurist sõltuma.

Finantstsükli tagasitulek tähendaks vajadust pangandussektor makromajanduslikke mudelitesse sisse tuua. Modelleerimiseks läheb loomulikult vaja põhjalikke teadmisi pangandussektori muutujate omavahelistest sõltuvustest. Neid on matemaatiliste mudelite abil uuritud küll juba 1980-ndate aastate algusest, ent pärast majanduskriisi on selles vallas teadustegevus tublisti hoogustunud.

Baltimaade ei ole praeguseni finantstssükleid suurt uuritud. Selle magistritöö eesmärgiks on võtta mõni ettevaatlik samm teel, mis viiks piirkonna finantstsükli uurimisele aluse panemiseni. Selleks läheb vaja kohaliku pangandussektori ja seda liikumapanevate tegurite põhjalikumat mõistmist.

Magistritöö analüüsib Baltimaade pankade varade ja kohustuste muutuse dünaamikat, eesmärgiga mõista paremini rahaloomeprotsessi finantstsükli vältel ja saada ka teada, kuidas muutuvad pangandussektori varad – põhimõtteliselt, kuidas muutub pankade poolt loodud raha hulk – sõltuvalt rahapoliitikast. Hüpoteesiks on, et laiendava rahapoliitika korral pankade varad suurenevad ja kitsendava rahapoliitika korral pankade varad kahanevad.

Pankade võimenduse tsüklilisuse uurimiseks on arvutatud Balti pankade kogukohustuste ja finantsvarade kuised muutused võrreldes aasta varasema ajaga ning kujutatud need graafiliselt. Pärast seda on kasutatud korrelatsioon- ja regressioonanalüüsi, et leida Eesti pankade finantsvarade sõltuvus Euroopa Keskpanga rahapoliitikast.

Pärast analüüsi selgus, et Baltimaade pankade võimendus on möödunud kümnendi jooksul olnud valdavalt atsükliline. Vaid Lätis oli möödunud kümnendi keskpaiga

majandusbuumi tipphetkedel märgata mõnevõrra protsüklilist võimendust. Poliitikakujundajatele on see kahtlemata hea uudis, sest näiteks USAs on pangandussektori võimendus protsükliline, suurendades nii majanduse kõikumise mõju reaalmajandusele.

Ka rahapoliitika mõju ei meenutanud täpselt USAd. Rahapoliitikal on väga nõrk, vaid neljaprotsendiline korrelatsioon Eesti pankade finantsvarade muutusega – vähemasti märk vastas püstitatud hüpoteesile. Pankade bilanss korreleerub 51-protsendiliselt hoopis siinse majanduskasvuga. Kui aga majanduskasvu ja rahapoliitika mõju ühte regressioonmudelisse panna, saame võrrandi, mis selgitab suure statistilise usutavusega 43 protsendi ulatuses Eesti pangandussektori finantsvarade varieeruvust.

Lõpuks tuleb ilmselt järeldada, et USA ja Eesti pangandus ei ole päris ühesugused. See ei tohiks kedagi üllatada.

APPENDICES

Appendix 1. Classification of models discussed

Bank run models
Diamond and Dybvig (1983)
Postlewaite and Vives (1987)
Allen and Gale (1998)

Financial amplifier models with fixed leverage
Williamson (1987)
Bernanke and Gertler (1989)
Bernanke, Gertler and Gilchrist (1996)
Bernanke, Gertler and Gilchrist (1999)
Kiyotaki and Moore (1997)
Schleifer and Vishny (1997)
Holmstrom and Tirole (1997)
Lorenzoni (2008)
Krishnamurthy (2003)
Gromb and Vayanos (2002)
Brunnermeier and Pedersen (2009)
Christiano, Motto and Rostagno (2005)
Carlstrom and Fuerst (2007)

Models of the leverage cycle
Geanakoplos (2009)
Geanakoplos (2010)
Danielson, Shin and Zigrand (2004)
Adrian and Shin (2008c)
Angeloni and Faia (2009)
Adrian and Boyarchenko (2012)
Adrian and Boyarchenko (2013)
Brunnermeier and Sannikov (2012)
He and Krishnamurthy (2012)

International borrowing crisis models
Bulow and Rogoff (1987)
Atkeson and Rios-Rull (1996)
Calvo (2000)

International borrowing crisis models with financial amplifier
Caballero and Krishnamurthy (2001)
Fostel and Geanakoplos (2008)
Mendoza (2010)

Model with financial sector as a root cause of the crisis
Gertler and Kiyotaki (2010)

Model of banking sector as a network
Allen and Gale (2000)

Models of banking sector as a complex network
Nier et al. (2008)
Cornand and Moisan (2009)
Amini et al. (2010)
Georg (2010)
Georg (2011)
Haldane and May (2011)
Arinaminpathy et al. (2012)

Appendix 2. Block scheme of shadow banking

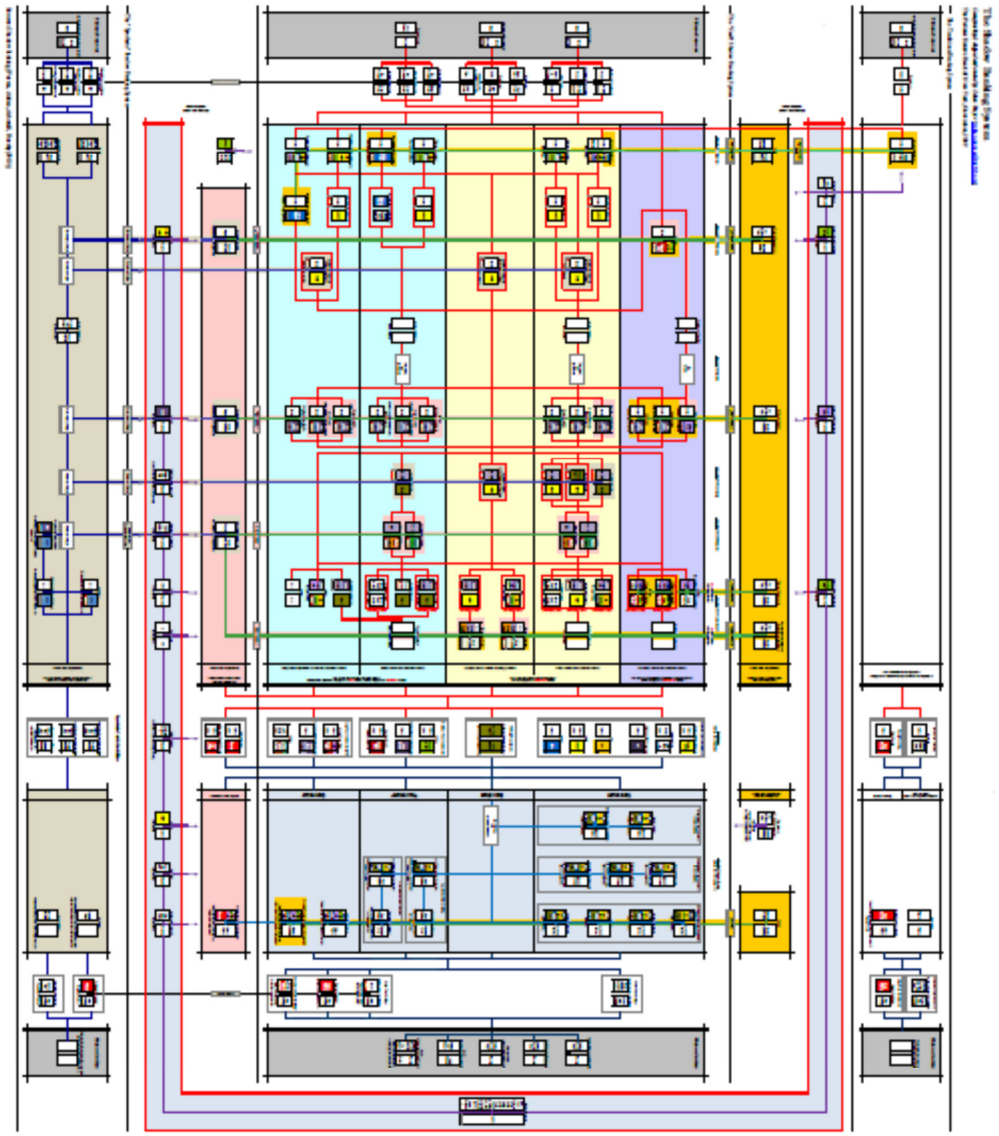

Chart 4. Diagram of the shadow banking system
Source: Poszar et al. (2010)

Appendix 3. R-output for regressions

$$Yearly\ changes\ in\ MFIs'\ financial\ assets = 0.26250 - 0.07490 * Taylor\ rule\ residual$$

Residuals:

Min	1Q	Median	3Q	Max
-0.241231	-0.055507	0.003634	0.076625	0.157624

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	0.26250	0.02276	11.535	2.67e-13	***
dataEst$Residual	-0.07490	0.30325	-0.247	0.806	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.09647 on 34 degrees of freedom

Multiple R-squared: 0.001791, Adjusted R-squared: -0.02757

F-statistic: 0.06101 on 1 and 34 DF, p-value: 0.8064

$$Yearly\ changes\ in\ MFIs'\ financial\ assets = 0.19558 + 1.07918 * GDP\ growth\ rate$$

Residuals:

Min	1Q	Median	3Q	Max
-0.17679	-0.06426	-0.01844	0.06924	0.16278

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	0.19558	0.02455	7.965	2.79e-09	***
dataEst$GDP	1.07918	0.30906	3.492	0.00135	**

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.08284 on 34 degrees of freedom

Multiple R-squared: 0.2639, Adjusted R-squared: 0.2423

F-statistic: 12.19 on 1 and 34 DF, p-value: 0.001351

$$Yearly\ changes\ in\ MFIs'\ financial\ assets = 0.10968 - 0.88019 * Taylor\ rule\ residual + 1.67523 * GDP\ growth\ rate$$

Residuals:

Min	1Q	Median	3Q	Max
-0.139393	-0.058130	0.001503	0.059574	0.141068

Coefficients:

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	0.10968	0.03526	3.111	0.00384	**
dataEst$Residual	-0.88019	0.28302	-3.110	0.00384	**
dataEst$GDP	1.67523	0.33592	4.987	1.92e-05	***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.07395 on 33 degrees of freedom

Multiple R-squared: 0.4308, Adjusted R-squared: 0.3963

F-statistic: 12.49 on 2 and 33 DF, p-value: 9.165e-05