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Institute of Economic Studies



BACHELOR THESIS

**Credit Growth in CEE Countries:
Empirical Analysis of Early Warning
Indicators**

Author: Jan Stříbný

Supervisor: Doc. PhDr. Adam Geršl, Ph.D.

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Declaration of Authorship

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Prague, May 14, 2013

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Abstract

Excessive credit growth is often considered to be an indicator of future problems in financial sector. Basel III regulatory package has introduced countercyclical capital buffer to improve stability of the banking sector and proposed using credit-to-GDP gap as an indicator for calibrating the buffer. In BCBS methodology, Credit-to-GDP gap is counted as a difference between current value and a long term trend obtained from data series using Hodrick-Prescott filter. In this work we used out of sample estimation method to create models for a determination of equilibrium credit to households' assets ratio and applied the results to compute the deviation from the long term equilibrium. We found that these alternative indicators can give signals different to credit to GDP gap, computed by using HP filter or OOS method, and sometimes they could even identify accumulation of risk in cases, where credit to GDP fails. The indicators were especially superior to using HP filter on CEE countries. The weakness is, however, the determination of a clear threshold for the indicator, when the credit growth should be classified as excessive.

JEL Classification E52, E51

Keywords early warning, credit to GDP, credit growth, credit cycle, banking crisis

Author's e-mail jan.stribny@gmail.com

Supervisor's e-mail adam.gersl@gmail.com

Abstrakt

Nadměrný růst kreditu v ekonomice je často považován za indikátor budoucích problémů ve finančním sektoru. Regulační balík Basel III obsahuje návrh na proticyklický kapitálový polštář s cílem zvýšení stability bankovního sektoru. Pro kalibraci polštáře je navrhováno sledovat odchylku růstu úvěrů ku HDP. V metodologii BCBS je tato odchylka počítána jako rozdíl mezi nynější hodnotou a dlouhodobým trendem, který je z časových řad tradičně získáván za použití Hodrick-Prescott filtru. V této práci používáme takzvanou out of sample metodu, pomocí které jsme vytvořili modely na odhadování rovnovážného poměru kreditu ku aktivům domácností a pomocí těchto modelů jsme následně spočítali odchylky jednotlivých zemí od dlouhodobého trendu. Zjistili jsme, že

tyto alternativní indikátory mohou dávat signál jindy než při použití úvěrů ku HDP, spočítané ať už HP filtrem nebo OOS metodou, a někdy dokonce mohou identifikovat růst rizika tam, kde úvěry ku HDP selhávají. Významně lepší pak byly naše indikátory v porovnání s použitím HP filtru na země střední a východní Evropy. Slabinou ovšem je volba jasné hranice pro hodnotu indikátorů, kdy by už měl být růst úvěrů vnímán jako příliš vysoký.

Klasifikace JEL

E52, E51

Klíčová slova

brzké varování, úvěry k HDP, růst úvěrů, úvěrový cyklus, bankovní krize

E-mail autora

jan.stribny@gmail.com

E-mail vedoucího práce

adam.gersl@gmail.com

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Acronyms

BCBS Basel Committee on Banking Supervision

CEECs Central and Eastern European countries

GDP Gross Domestic Product

HP Hodrick-Prescott (filter)

IMF International Monetary Fund

IMF IFS International Financial Statistics database of International Monetary Fund

OECD Organisation for Economic Co-operation and Development

OOS Out of Sample (estimation method)

RoE Return on Equity

RWA Risk-weighted assets

Bachelor Thesis Proposal

Author	Jan Stříbný
Supervisor	Doc. PhDr. Adam Geršl, Ph.D.
Proposed topic	Credit Growth in CEE Countries: Empirical Analysis of Early Warning Indicators

Excessive credit growth is often considered to be an indicator of future problems in financial sector. Basel III regulatory package has introduced “countercyclical capital buffer” to improve stability of banking sector and proposed using credit-to-GDP gap as an indicator for calibrating the buffer. In BSCS methodology, Credit-to-GDP gap is counted as a difference between current value and a long term trend obtained from data series using Hodrick-Prescott filter. Current research was mainly focused on developed countries with long data series. However, there are some drawbacks to be concerned with when applying this method to CEE countries. Firstly, Hodrick-Prescott filter can be problematic when used on shorter data series than at least 20 years and also this filtering method becomes unreliable at the end of the data period. Secondly, rapid credit growth in this region can simply mean convergence to values typical for developed countries.

To avoid these drawbacks, this paper uses so called out of sample method to create a model for approximation of “normal” credit-to-GDP for a country and long term trend is then extracted from this model. Furthermore, in addition to credit-to-GDP, credit-to-assets ratio is used as another measure of risk in the system to construct more reliable early warning indicator suitable for CEE countries.

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Author

Supervisor

Chapter 1

Introduction

Basel Committee on Banking Supervision (BCBS) introduced the Basel III regulatory package in 2010. The aim of the reform (BCBS (2010)) is to increase resilience of the financial sector while decreasing the procyclicality of the regulation. One of the most important parts is a new capital buffer with the size dynamically determined based on the risk in the financial sector, suggested to be measured by Credit-to-GDP gap. The aim is to curb credit growth when it is too fast and releasing the buffer when there is a danger of a credit crunch. However, to calibrate the buffer properly it has become very important to also estimate the gap precisely. BCBS (2010) suggests using Hodrick-Prescott filter method which is very common for filtering trend and short term deviations. This method, however, can be unsuitable for Central and East European (CEE) countries.

CEE countries were undergoing a period of a very rapid credit growth in 2000s which led many economists and regulators to worry about excessiveness of this growth (e.g. Égert *et al.* (2006)). However, CEE region consists of economies which were going through difficult transition in 1990s from centrally planned economies, which very much determined their low credit level compared to the countries of the same level of development. Therefore, rapid credit growth might be only a manifestation of a convergence mechanism to reach levels of credit appropriate for the country of the same level of development.

Credit boom in CEE countries in 2000s provides an interesting example to apply methodology proposed by BCBS. Some commentators argued that credit growth might be overshooting in some countries and HP filter would, indeed, signal necessity for increasing the buffer. One must also, however, take

into account the very low level of Credit-to-GDP in CEE region. Furthermore, while time series for CEE countries are usually very short, 2000s boom would be incorporated into trend determined by HP filter (Cottarelli *et al.* (2005)). Therefore it makes sense to estimate the level first by a set of economic fundamentals using out of sample method while applying the results on in sample countries to compute the credit-to-GDP gap (Geršl & Seidler (2012)).

In this paper, we propose another alternative approach to measuring the risk in financial sector. While Credit-to-GDP can be seen as a paralel to a commercial bank asking about the income of the borrower, it is also important whether the borrower has any assets which may be used to pay back the debt. Therefore, I try to estimate Credit-to-Assets ratio using various variables as a proxy for households' assets and use the results to improve the performance of Credit-to-GDP gap as an indicator of possible stress in the financial sector.

In chapter 2, we discuss early warning indicators literature useful for buffer calibration, then in chapter 3 we review the situation in CEE region in 2000-2008 and discuss issues with measuring excessiveness of credit growth in the region. In chapter 4 we estimate two credit to assets models, chapter 5 discusses a performance of the indicators and chapter 6 concludes.

Chapter 2

Early Warning Indicators for Banking Crises

2.1 Early Warning Indicators

Recent financial crisis has once again increased demand for reliable early warning indicators. Both national regulators and authors of new complex regulatory packages like Basel III face the problem of detecting the accumulation of risk in the financial sector to make preventive action possible and adjust their tools properly. Two kinds of indicators are demanded. First, indicators able to detect run up phase to the crisis by spotting imbalances in the economy, possibly showing signal 1-3 years before the crisis, i.e. early warning. The second type of indicators is more focused on a very short term estimation, when the crisis is unavoidable and the indicator is only used to help regulators prevent the worst case scenarios, e.g. credit crunch. In this paper we will focus on the first type of indicators, i.e. detecting the fragility in the system during the run up phase.

Risk in the financial sector usually accumulates during periods of aggressive risk-taking while feeding (and at the same time being driven by) unsustainable economic expansion (Borio & Drehmann (2009)). On the other hand, during the times of banking stress, financial system completely reverses and credit conditions become very tight (Reinhart & Rogoff (2009)). Even though the exact time of this reversal is impossible to predict, we know that "the longer the imbalance persists, the higher the likelihood of the reversal" (Borio & Drehmann (2009)). To make prediction even harder, these unsustainable expansions are usually justified by some fundamental change in the structure of the economy, thus increasing its normal pace of growth, e.g. structural reforms or financial

innovations. This is also the case of CEE countries, where finished transition process left them in a position much different than comparable countries in terms of the level of development and financial deepening was used an explanation of a booming credit.

Borio & Lowe (2002) provide a preliminary analysis of indicators based on asset price gap, credit gap, investment gap and real credit growth, where gaps are measured as deviations from their trends. To assess quality of these indicators, authors minimize their noise to signal ratio which is a ratio of Type II errors (crisis signalled but did not happen) and Type I errors (crisis happened with no signal from indicator) and at the same time they are trying to maximize the percentage of crisis predicted by setting thresholds for indicators which, when crossed, yield signal. From this exercise, asset prices and credit gaps show the best noise to signal ratio while predicting approx 70% of crisis 2-3 years in advance. Although asset prices were found useful for predicting the crisis, the data are hard to obtain and their comparability is very questionable. Also in emerging economies, these troubles are even more complicated due to short time spans of data at that time given first 10 years are used purely for trend estimation. Due to these limitations, stock prices are usually used as asset prices, methodology not applicable to CEE due to undeveloped financial markets. Furthermore, Borio & Drehmann (2009) state that even though some indicators perform very well when looking backwards, its predicting power is questionable, that is its out of sample performance.

Borio & Drehmann (2009) found out that indicators performance can be improved significantly by using equity prices and property prices. While this is true when used in sample, out of sample performance is very bad when it comes to recent financial crisis. Equity prices peaked in the early 2000s and property prices gap peaked as early as 2004 for Case-Schiller 10-city index, but in sample these indicators usually peaked 2 years before the crisis (Borio & Drehmann (2009)). Another drawback of simple indicators mentioned above is that they do not take into account cross border exposures, thus completely missing risk of some countries hardly hit by financial crisis (Borio & Drehmann (2009)). Even though Borio & Drehmann (2009) address these issues, authors conclude, that policy can not be 100% based on these indicators and some role of judgment always needs to be taken into account.

2.2 Countercyclical Capital Buffers

Davis & Karim (2008) define banking crisis as "occurrence of severely impaired ability of banks to perform their intermediary role". Only between years 2007 and 2010, "major global banking institutions reported cumulative write-downs to the tune of \$1.3 trillion." (Drehmann *et al.* (2011)). Large write-downs led to increased sensitivity to counterparty risk as well as undercapitalisation of particularly troubled banks. The consequences of financial intermediaries not being able to perform their role can be severe. During 12 months between middle of 2008 and middle of 2009, world GDP contracted by 1.6% (?).

According to Drehmann *et al.* (2011) countercyclical capital buffers could be used to meet three goals. First, smoothing of the business cycle, which is the most ambitious goal and hardest to achieve. Second and less ambitious is smoothing of the credit cycle, because increased requirements on capital decrease free resources of the bank which could be used for lending, while decreased requirements on capital have the opposite effect. Therefore, capital requirements could be used "as a means of achieving a broad macroprudential goal." (Drehmann *et al.* (2011)) The third objective is to protect banks from systemic risk. However, because credit cycle and business cycle do not match each other too much, it is very hard to use the buffer as a tool for this purpose. Because of that Drehmann *et al.* (2011) suggest to focus only on not so ambitious third objective, i.e. protecting the financial sector from consequences of financial stress.

Basel Committee on Banking Supervision (BCBS) has introduced countercyclical capital buffer as part of Basel III regulatory package (e.g. BCBS (2010)) with the objective to fight procyclicality of the current regulation. Countercyclical buffer should be accumulated in good times, when credit is booming too fast. When crisis looms, buffer should be used to cover losses of the bank and help to avoid too tight credit conditions, or so called credit crunch. In other words, the buffer should be used so that credit conditions are the same as before the crisis event. On top of that, accumulation phase of the buffer might lead to decrease of the credit growth and work as a preventive action on rapid credit growth. The possibility of curbing the credit growth before it is too late is more a beneficial side effect than primary purpose of this regulatory tool.

Calibration of the buffer relies on decisions of national regulatory authority. The buffer should be set within the range of 0% to 2.5% of risk weighted assets

based on the perception of system-wide risk. However, the buffer needs to be released at the right moment. Any increases in the size of the buffer need to be announced 12 months in advance so that banks can prepare for the new situation (BCBS (2010)). On the other hand, releasing of the buffer can be done immediately. This makes the process of estimation of the risk in the system even more demanding as not only it needs to be precise, but also the timing is very important. Although BCBS proposes using credit-to-GDP as a good starting point for buffer calibration, it leaves space to national authorities to use any meaningful methodology, which must be disclosed by the authority.

Requirements on indicators used to detect run-up phase to the crisis differ a lot from indicators used for releasing the buffer (Drehmann *et al.* (2011)). While run-up phase to the crisis can take a long time and the risks in the financial sector build up gradually, beginning of the crisis can come very suddenly. Therefore, early warning indicators must be employed to detect build up phase, on the other hand releasing the buffer is more a matter of nowcasting, i.e. detecting the current situation, as buffer needs to be released promptly to achieve maximal effectiveness. BCBS methodology suggests using credit-to-GDP gap, i.e. difference between ratio credit-to-GDP and its long term trend, as an indicator of future financial stress. Even though this indicator has some drawbacks, it performs very well in predicting banking stress 2-3 years in advance, which allows both authorities and banks to prepare for the crisis (e.g. Borio & Lowe (2002)). This indicator has also a very favourable noise-to-signal ratio, and thus gives only a small proportion of false warning signals. On the other hand, its performance is unsatisfactory when used for giving signals for releasing the buffer. A fall in GDP leads to an actual increase in the ratio at the time of financial stress. Furthermore, deleveraging is a long time process and outstanding amount of credit does not fall quickly enough to indicate a need of releasing the whole buffer. Thus some judgement needs to be incorporated into decision making mechanism and at the same time keep the level of transparency and accountability. BCBS (2010) proposes very simple rule for operating the buffer:

$$\left(\left(\frac{CREDIT_t}{GDP_t}\right) \times 100\%\right) - (TREND_t) < 2\%, \text{ the buffer add-on is zero}$$

$$\left(\left(\frac{CREDIT_t}{GDP_t}\right) \times 100\%\right) - (TREND_t) > 10\%, \text{ the buffer add-on is at its maximum}$$

This setting means, that when deviation of credit-to-GDP from its trend

(credit-to-GDP gap) is lower than 2%, then the buffer is set to zero. Between 2% and 10% the buffer should be increased linearly from 0% to 2.5% of risk-weighted assets, and from 10% and higher it should be at its maximum. The issue of this setting is a determination of the trend. BCBS proposed using usual method for trend filtering called Hodrick-Prescott filter, but this method has its drawbacks admitted also by BCBS, which in the final version of Basel III (BCBS (2010)) leaves significant freedom to regulators in determining the trend and variables for setting the buffer.

Chapter 3

Early Warning Indicators in CEECs

3.1 Credit Boom in CEE Countries

Interesting example which caught an eye of many commentators is credit boom in Central and East European (CEE) countries during years 2000 to 2007/2008 and whether these rates were sustainable in the medium to long run (e.g. Égert *et al.* (2006)). During parts of this period, "growth rates of credit to private sector were often in the range of 30-50 percent per annum" (Hilbers *et al.* (2005)). Borio & Lowe (2002) conclude that "one of the relatively few robust findings to emerge from the literature on leading indicators of banking crisis is that rapid domestic credit growth increases the likelihood of a problem". Thus given that growth rates of credit-to-GDP in some CEE countries were close to values observed in Indonesia, Korea, or Sweden on the way to their 1990s crisis (Boissay *et al.* (2006)) and IMF (2004) study saying that 75% of credit booms were ended by banking or currency crises. Some national regulatory authorities even used measures to curb this growth during the period 2004-2007, e.g. increased risk weights on selected loans (Estonia) and restrictions on credit portfolio growth (Bulgaria) (Geršl & Seidler (2012)).

3.1.1 On the Road to the Crisis

One feature which makes CEE countries different from the others is that during 1990s they went through difficult transformation process from centrally planned economies to market economies, with distinct results among the set and with different levels of success. While banking crisis in Czech Republic was ended by finally privatizing the banking sector (which can accelerate credit growth), Bulgaria was experiencing full scale systemic crisis with inflation of 2000% in

March 1997 (Boissay *et al.* (2006)). In general during this transition, CEECs banking system went through three phases (Cottarelli *et al.* (2005)):

- Bad loans write off, usually from public banks to state enterprises or at least under state pressure to stimulate companies.
- The sale of banks, mostly to foreign investors.
- Consequently, banking system providing standard operations as lending to creditworthy private enterprises.

One notable exception in terms of selling banks to foreign investors is Slovenia, where the share of foreign-owned banks was only approx. 30% in the year 2009 (Haiss & Ziegler (2011)). This deviation is seen as one of the main causes of the current banking crisis in Slovenia (Parussini (2013)), because foreign ownership is trusted to improve corporate governance of banks, which leads to implementation of more responsible lending standards and risk management. Second notable feature is that CEE financial systems are mostly bank based with alternative financing (equities and bonds) not so common (Cottarelli *et al.* (2005)). The initial differences in credit-to-GDP levels among the CEECs group can be traced to the financing of enterprises under central planning and strongly diverging inflation patterns at the initial stage of transition (Égert *et al.* (2006)). This history can help to explain why CEE countries mostly started new century with lower credit-to-GDP ratio than countries at the same level of development (Boissay *et al.* (2006)).

The trend of rapid credit growth was often explained as a natural convergence from these artificially low levels (e.g. Hilbers *et al.* (2005)) and as a result of financial deepening and improving the strength of financial system as well as institutional reforms. However, rapid credit growth also leads to increasing demands on banks' resources in terms of both monitoring and risk management (Hilbers *et al.* (2005)). This can lead to wrong assessment of borrowers and their ability to repay the loan. Banks also consider borrowers' assets when deciding about their creditworthiness, but asset prices tend to be inflated during boom times (working as financial accelerator) and get depressed quickly when the boom ends, leading to even more strict credit conditions and therefore procyclical behaviour of banks. Thus even though a convergence is a reasonable argument, concerns were growing about the magnitude of the growth and whether this high pace of growth can lead to increased vulnerabilities in the system (Hilbers *et al.* (2005)).

Hilbers *et al.* (2005) draws on historical data of countries which experienced lending booms and consecutive systemic banking crisis. Authors identify four types of lending booms episodes:

- Episodes where rapid credit growth was justified by large investment needs and consumption expansion as a result of structural reforms. This can be called a result of financial deepening.
- Lending booms which ended by banking crisis.
- Continuing lending booms in euro-convergence countries, e.g. Greece, Ireland, Portugal and Spain.
- Continuing lending booms in CEE countries, e.g. Hungary, Latvia, Lithuania.

The study is limited by the fact that nowadays we know the fate of these countries. Booms in Greece, Ireland, Portugal and Spain have turned out to be harmful for their economies and consequences of this boom and bust are still to be solved (and therefore we also disregard these countries in the empirical part). Also in some CEE countries (not mentioned in the study) the rapid growth trend was only lifting off in 2003 and therefore was not noticed yet.

Boissay *et al.* (2006) dig deeper into determinants of credit growth, however, they use only data up to 2005, when it was still early to question credit growth in the Czech Republic and Slovakia as these countries were still affected by banking crisis of late 90s. Authors are particularly concerned about countries with annual credit growth higher than 20% (Latvia, Bulgaria, Lithuania and Estonia) and above 10% (Hungary, Croatia and Romania) over the studied period 1999-2004.

Some of the CEE countries maintained fiscal and monetary policy mix which could further spur credit growth, e.g. pegged or tightly predictable exchange rates (Hilbers *et al.* (2005)), e.g. in Estonia, Lithuania and Latvia. This exchange rate predictability together with wide differences in interest rates created incentives for increased borrowing in foreign currencies. E.g. in Estonia government incentives such as interest rate deductibility stimulated growth of mortgage loans (Hilbers *et al.* (2005)). Thus, in many CEE countries (except for the Czech Republic, Slovakia and Poland) the credit growth was financed using foreign sources (Geršl & Seidler (2012)), which increases risk of not having sufficient balance-sheet liquidity (roll-over risk).

3.1.2 Impact of the Crisis on CEE Countries

Fall of the Lehman Brothers and consecutive financial crisis very much ended the credit boom in the studied region with various impact on different countries. The Baltic countries which experienced very high growth rates during 2000s were hit particularly hard. The impact on the CEE region was even more magnified by foreign banks spreading their troubles from domestic markets to their subsidiaries in the CEE region (Bakker & Gulde (2010)). Cumulative output of Estonia, Latvia and Lithuania fell by 20-25 percent from their peak levels (Purfield & Rosenberg (2010)). At the end of 2008, Latvia requested help from IMF, the EU and Nordic countries, which provided resources to support the financial system, finance the budget deficit and support the currency peg. Out of Baltics, the hardest hit was Latvia followed by Estonia and Lithuania being the least affected (Purfield & Rosenberg (2010)). However, when considering only impact on the banking sector, Estonia's banking system was in a much stronger position in 2009 compared to both Latvia and Lithuania (Purfield & Rosenberg (2010)). The rest of the region was not as severely affected as Baltics. With only Bulgaria, Romania and Hungary falling by 5-6 percent of GDP in the real terms (Gardó & Martin (2010)).

3.2 Detection of Excessive Credit Expansion

Boissay *et al.* (2006) states that in theory, excessive rate of credit growth can be defined as a rate which "endangers financial stability via financing undeserving projects that will eventually turn into bad loans" or "leads to unsustainable macroeconomic developments, such as a deteriorating external position leading to an unsustainable build up of external debt". In the methodology of IMF (2004) the excessive credit growth is defined as fluctuation from trend of more than 1.75 times standard deviation. Statistically this makes sense as this means a deviation of probability only 5% if we assume normal distribution. However, extraction of a trend is the issue.

Traditionally, **Hodrick-Prescott (HP) filter** is applied to obtain a trend from time series. The filter assumes (Hodrick & Prescott (1997)) that components of time series y_t are sum of a growth component g_t and cyclical component c_t . Deviations c_t are then assumed to average near zero over the long time. Growth component (or trend) is then extracted by solving following minimization problem:

$$\min\left\{\sum_{t=1}^T c_t^2 + \lambda \sum_{t=1}^T [(g_t - g_{t-1}) - (g_{t-1} - g_{t-2})]^2\right\}$$

Then actual values of credit-to-GDP are compared to the trend obtained using HP filter, this method is used e.g. in Borio & Lowe (2002).

However, HP filter method has several drawbacks for estimation of time series of CEECs, discussed e.g. in Geršl & Seidler (2012). The time series trend is very dependent on the length of time series as well as smoothing parameter (λ). Also "end-point bias" is a problem especially for decisions of regulatory authorities, as HP filter generates highly unreliable results at the end of time series. Thus, its usefulness for estimating the gap in current situation rather than on historical data is limited. Especially problematic are time series in CEE countries which are insufficient for a proper trend extraction because they are usually very short (Basel III recommends at least 20-year period) and affected by turbulent times of the 90s. Furthermore, when HP filter is applied to short time series, the rapid credit growth can be incorporated into trend itself (Cottarelli *et al.* (2005)). In case of e.g. Czech Republic, decreasing trend in early 2000s due to banking crisis leads to even more troubling downward bias of the trend. Geršl & Seidler (2012) also raise a question of using alternative denominators besides GDP, such as financial assets or total assets of the private sector while depending on HP filtering Credit-to-GDP time series would implicitly assume that it is the only relevant indicator. Question which this thesis is trying to address.

The second pillar of HP filter criticism is based on not taking economic fundamentals into consideration. Boissay *et al.* (2006) proposes "to focus on both macroeconomic fundamentals as well as on the gap between the actual credit-to-GDP ratio and an equilibrium level." Authors wanted to model credit growth as a function of GDP growth, interest rate and credit-to-GDP gap and thus estimate proper elasticities. Then expected credit growth can be estimated using these estimated elasticities and excessive growth is defined to be above this expected growth. Although the study was focusing on credit in level, rather than credit-to-GDP, authors show that this approach can yield results totally different from these obtained using only statistical filtering.

In the example provided by Geršl & Seidler (2012), authors simulate using HP filter to calculate Credit-to-GDP gap on quarterly data for Czech Republic from 1998 to 2008. To make the simulation more realistic, they apply HP filter recursively to take into account only data available to policy makers at the

time of estimation. Although banking crisis affected the trend in credit-to-GDP ratio a lot in years 1998-2002, the credit growth in Czech Republic is found to be excessive as early as in the year 2004. On the contrary, HP filter applied to the whole data period finds the gap to be negative in 2004 (almost -10%). Moreover, as opposed to HP filter findings, Czech Republic had credit-to-GDP ratio lower than selected EU countries when they were at the same level of development even in a year 2009 (Geršl & Seidler (2012)).

Boissay *et al.* (2006) found excessive credit growth for Bulgaria and Latvia and somewhat higher than expected in Lithuania, Estonia, Hungary and Croatia. They also mention a concern about credit growth in Hungary being driven by credit to households. Significant risk is evaluated in Estonia from foreign currency denominated loans (80% of total).

It is also important to distinguish between aggregate credit to private sector and disaggregated time series. Boissay *et al.* (2006) show, that when some countries exhibit excessive credit growth at the aggregate level, then also credit to households and credit to corporates grows excessively. However, e.g. Estonia (in the period 1999-2004) was showing excessiveness only in growth of credit to households. This disaggregation is also suggested by Haiss & Ziegler (2011), given the fact, that while credit to non-public corporations is supposed to have positive impact on economic growth, credit to households does not generate any long-term income. Also boom of credit to households might lead to financial crisis, while impact of boom in credit to non-public enterprises tend to be not so severe (Herzberg (2010)).

3.3 Estimation of the Equilibrium Credit Level

Terrones & Mendoza (2004) review both empirical and theoretical work on relationship between credit and economic growth. They conclude that there is a statistically significant positive relationship between credit and GDP growth with elasticity greater than one. Thus credit-to-GDP ratio rises as per capita GDP increases, a process called financial deepening (Égert *et al.* (2006)). Most empirical studies also suggest that it is credit growth what spurs economic growth (see e.g. Levine *et al.* (2000)). Recent studies, however, show that the relationship between financial development and economic growth is more complicated and some positive correlation might have even diminished (Haiss & Ziegler (2011)), this topic is, however, over the scope of this text.

Given that CEE countries started from a very low credit level due to histor-

ical reasons discussed earlier, the rapid growth of 2000s would make estimated elasticities to be overstated (Égert *et al.* (2006)). Thus the estimation using panel data of CEECs would hardly help to compute equilibrium level of credit as transition economies have probably not reached the equilibrium during the period and more importantly, the Credit-to-GDP must remain stable at the equilibrium while for CEE countries the ratio was still growing rapidly.

To avoid these problems, it is common to use out-of-sample (OOS) panel estimation, i.e. we use different set of countries (in-the-sample) to estimate the elasticities first and then apply the results to OOS countries to estimate the level of credit-to-GDP. Weaknesses of this method are, firstly, that we implicitly assume that our in-sample countries are at the equilibrium level of credit and, secondly, the results are very sensitive to sample selection. Usually, developed countries of the EU or some selection of OECD countries (e.g. Égert *et al.* (2006); Geršl & Seidler (2012)) are used as in-sample countries, because credit level in these economies is much more stable over time. However, Geršl & Seidler (2012) suggest to remove countries, which are now seen as problematic, from the sample, i.e. Portugal, Italy, Ireland, Greece and Spain, as it could again bias the estimated credit level upwards. In this study we also start with the in sample panel based on developed EU countries though somewhat more limited due to data availability. It would be even more convenient to use only countries similar to the studied region to build the in sample panel, on the other hand, this imposes even more restrictions on the data. Thus, because of data requirements of the econometrics method we use, we do not restrict the in-sample panel further.

Chapter 4

Empirical Estimation

4.1 Credit to Assets Ratio

The Credit-to-GDP ratio as proposed in Basel III was found to be a good indicator by many studies. GDP usually traces growth of borrowers income tightly, thus the ratio is a good proxy for borrowers ability to repay their debts in the future. If the ratio suddenly lifts off, it means that growth of income is lagging behind the growth of credit and thus leading to possible problems. In this chapter, this thesis draws further on the analogy with commercial banking. Credit-to-Assets ratio can be seen as a complementary indicator because the bank, when it is assessing creditworthiness of its clients, considers not only the income, but also assets which can be used to pay back the loan. It can be the case that even though GDP growth slows down, credit growth can keep its pace and still avoid the painful recession due too high net worth of borrowers. To some extent, this could catch the situation when the credit is used for consumption rather than to buy assets as well as what happens when the price of assets drops suddenly.

4.2 Review of Data

Data were obtained from IMF International Financial Statistics (IMF IFS) database, OECD, World Bank and Eurostat. IMF IFS database provides historical time series sufficiently long, starting in 1980. Obtaining data on households assets, especially non financial assets, turned out to be a real problem. Although some data on non financial assets can be found, the time series were too short and available only for a very limited number of countries. Thus we

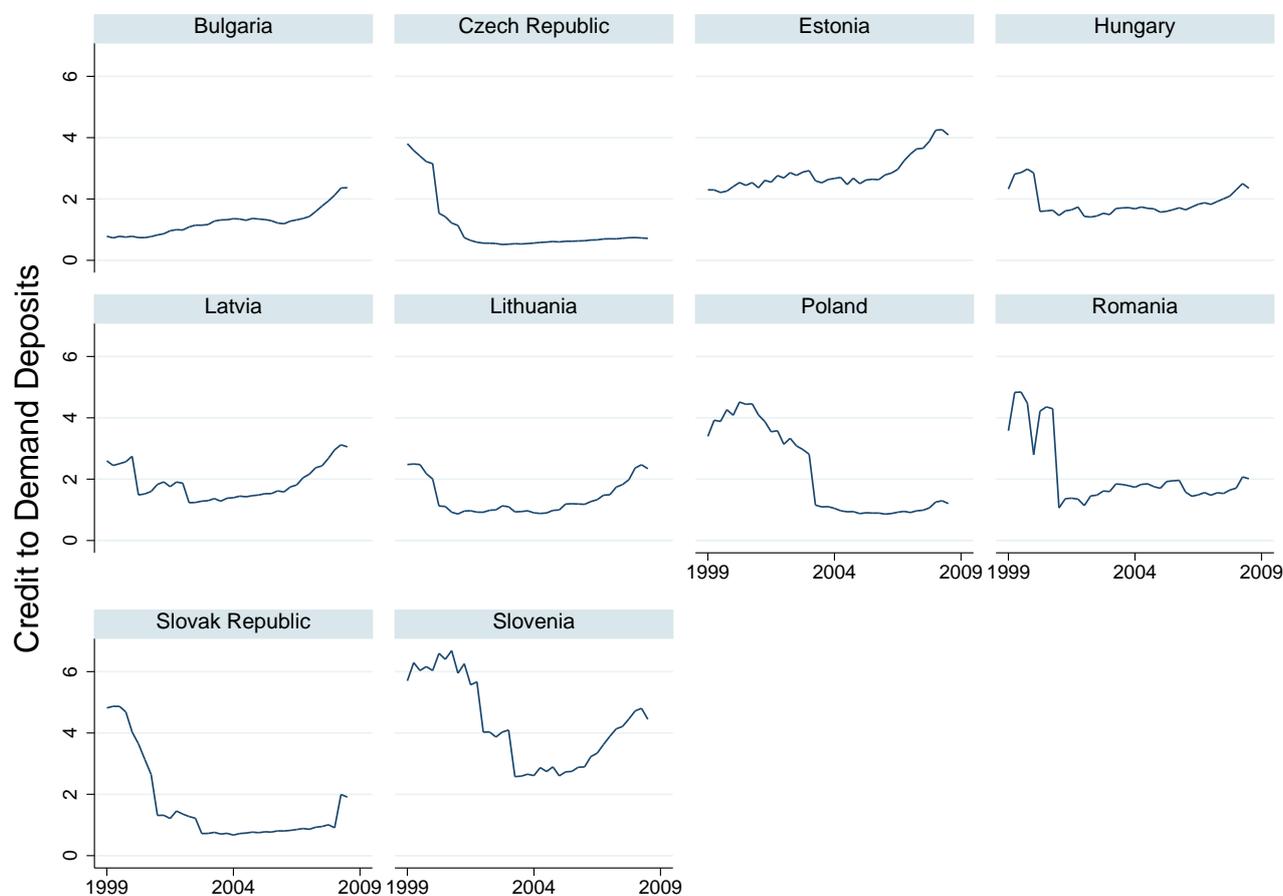
had to focus on financial assets as a proxy for total assets and we ended up with data on demand deposits (IMF IFS), total deposits (IMF IFS) and total stock of financial assets (Eurostat). As a credit we use claims on private sector (IMF IFS). OECD is gathering some information on households' assets, however, the series were too incomplete for our study. All data obtained is quarterly or linearly extrapolated from yearly data. For more information on data used, please see appendix.

In this study, our out of sample (OOS) countries are Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic and Slovenia, though not all results are applied to all OOS countries due to data inavailability. The in-sample panel consists of Austria, Belgium, Denmark, Finland, France, Germany, Netherlands and Sweden. While higher number of countries would be more convenient, we had to drop some countries due to current problems of PIIGS and also because of data availability.

4.2.1 Credit to Demand Deposits

First, we will analyze our sample in terms of private credit to demand deposits during the period 2000 to 2009. Countries can be divided into three groups. Bulgaria, Estonia, Latvia and Lithuania show acceleration in the upward trend during the period, with Estonia entering the period with already somewhat elevated level. Especially after the year 2006 acceleration becomes very significant. To some extent we can add Hungary to this group, however its level is much more stable and upward trend is very mild. Second group consists of Czech Republic, Poland, Romania and Slovakia. These countries have maintained very stable level of credit to demand deposits ratios with Czech Republic being the most stable while Romania is the most volatile in the group. Slovak Republic experienced sudden upshot at the end of the period, but this might be due to methodological changes due to adoption of the euro currency. Slovenia can be seen as a special group of its own. While during first half of the period the ratio was decreasing rapidly, it started growing again in the second half with the growth being as fast as in Baltics.

Figure 4.1: Credit to Demand Deposits Ratio

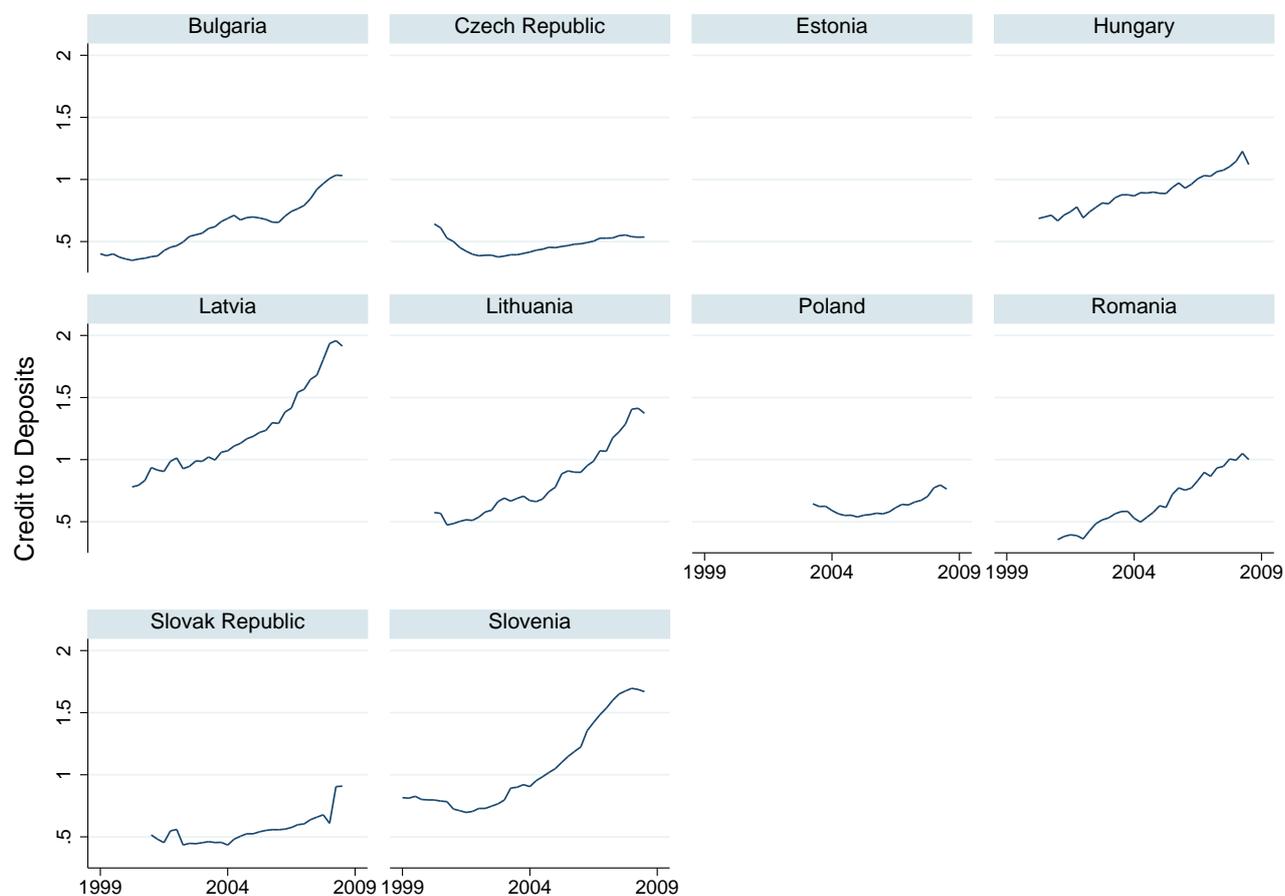


Source: IMF IFS, author's computations.

4.2.2 Credit to Total Deposits

We also aggregate together demand deposits and other deposits to calculate credit to deposits ratio again for the period from 2000 to 2009. Now Bulgaria, Hungary, Latvia, Lithuania, Romania and Slovenia show clear upward trend with slope of Latvia, Lithuania and Slovenia being the highest. Graph for Slovenia is now much smoother, therefore our previous finding of decreasing trend turning to uptrend could be explained by change in the structure of deposits. Czech Republic is showing again very solid and stable ratio. Also Slovak Republic and to some extent Poland are very stable. Estonia is dropped for the lack of data.

Figure 4.2: Credit to Total Deposits Ratio

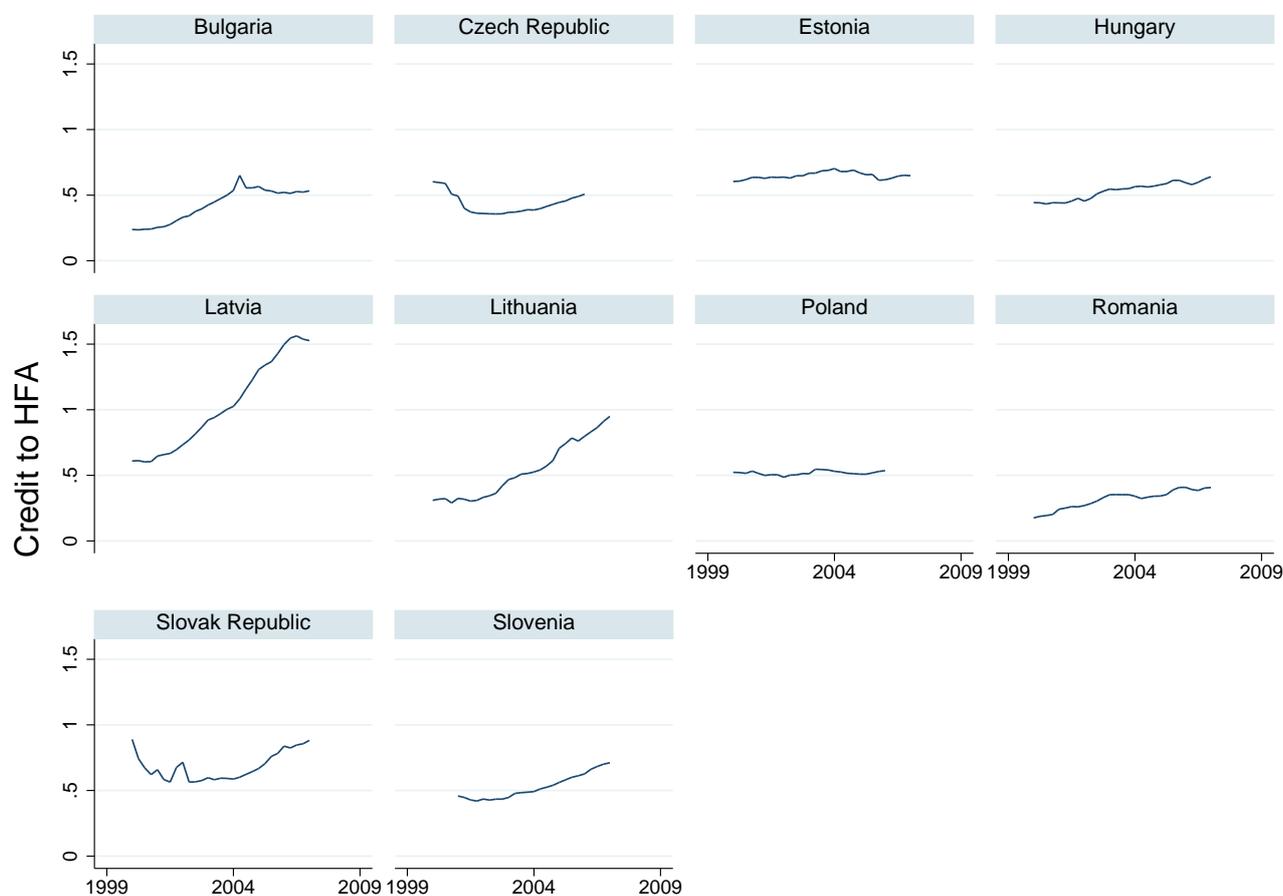


Source: IMF IFS, author's computations.

4.2.3 Credit to Households' Financial Assets

Households' financial assets (HFA) data by Eurostat are available only for the period from 2000 to 2007. Using the ratio of credit to private sector to HFA, we find the levels of many countries very stable, result notable for Bulgaria and Estonia, even though Bulgaria almost doubled the ratio since 2000 to 2005. Both Latvia and Lithuania show significant uptrend differing from the rest of countries, which could have raises questions about the sustainability of such a rapid growth. One must also note, that Bulgaria and Estonia are the only two countries, where HFA as a percentage of GDP was increasing very rapidly from approx. 50 percent to 120 percent for Bulgaria and almost 150 percent for Estonia. On the other hand, Slovakia was the only country which experienced decreasing ratio of HFA to GDP.

Figure 4.3: Credit to Total Stock of Households Financial Assets Ratio



Source: IMF IFS, author's computations.

4.3 The Model

Geršl & Seidler (2012) suggest using pooled mean group estimator (PMG) for estimating Credit-to-GDP. PMG is a version of error correction model which allows short run part to differ among the sample while long run elasticities are assumed to be the same for all countries. Pesaran et al. (1999) suggest using PMG for "large T, large N panels", i.e. panels with time series long enough to be estimated on their own, while number of countries in sample (N) is of the same magnitude. Due to data unavailability, our panel was significantly reduced in both N and T and using PMG estimator turned out to show confusing and non robust results. Therefore in this study we employ more common

fixed effects estimator, which allows intercepts (i.e. levels) to differ among the sample, while elasticities must be the same.

4.4 Credit to Deposits Estimation

In this exercise we will not estimate Credit to Demand Deposits alone as this relationship was very volatile even among developed countries and it is therefore hard to determine what should be the actual equilibrium level. First, we estimate a model for equilibrium level of Credit-to-Deposits ratio. As in sample countries we use: Austria, Belgium, Denmark, Finland, France, Germany, Netherlands and Sweden. In general, we use data for the period from 1980 to 2009 based on data availability. In the model we use following variables:

RGDPpercapita is GDP per capita rescaled to tens of thousands USD. Process of financial deepening is trusted to be correlated with increase in GDP per capita. Usually as country becomes more and more rich, its financial services also tend to improve. This can manifest in the increase in the amount of loans. Also better financial services lead to better risk management thus decreasing the requirements on collateral. On the other hand this can be also seen as irresponsible behaviour - banks are lending more and more risky money. Furthermore, this increase in Credit-to-Deposits ratio can be driven by depositors finding more profitable financial products. As a result, we expect this coefficient to be positive.

ConsToGdp is a ratio of consumption to GDP. As consumption rises, it is likely that consumers require more credit. Higher propensity to consume can also result in a decrease in the amount of deposits. Thus we expect the sign to be negative.

inf is inflation computed as a difference in GDP deflators. Expected direction of the effect is hard to determine. Inflation should lead people to save less and spend more, decreasing the total amount of deposits. Also inflation motivates people to borrow more as it makes it easier to pay back the loan in the future. On the other hand, banks usually become more cautious when inflation rises and calibrate their lending rates properly which in turn decreases lending.

InterestRate is lending rate obtained from IMF IFS. Interest rate increase should lead agents to borrow less as a price of money increases. At the same time increase in interest rates should also increase interest rates on deposits and increase incentives to save more. The expected sign is thus negative.

Table 4.1: Estimation results : Credit to Deposits

Variable	Coefficient	(Std. Err.)
RGDPpercapita	0.499	(0.024)
ConsToGdp	3.115	(0.469)
inf	-0.841	(0.201)
InterestRate	0.013	(0.003)
Intercept	-1.845	(0.298)

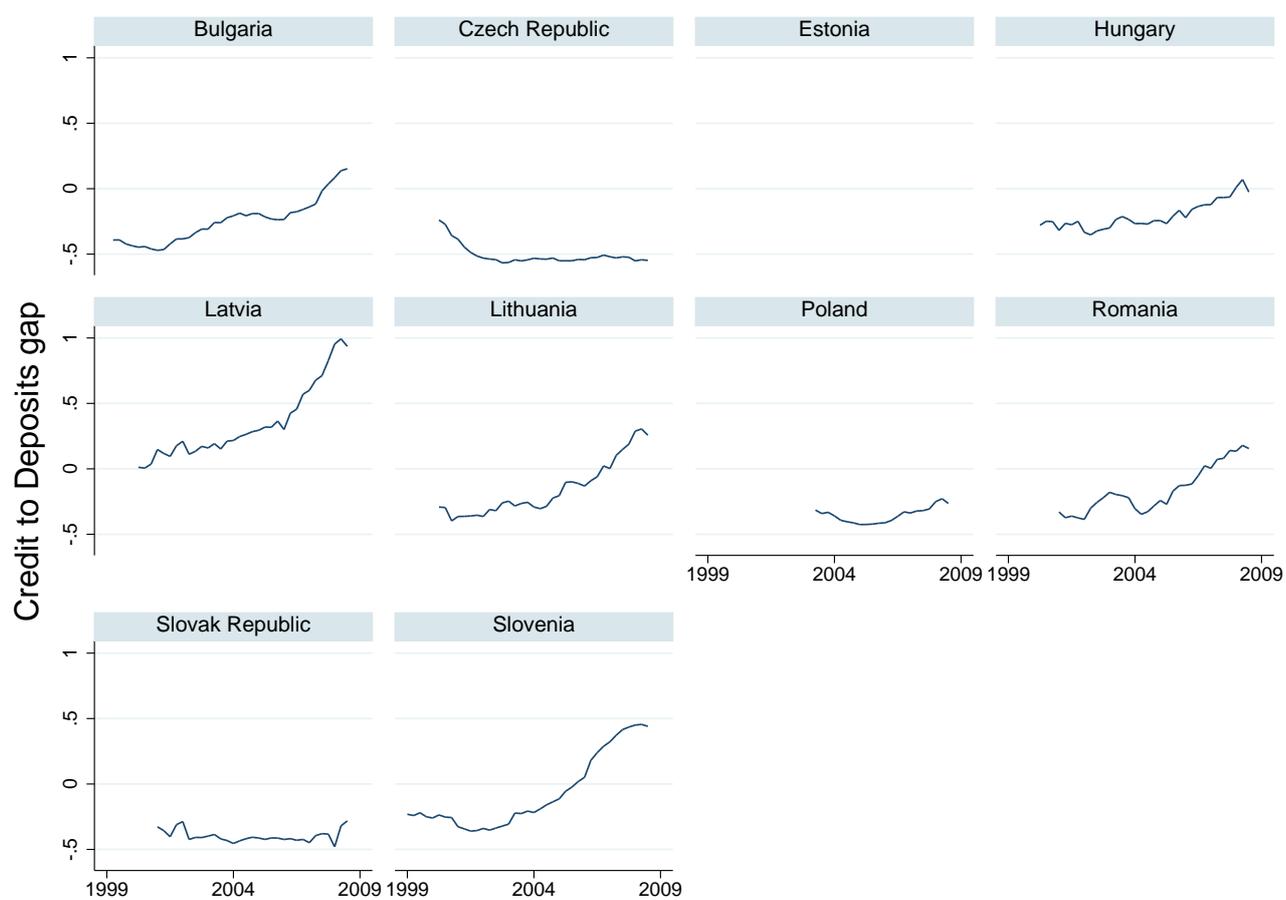
In the first equation (Table 4.1) all coefficients are significant at a very high level of confidence using t-test. Estimation results meet our expectations with the exception of interest rate. The positive effect of interest rate is hard to explain. Because time series on interest rates are shorter compared to the rest of data, including interest rate in the regression decreases the sample size significantly. More notable drawback of this model is that it is not applicable on Poland, while we do not have sufficient data on interest rate in a year 2008. To test robustness of this model, we also estimate a model without interest rate:

Table 4.2: Estimation results : Credit to Deposits

Variable	Coefficient	(Std. Err.)
RGDPpercapita	0.364	(0.013)
ConsToGdp	1.766	(0.336)
inf	-0.442	(0.169)
Intercept	-0.650	(0.204)

Even though the coefficients are very different, estimated trend values of OOS countries are very similar for both models when applied over the period, thus we decide to stick with the second model not to be forced to drop Poland out of OOS countries panel. Now we can take our estimated long term elasticities and apply them to compute Credit-to-Deposits gap (see Figure 4.4). Czech Republic is very firmly under its equilibrium ratio providing support to the often cited fact that banks in Czech Republic have actually too much liquidity. Slovak Republic and Poland are also very firmly under the equilibrium. Hungary crosses the equilibrium line only at the end of the period. Cases of Bulgaria, Romania and Lithuania show somewhat more persuasive gap, when rapid growth first approached equilibrium level and then exceeded it. The most disturbing cases are Slovenia and Latvia. Slovenia has reached the equilibrium level in year 2006 but after that the ratio grew even more rapidly. Latvia is the only country with steady positive gap which was increasing during the whole period until it almost reached 100%.

Figure 4.4: Credit to Deposits gaps, p.p.



Source: IMF IFS, author's computations.

4.5 Credit to Households' Financial Assets estimation

Next model is based on Households' Stock of Financial Assets (HFA) provided by Eurostat. As already mentioned, even though these data are basically the best for our purposes, these time series have several drawbacks. First, data covers only period from 2000 to 2007 with even few observations for years 2000 and 2007 missing (this is very unfortunate especially in data for Czech Republic). Eurostat also made clear that these series will not be continued, however, recent survey by ECB (2013) shows willingness to gather better data on households' net worth in the future. However, for this study, ECB paper is of limited utility as it provides data only for one year for each country and also it focuses exclusively on Eurozone.

This can also show a drawback of our previous estimation. While deposits are pretty good estimator of households' wealth in CEECs given most of the financial wealth is kept on personal accounts in banks, in more developed countries the situation is much more complicated. Wider variety of financial products together with higher trust in financial institutions and tradition of stable financial system leads to lower balances on deposits in developed countries in comparison to other financial assets. However, if we use more proper measure, i.e. households' stock of financial assets, the ratio of Credit to Assets is much more comparable to CEECs and often even lower. Due to these facts, differences in gap estimation might be a reason to question our first approach. On the other hand, financial assets are always only part of the story and real assets, especially real estate, are a significant part of households' wealth. This can lead to a significant difference between gaps computed using financial assets as opposed to total assets, especially when credit boom is driven by mortgages. This type of data is, however, not available.

Table 4.3: Estimation results : CreditToHFA

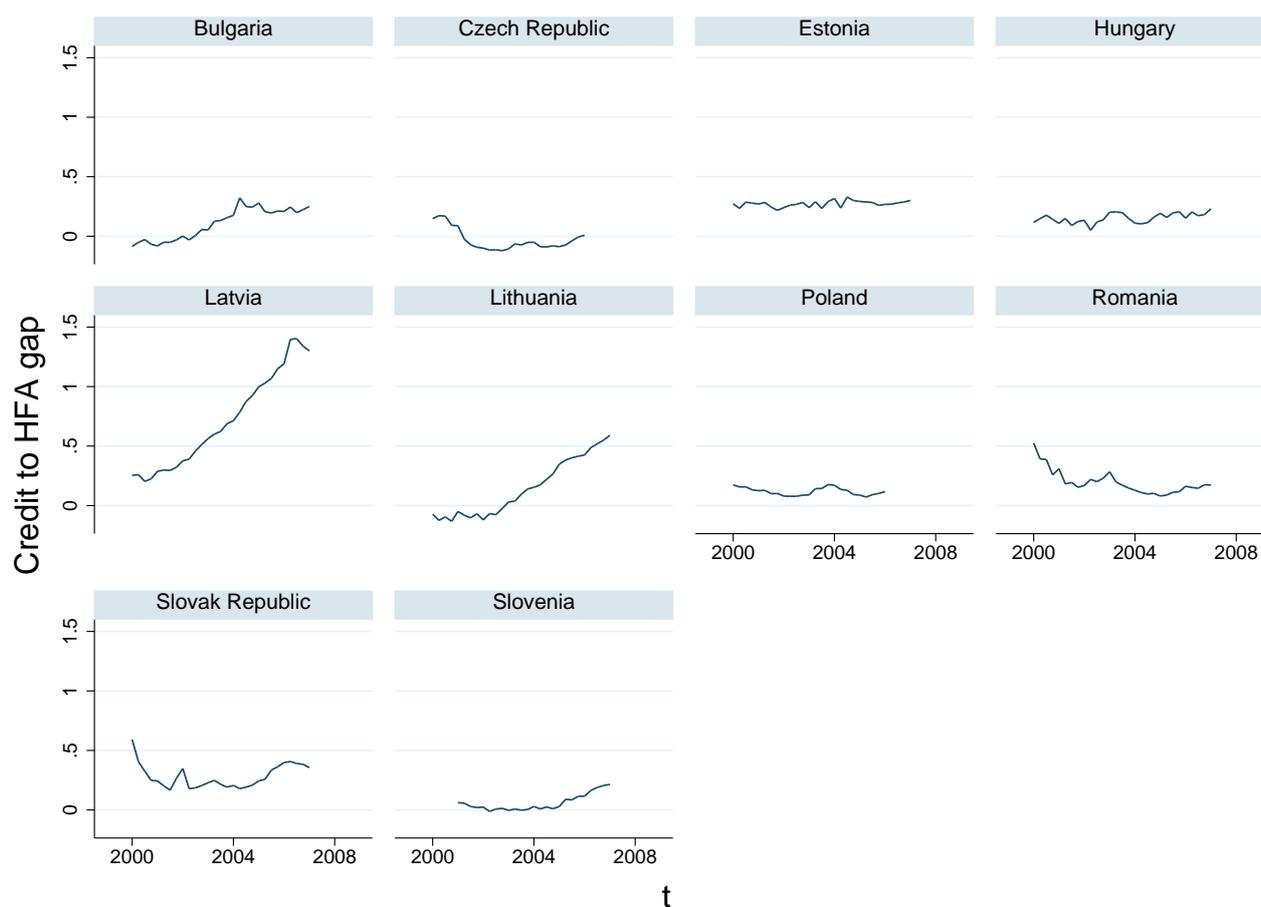
Variable	Coefficient	(Std. Err.)
RGDPpercapita	0.090	(0.017)
inf	-1.310	(0.217)
Intercept	0.317	(0.053)

Both interest rates and consumption to GDP were dropped due to insignif-

ificance. The other variables are significant even at 99 percent level, incl. intercept.

During the period 2000 to 2007, most of the selected countries gaps are between 0% and 50% (see Figure 4.5), only Czech Republic was steadily maintaining negative gap after solving the problems in banking sector in the early 2000s. Slovakia and Estonia show stable, though elevated gaps during the whole period. Estonia is also interesting example to show the difference in structure of HFA. While Czech Republic maintains its very high share of deposits on total HFA, Estonia's share was only 17.6% at the end of studied period (Eurostat (2009)). The only rapidly widening gaps can be found for Latvia, which is clearly an outlier in this group, and Lithuania. Both of these countries were already identified experiencing suspiciously fast credit growth.

Figure 4.5: Credit to HFA gaps, p.p.



Source: IMF IFS, Eurostat, author's computations.

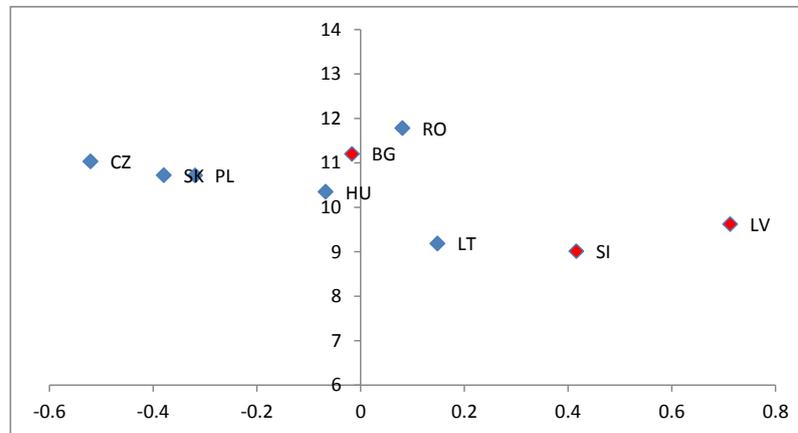
Chapter 5

Results

5.1 Indicators Performance Assessment

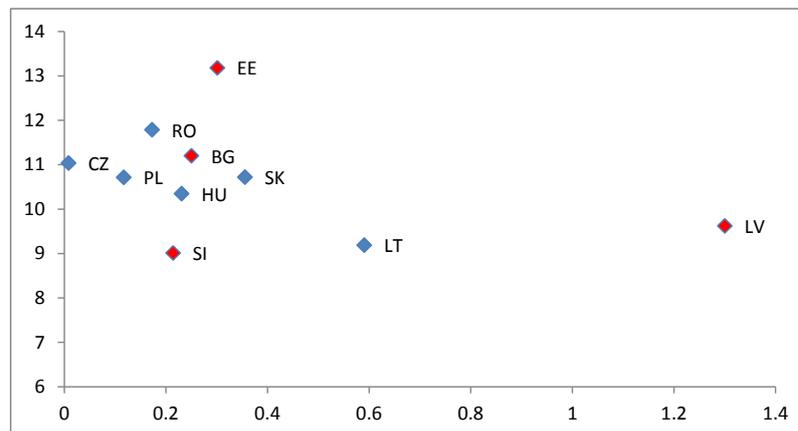
In this analysis we build upon the work of Geršl & Seidler (2012). First, we compare both of our indicators with Tier 1 ratio in the year 2008. This exercise shows whether these countries were aware of the excessive nature of credit and whether regulatory authorities increased the requirements on regulatory capital. Next, we compare the indicator with return on equity (RoE) of banks as a measure of the impact on banks. Countries identified by Geršl & Seidler (2012) as problematic are marked by red symbols as opposed to blue symbols of countries with buffers set to 0% based on their methodology.

Figure 5.1: Credit-to-Deposits gap in p.p., Tier 1 ratio in p.p. of RWA



Source: IMF IFS, Geršl & Seidler (2012), author's computations.

Figure 5.2: Credit-to-HFA gap in p.p., Tier 1 ratio in p.p. of RWA



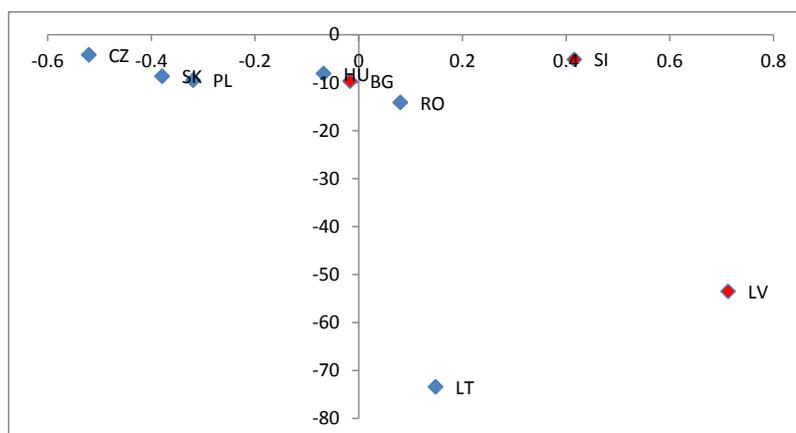
Source: IMF IFS, Geršl & Seidler (2012), author's computations. Gap for CZ and PL from 2006.

Both Credit-To-Deposits gap and Credit-to-HFA gap show little to no correlation with Tier 1 capital ratio (see Figure 5.1 and Figure 5.2). Note that in

Estonia the level is much higher than for the rest of our sample because data for Estonia were available only for the last quarter of 2008, when a lot of financial stress already materialized. These results can also serve as an argument for using countercyclical buffer as banks in troubled countries would be more capitalized compared to the past setting as the capital ratio was apparently not higher in countries, where the risk of financial stress was higher.

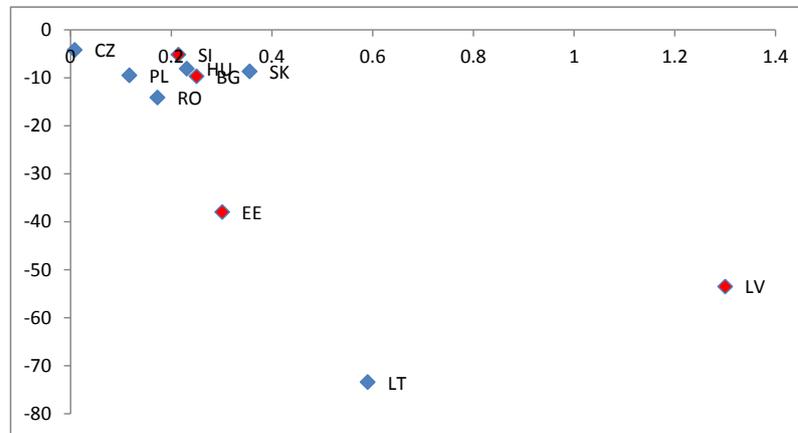
As in Geršl & Seidler (2012) we choose return on equity (RoE) ratio change between 2008 and 2009 to compare the impact of crisis on various countries (see Figure 5.3 and Figure 5.4). The RoE captures both credit and market losses and other possible increases in funding costs due to higher riskiness. Both indicators show mixed results. While Latvia and Lithuania show excessive gaps in Credit-to-Deposits ratio, the small difference between Lithuania and Romania compromises reliability of the indicator and shows it is unsuitable for linear relationship with the size of countercyclical buffer. Credit-to-HFA performs better in identifying Lithuania as a concern, however, it would need larger sample to determine clear threshold as under 40% the group of countries is very close together. Credit-To-HFA gap also fails to indicate excessive credit for Estonia. On the other hand it shows Slovakia has the third largest gap even though RoE change does not show troubles in financial sector.

Figure 5.3: Credit-to-Deposits gap in p.p., RoE change in p.p. of RWA



Source: IMF IFS, Geršl & Seidler (2012), author's computations.

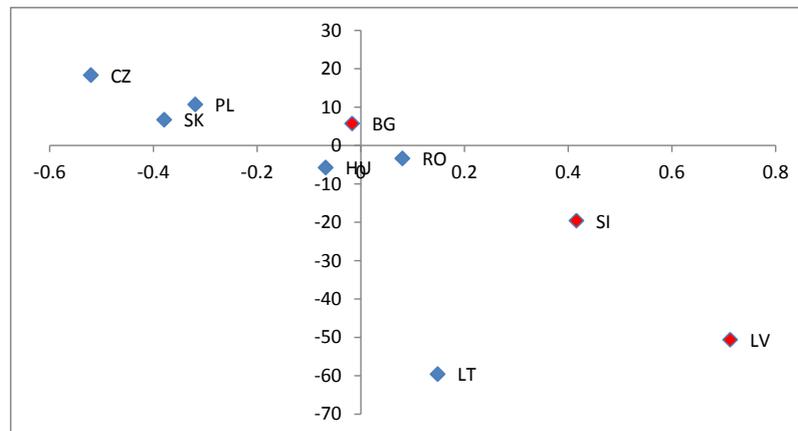
Figure 5.4: Credit-to-HFA gap in p.p., RoE change in p.p. of RWA



Source: IMF IFS, Geršl & Seidler (2012), author's computations. Gap for CZ and PL from 2006.

In the year 2008 the crisis in the region began by fall of Lehman Brothers and the beginning of global financial crisis. Thus the crisis in the region, especially Baltics, was not only a result of its internal imbalances. Nevertheless these imbalances made the impact of the crisis worse, if we compare credit growth and severity of recession in particular countries. The alternative hypothesis can be, that banking sectors were not hit so hard because the problems of 2008 were not manifestation of the whole internal imbalances yet and could not be caught by difference between years 2008 and 2009 only. For this reason we focus on the whole period from 2008 to 2012 to find lowest and highest values of RoE.

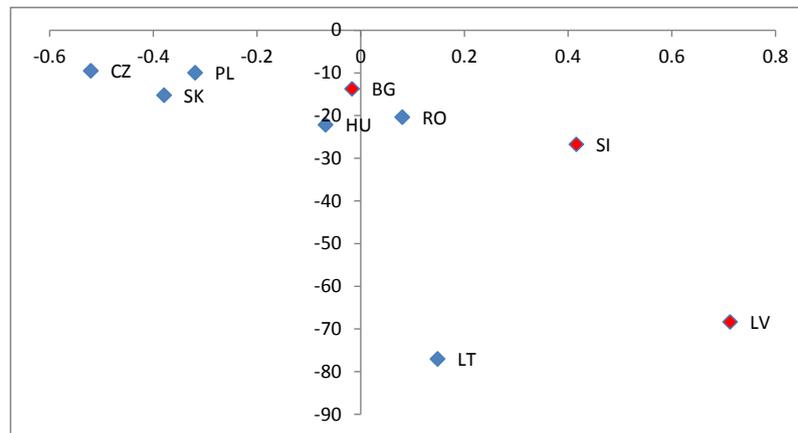
Figure 5.5: Credit-to-Deposits gap in p.p., Lowest RoE in p.p. of RWA



Source: IMF IFS, Geršl & Seidler (2012), author's computations.

RoE of every country with positive Credit-To-Deposits gap went into negative territory sometimes in the period. The only exception is Hungary, where RoE also went negative but was not showing excessive Credit-To-Deposits ratio. Note that Slovenia, at the beginning no outlier in terms of RoE change but showing very high gap in Credit-to-Deposits, is now firmly in south east region of the plot. To avoid possible fail in judgment due to different pre-crisis RoE levels, we also use highest and lowest values of RoE to compute a difference. This, however, only confirms our previous results.

Figure 5.6: Credit-to-Deposits gap in p.p., RoE High-Low difference in p.p. of RWA

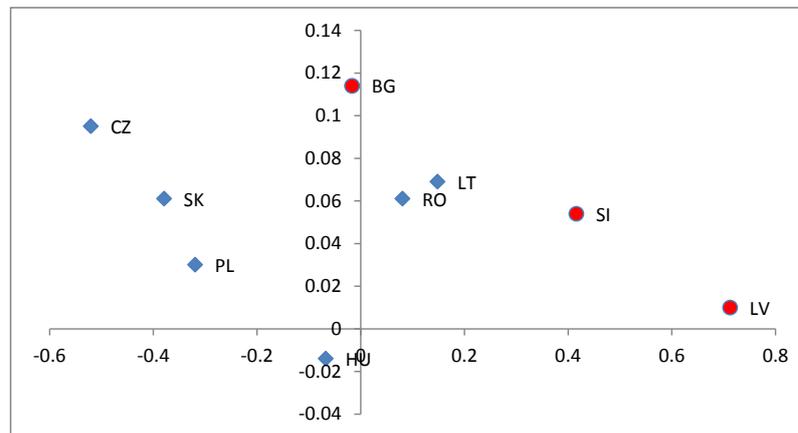


Source: IMF IFS, Geršl & Seidler (2012), author's computations.

5.2 Comparison With Other Indicators

Figure 5.7 compares the results of Credit to Deposits gap using our method, Credit to GDP gap using HP filter and countries with excessive credit growth as found in Geršl & Seidler (2012) (where circle marker means excessive credit according to this study). Our indicator performs better compared to HP filter as it does not signal excessive credit for Czech, Slovakia and Poland, which proven to be well prepared for the crisis. As mentioned earlier, it also catches Lithuanian credit boom.

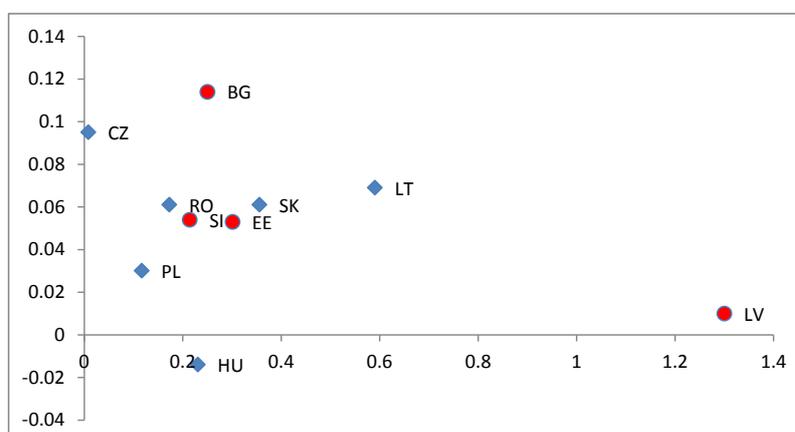
Figure 5.7: Credit-to-Deposits gap in p.p., Credit-to-GDP gap using HP filter



Source: IMF IFS, Geršl & Seidler (2012), author's computations.

Again, Credit to HFA gap yields more inconclusive results (Figure 5.8). Latvia and Lithuania could be easily detected by setting threshold for the Credit to HFA gap around 50 percent of HFA. Estonia is impossible to separate from the group consisting of Slovakia, Romania and Slovenia. This can happen because of the popularity of foreign credit, which is not included in our data. Also, HFA as a percentage of GDP was rapidly growing in Estonia. Even though we can see this as a positive trend, because available collateral of households is increasing, the mechanism of using assets for paying back the debts and its impact on economy and banks would need to be examined. The only positive outlier is Czech Republic with negligible Credit to HFA gap compared to the rest of sample, providing support to the hypothesis of a very robust banking sector in this country.

Figure 5.8: Credit-to-HFA gap in p.p., Credit-to-GDP gap using HP filter



Source: IMF IFS, Geršl & Seidler (2012), author's computations.

5.3 Further Research Questions

Our estimation has shown that alternative indicators which use some kind of assets can give different results than using solely Credit to GDP gap, whether computed using HP filter or out of sample method. On the one hand, this is good as our indicators were able to somehow spot imbalances, where problems unnoticed by other methods emerged. On the other hand, when the regulator needs to make real time decisions, contradictory indicators are not any help. Especially when our method also signals troubles for countries, where banking sector was resilient and well prepared for the crisis (e.g. Slovakia). More comprehensive study with larger sample could help to solve this issue of setting proper bounds for the indicators as well as improve their calibration.

The study was very limited by data availability. Thus obtaining comparable data for households' assets could help to build much better indicators than what is feasible nowadays. Even though individual central banks provide some further data on this topic, their definitions vary among the countries as well as whether they are made public. However, recent attempts by ECB to gather together comparable data are promising. Also disaggregating private credit could lead to interesting results. As mentioned earlier in the thesis, some

countries were not showing excessive private credit growth during the period but consumer credit was dangerously booming. The indicators would also need to be improved to be able to spot risk in cross country exposures but this weakness was well known to the authors and was not part of this work to keep the simplicity of the indicators.

Chapter 6

Conclusion

In this thesis, we were focusing on the problem of early warning indicators in Central and Eastern European Countries. Past literature on early warning indicators identified ratio of Credit (usually some kind of private credit) to GDP and its deviation from a long term trend as the best indicator. Thus, it is also suggested as a good indicator variable for countercyclical capital buffer as proposed in Basel III regulatory package by BCBS. We argued, that suggested Hodrick-Prescott filtering method for trend extraction would lead to spurious signals for CEE countries in 2000s, because time series available for these countries are not long enough to calibrate the trend properly.

Alternative solution to this issue is estimating the trend or level by a set of economic fundamentals using a panel of suitable developed countries, where the ratio is assumed to be at equilibrium. We build upon the work of Geršl & Seidler (2012), who estimated elasticities for computing the trend of Credit to GDP ratio. In this thesis we wanted to test the performance of various different denominators representing some kind of proxy of households' net worth or assets. Due to limited data availability, we used demand deposits, total deposits and households' stock of financial assets. Using a change in the return on equity of banking sector as a proxy for financial stress, we assessed the performance of these new indicators. Credit to Households' stock of financial assets gap succeeded in identifying Latvia and Lithuania as potentially problematic. However, it failed completely in case of Estonia and it also assesses Slovakia's gap very high compared to ex post knowledge of Slovakia's system proving itself very robust. Credit to Deposits gap performs much better, especially when considering the whole period from 2008 to 2012 to find lowest return on equity, what enables to catch also Slovenia's current problems in banking sector. The

indicator is somewhat non linear though, given higher value does not necessarily mean more trouble in the future. Also two contrast cases emerge - Romania and Lithuania - which both have gaps of comparable size, however, Romania's problems were nowhere near Lithuania's.

Further work would need to be done to determine precisely thresholds for what is a signal and what is not. Next, e.g. Estonia experienced also a rapid growth of financial assets as well as a rapid credit growth and bust, so the mechanism in which assets are used to pay back the loans and its impact on banks would need to be examined. Also new data on households' net worth would be a good starting point as even though banks play very important role in the studied region, variables we used might not be as good proxies as we would like them to be.

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Appendix A

Data

Table A.1: Data Sources

Name	Database	Code
Claims on Private Sector	IMF IFS	22D__ and FOSAOEA
Claims on Private Sector	IMF IFS	32D__
Demand Deposits	IMF IFS	24__
Demand Deposits	IMF IFS	32B__N
Private Final Consumption Expend.	IMF IFS	NCP
GDP deflator	IMF IFS	NGDP_D
Gross Domestic Product	IMF IFS	NGDP
Interest Rate	IMF IFS	FILR
Other Deposits	IMF IFS	35__N
GDP per capita	World Bank	
Household's Stock of Financial Assets	Eurostat	