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Procyclicality in Basel II and Basel III

Diploma Thesis

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Abstract

The term procyclicality refers to the ability of a system to amplify business cycles. The recent financial crisis has revealed that the current regulatory framework, Basel II, affects the business cycle in exactly that manner. The newly published Basel III therefore sought to include tools that would mitigate the procyclical nature of regulatory framework. The aim of the thesis is to analyze whether such tools are effective and whether the procyclicality under Basel III has been mitigated when compared to Basel II. In order to conduct such analysis we employ a simple model with the households and firms sector. Using the OLS estimation method we estimate the sensitivity of Basel risk weights to the business cycle under both Basel II and Basel III conditions.

As the Basel III framework has been published only recently, there are few studies that would analyze its effect on procyclicality. The main contribution of this thesis consists of implementation of Basel III countercyclical tools and the comparison between both frameworks. The thesis further contributes to the existing literature by conducting the analysis on the data for the Visegrád Group, that is for the Czech Republic, Slovakia, Hungary and Poland.

JEL Classification	E32, E44, E58, G21
Keywords	procyclicality, Basel II, Basel III, banking supervision

Abstrakt

Termínem procykličnost se označuje schopnost systému zesilovat výkyvy hospodářského cyklu. Nedávná finanční krize prokázala, že současný regulační rámec Basel II na hospodářský cyklus působí přesně tímto způsobem. Nový rámec Basel III proto obsahuje nástroje, které by procykličnost měly snížit. Cílem této práce je zjistit, zda jsou tyto nástroje efektivní a zda se procykličnost Basel III v porovnání s Basel II sníží. V rámci analýzy použijeme model jednoduché ekonomiky se sektorem domácností a sektorem firem. Pomocí MNČ odhadneme citlivost rizikových vah, definovaných Basilejskými dohodami, na hospodářský cyklus.

Vzhledem k tomu, že finální verze Basel III byla publikována teprve nedávno, nenabízí současná literatura mnoho analýz dopadu Basel III na procykličnost. Proto je hlavním přínosem této práce model zahrnující proticyklické nástroje podle Basel III a následné srovnání vlivu obou Basilejských dohod na hospodářský cyklus. Přínosem je také analýza procykličnosti přímo pro region Visegrádské čtyřky.

JEL klasifikace	E32, E44, E58, G21
Klíčová slova	procykličnost, Basel II, Basel III, bankovní dohled

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Declaration of Authorship

The author hereby declares that she compiled this thesis independently, using only the listed resources and literature.

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Prague, May 19, 2011   _____
                                                                           Signature

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Master Thesis Proposal

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Proposed Topic:

Procyclicality in Basel II and Basel III

Topic Characteristics:

The Basel Committee on Banking Supervision, hosted by the Bank for International Settlements, is without doubt the most influential authority dealing with the bank supervisory matters. The supervisory recommendations provided by the Committee are presented in the form of Basel Accords. The current set of recommendations, called Basel II, has been issued in June 2004, greatly improving the original Basel Accord from 1988. Basel II is based on three pillars, namely the minimum capital requirements (dealing with credit, market and operational risk), the supervisory review process and the transparency and market discipline. However, despite several updates, the second Basel Accord still faces some fundamental problems as the recent financial crisis has revealed. Therefore, the Committee has started the work on new improved set of guidelines, referred as Basel III. Key areas of the third Basel Accord concentrate on improved quality and transparency of the capital base, stronger risk coverage, newly set minimum liquidity standards and especially measures to mitigate procyclicality of Basel II in form of promoting built-up capital buffers.

The experts differ about the potential impact of the new set of recommendations on banks and fear the reduction of global growth due to banks inability to provide sufficient credit for recovery of the economy. The aim of this diploma thesis will be therefore to analyze the potential impact of Basel III framework on performance of banks. We will concentrate on economies of Central Europe, namely on Czech Republic, Slovakia, Poland and Hungary with reference to developed markets of Germany, France and Spain. Based on the data provided by the Bankscope database we will examine ex post the bank performance in Central Europe under the Basel II framework and during the crisis and we will estimate the impact of Basel III rules especially in the area of capital requirements and procyclicality measures. The effect of procyclicality measures in Central Europe will be analyzed in comparison to Spain as this country already had to adopt similar measures after the euro adoption.

Hypotheses:

1. Basel II rules led to higher capital increase in CEE countries when compared to the countries of Western Europe such as Germany.

2. Basel III framework will also have higher impact on CEE countries regarding the capital requirements than on countries of Eurozone.

3. Compared to the CEE countries, there will be lower effect of procyclicality measures proposed by Basel III in Spain.

Methodology:

The method of stress-testing will be used to investigate the hypotheses specified above. It is a method used in many banks, including the Czech National Bank, to investigate stability of banking sector and its immunity against shocks. Capital requirements of Basel Accords are expressed in a form of capital adequacy ratio, which specifies proportion of capital (divided in Tier 1 and Tier 2 capital) to the risk-weighted assets (RWA). The total amount of regulatory capital changes depending on the predicted performance of the bank while RWA can be modeled for every risk separately based on stress scenarios. The stress scenarios are provided based on macroeconomic prediction as well as the risks identified.

The assumptions for stress scenarios in this diploma thesis will be based on reports about economic impacts of Basel III proposal. One study, provided by the Institute for International Finance, is to be issued in these days while the Basel Committee is expected to provide its own report later this year.

Outline:

1. Introduction
2. Theoretical background
    2.1. Basel II framework and bank capital management
    2.2. Bank performance during financial crisis
    2.3. Basel III proposal
3. Empirical analysis
    3.1. Literature review
    3.2. Methodology
    3.3. Data analysis
    3.4. Results
4. Conclusion

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ACRONYMS

AMA	Advanced Measurement Approaches
BCBS	Basel Committee on Banking Supervision
BIA	Basic Indicator Approach
BIS	Bank for International Settlements
DSGE	Dynamic Stochastic General Equilibrium
EAD	Exposure at Default
ECAI	External Credit Assessment Institution
FASB	US Financial Accounting Standards Board
FVA	Fair Value Accounting
GAAP	Generally Accepted Accounting Principles
HCA	Historical Cost Accounting
IAS	International Accounting Standards
IASB	International Accounting Standards Board
IFRS	International Financial Reporting Standards
IMA	Internal Models Approach
IMF	International Monetary Fund
IOSCO	International Organization of Securities Commissions
IRBAA	Internal Rating Based Advanced Approach
IRBFA	Internal Rating Based Foundation Approach
LCR	Liquidity Coverage Ratio
LGD	Loss Given Default
M	Maturity
NSFR	Net Stable Funding Ratio
OLS	Ordinary Least Squares
PIT	Point-in-time rating
PD	Probability of Default
RWA	Risk-weighted assets
SA	Standardized Approach
TTC	Through-the-cycle rating
VaR	Value at Risk

Chapter 1: INTRODUCTION

"Bankers have a bad habit of making economic cycles worse. They are notorious for lending people umbrellas when the sun is shining and asking for them back when rain starts to fall." With these exact words The Economist introduced its article on banking regulation and its adjustment to the economic cycle in April 2008. The title mirrors the vibes towards banking regulation after the onset of the financial crisis. The current crunch has raised many talks about regulatory framework and revealed that current rules for supervision are not sufficient as they failed to predict or even avoid such a crisis.

Within the discussions the increased risk sensitivity and procyclicality of the actual set of regulatory rules, the Basel II framework, came to light. Certain financial instruments have the ability to intensify business cycles. They deepen the recessions and pronounce periods of expansion. Basel II appears to be one of them. Its capital adequacy formula has been updated to a risk sensitive version which causes the required amount of capital to grow in times of economic downswing and vice versa. With a higher amount of capital necessary to keep as a capital adequacy banks may offer less credits and force the economy deeper into recession.

Many studies have been published which demonstrate the procyclicality of Basel II in comparison to risk insensitive Basel I. Such evidence contributed to the call for a better framework and a new, improved set of rules has been developed. The body responsible for the framework is the Basel Committee on Banking Supervision (BCBS) which is operating under the Bank for International Settlements (BIS). It consists of the members of central banks and bank regulators worldwide and has been responsible for rules on banking supervision since 1988 when the first Basel Accord was published.

Although Basel II had officially come into force not long before the crisis BCBS started the work on new and better rules. First, the current system has been upgraded and after its publication the responses of the banking world have been

collected and further employed to calibrate the framework. Sometime during this process the improved framework has adopted the title Basel III.

One of the objectives of Basel III is to mitigate the procyclicality of previous framework. The aim of this thesis is to analyze how much procyclicality has been mitigated under the new rules when compared to Basel II. We will do so on a macroeconomic level concentrating on the countries of the Visegrad Four, that is on the Czech Republic, Slovakia, Poland and Hungary, by comparing development of the risk weights of Basel capital adequacy to the business cycle for both regulatory frameworks. The analysis revolves around three hypotheses which we are going to verify. First hypothesis states that there is a strong negative correlation between the business cycle and the risk weights for Basel II. Further we assume that such correlation will be weaker for Basel III framework. And final hypothesis states that the effect of Basel Accords will differ given the heterogeneous response of the countries towards the financial crisis.

The structure of this thesis is as follows: in Chapter 2 we first introduce the existing set of rules, Basel II, with emphasis on the risk sensitive approach to credit risk. Then we briefly describe bank performance during the crisis, which disclosed many shortcomings of the existing system and which has lead to the creation of new set of rules, Basel III. Those are described at the end of second part. For the sake of completeness the whole Basel II and Basel III framework will be introduced. However, the emphasis will be put on procyclical features and the tools for their mitigation. After introducing the core ideas and methods of the existing literature in the field of procyclicality analysis Chapter 3 presents the empirical analysis. The model is based on the regression analysis of time series of risk weights which are calculated based on the Basel formulae for capital adequacy. In order to implement countercyclical tools of Basel III we calculate for excessive credit growth, transfer it into countercyclical buffer and add the buffer to the capital adequacy formula in order to obtain new time series of risk weights under Basel III. From the time series of risk weights the sensitivity to the business cycle is obtained and compared for both regulatory frameworks. Basel regulatory framework refers to additional source of procyclicality and that are the accounting standards. Recent switch from Historical Cost Accounting to Fair Value Accounting has increased the volatility of accounting

information as it more directly reacts to market conditions. The discussion about the impact of accounting standards on procyclicality and the reforms to mitigate it are discussed in Chapter 4. Chapter 5 finally provides the conclusion of the topic followed by the Appendices which supply the detailed numerical results of the empirical model.

Chapter 2: THEORETICAL BACKGROUND

2.1. BASEL II FRAMEWORK AND BANK CAPITAL MANAGEMENT

The current set of rules for banking supervision, commonly referred as Basel II, was officially published in June 2006 by the Basel Committee on Banking Supervision under the name *"International Convergence of Capital Measurement and Capital Standards"*. It was a result of long term process of improvement of the original Basel Capital Accord from 1988, a document which provided first comprehensive set of rules for banks' supervision. With growing globalization and integration of the banking sector this Basel Capital Accord, or Basel I, soon proved to be insufficient. However, its capital adequacy framework together with the structure of the 1996 Amendment incorporating market risk[1] formed a basis for the new set of rules, Basel II.

The aim of Basel II was to "develop a framework that would further strengthen the soundness and stability of the international banking system while maintaining sufficient consistency that capital adequacy regulation will not be a significant source of competitive inequality among internationally active banks" (BCBS, 2005). Improving Basel I meant to address its main criticisms. Among those were especially low risk sensitivity, limited recognition of collateral, incomplete coverage of risk sources and no diversification. The first set of proposals was issued already in June 1999 as the first Consultative Paper (CP1). It was followed by the second Consultative Paper in January 2001 and CP3 in April 2003. The final version was published in June 2004 and its revised version in June 2006.

2.1.1. Structure of Basel II

The New Basel Capital Accord, as the Basel II framework is also called, is based on three pillars as depicted in Figure 2.1. First pillar deals with the minimum

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[1] 1996 Amendment to the Capital Accord to Incorporate Market Risk, updated 2005

capital requirements; second pillar concentrates on the supervisory review process while the third pillar handles the agenda of market discipline.

Figure 2.1: Structure of Basel II
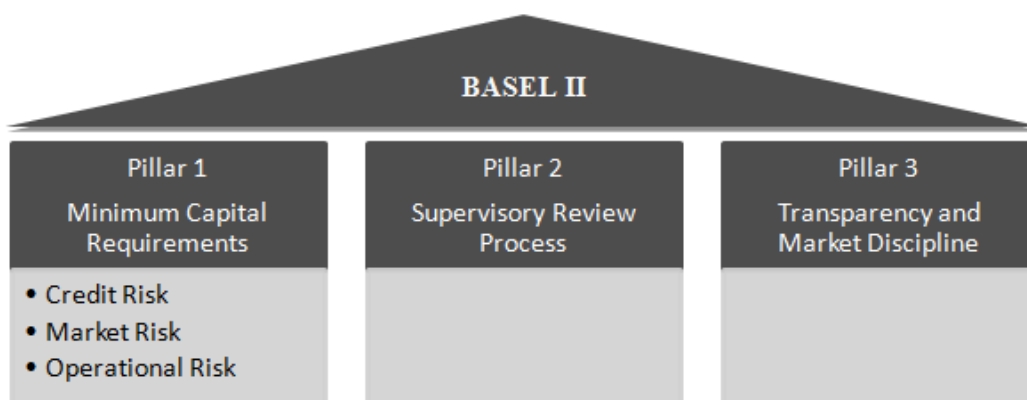
Source: BCBS (2006)

2.1.2. Pillar 1

The first pillar of the New Basel Accord presents rules for risk management and the calculation of minimum capital requirements which are supposed to serve as a buffer in case of unexpected losses. The minimal required capital is calculated by means of eligible regulatory capital and risk-weighted assets (RWA, see Equation 2.1) and it is set at the value of 8%.

Equation 2.1

$$capital\ ratio = \frac{eligible\ regulatory\ capital}{RWA_C + RWA_M + RWA_O} \geq 8\%$$

Where RWA_C…risk-weighted assets related to credit risk

RWA_M…risk-weighted assets related to market risk

RWA_O… risk-weighted assets related to operational risk

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As we can see on the Figure 2.1 Basel II takes into account credit risk, market risk and operational risk. All the three risks must be taken into account when calculating RWA.

Credit risk refers to a risk of borrower entering into default and not being able to repay the loan. Its management is based on the *solvency ratio* of the 1988 Basel Capital Accord, however, upgraded significantly. The improvement enhances flexibility and offers banks more possibilities for determining capital requirements based on their risk and other characteristics. In addition to the standardized approach to capital requirements Basel II namely allows the use of internal ratings of the banks. As these ratings sometimes lead to lower capital requirements there is a motivation element built in Basel II for banks to upgrade their internal risk management systems.

The standardized approach derives the risk weights from ratings provided by independent institutions which have to be approved by regulators. Such institutions are either export credit agencies (ECAs) or external credit assessment institutions (ECAIs).

There are two approaches based on internal ratings of banks. It is the Internal Rating Based Foundation Approach (IRBFA) and the Internal Rating Based Advanced Approach (IRBAA). Both approaches replace the external ratings of clients by credit risk models where the certain parameters are estimated by the bank itself. The extent of such parameters depends on the level of approach chosen and on the type of risk exposure (divided according to the class of assets into corporate, sovereign, bank, and equity and retail exposure). In general the foundation IRB approach allows banks to estimate only the probability of default (PD) while under more advanced approach banks may use their own estimation of other risk characteristics such as loss given default (LGD), exposure at default (EAD) and own calculation of maturity (M). There are, however, criteria the estimations must meet and the use of internal based approaches has to be approved by regulators. Appropriate risk weights are calculated with Basel capital formula, which is a function of just the latter mentioned variables; PD, LGD, EAD and M. More detailed

description of the capital requirements calculation including related Basel formulae is provided in Chapter 3.

The treatment of market risk under Basel II is based on the 1996 *Amendment to the Capital Accord to Incorporate Market Risk* (BCBS, 1996). By definition market risk is the risk of losses due to movement in market prices. This includes interest rates risk, exchange rate risk and risk in trading books (that means collections of financial instruments and commodities which are held either to be traded or to be used for hedging). Except for interest rate risk the treatment of market risk remained unchanged offering two approaches: Standardized Approach (SA) and Internal Models Approach (IMA). SA works with general and specific risk, differentiating RWAs based on type and maturity while IMA allows banks to use their own models of estimation of Value at Risk (VaR) when meeting certain conditions.

At the first time of publishing Basel II (in 2004) there were still some open issues, including the trading activities and the treatment of double default. Therefore in July 2005 the BCBS issued complementary paper, *The Application of Basel II to Trading Activities and the Treatment of Double Default Effects* (BCBS, 2005), that was fully incorporated into the revised vision of Basel II from 2006.

Operational risk, which represents the possibility of losses due to inadequate or failed internal processes can again be measured by three methodologies: the basic indicator approach (BIA), standardized approach (SA) or advanced measurement approaches (AMA). All three methods as well as the inclusion of operational risk into calculation of capital adequacy in general are one of the major improvements included in Basel II. Under the BIA banks are obliged to hold capital amounting to 15% of average annual gross income from the last three years. The SA works on similar basis but divides the activities of banks into business lines where every business line has different percentage of annual gross income assigned. And finally AMA takes advantage of banks own internal systems of operational risk measurement. Banks have to meet certain criteria to be allowed to use more sophisticated approaches and at the same time cannot switch to a simpler approach without permission of a supervisory authority.

It is obvious that Basel II widely concentrates on risk management giving the banks options for measurement of capital requirements and at the same time providing incentives for banks to enhance and use their own internal systems of risk measurement and use their capital more effectively. Figure 2.2 summarizes the approaches offered under each kind of risk included in the Pillar 1 of New Basel Accord.

Figure 2.2: Options for calculation of capital requirements under Basel II

	Credit Risk	Market Risk	Operational Risk	
− Capital Consumption +	Standardized Approach (SA)	Standardized Approach (SA)	Basic Indicator Approach (BIA)	− Complexity +
	IRB Foundation Approach (IRBFA)	Internal Model Approach (IMA)	Standardized Approach (SA)	
	IRB Advanced Approach (IRBAA)		Advanced Measurement Approaches (AMA)	

Source: BCBS (2006)

2.1.3. Pillar 2

The principles of supervisory review process are the most general part of Basel II. It is regulators task to review banks capital adequacy in the context of all the risks a bank faces and it is the banks responsibility to have such internal processes that are able to identify all risks and reflect them in the size of capital. As every bank faces different risk profile, it is difficult to list precisely all the risks concerned. However, as (Balthazar, 2006) points out the second pillar does not even specify the right amount of capital needed to cover such risks. In this context Balthazar refers to a PwC study on impacts of Basel II proposal (PricewaterhouseCoopers, 2003) which questioned bankers and found out that the bankers think Supervisory Review Process being inefficient and regulators not to have enough skills and resources to implement it effectively.

The goal of Pillar 2 is to ensure that banks have enough capital to cover all the risks which are divided into three areas: risks that are considered but not fully

captured under Pillar 1 (e.g. credit concentration risk); risks not covered by Pillar 1 at all (e.g. interest rate risk in the banking book) and risks external to the bank (e.g. effects of business cycle). For setting adequate level of capital coverage banks must develop Internal Capital Adequacy Assessment Process (ICAAP). The target capital level obtained through ICAAP is subject to review by supervisor and can be changed in case the supervisor finds it inadequate to the banks risk profile. In general capital adequacy of 8% represents minimum and banks are expected to hold capital reserves of higher share.

The whole second pillar can be summarized under four key principles which the supervisory review process is built upon. There are as follows:

1. Banks should have a process for assessing their overall capital adequacy in relation to their risk profile and strategy for maintaining their capital levels.

2. Supervisors should review and evaluate internal capital adequacy assessments and strategies of banks as well as their ability to monitor and ensure their compliance with regulatory capital ratios. Supervisors should take appropriate action if they are not satisfied with the result of this process.

3. Supervisors should expect banks to operate above the minimum regulatory capital ratios and should have the ability to require banks to hold capital in excess of the minimum.

4. Supervisors should seek to intervene at an early stage to prevent capital from falling below the minimum levels required to support the risk characteristics of a particular bank and should require rapid remedial action if capital is not maintained or restored.

2.1.4. Pillar 3

Third pillar of Basel II complements minimum capital requirements and supervisory review process with market discipline. Under Pillar 1 banks are obliged to assess and cover risks originating from their activities, Pillar 2 concentrates on

supervisors task to assess the adequacy of actions taken by banks to cover the risks and Pillar 3 focuses on market participants and enables them further supervision by forcing the banks to disclose all relevant information on the scope of application, on capital, risk exposures and risk assessment processes and therefore enhances the market discipline.

It is up to the supervisors to set which information a bank should disclose. The extent of publicly available information varies for every bank and is dependent on national regulations as well as on the complexity of methods used to set appropriate capital adequacy under Pillar 1. There is, however, a list of general disclosures mandatory for all banks.

2.1.5. Bank Capital Management

Since this thesis focuses on procyclicality of both Basel II and Basel III Accords, the first Pillar is considered to be of the highest importance. Pillar 1 sets the rules for capital which banks are required to hold adequately to their portfolio. Changes in the required capital throughout business cycle influence resources available to the bank when providing for credits. Degree of availability of credits in banking system in different stages of business cycle can accentuate the swings of the cycle and therefore cause procyclicality.

But Pillar 3 has to be kept in mind as well as it is the source of information about banking sector for the public. There is, however, an important distinction between capital considered under Pillar 1 and Pillar 3.

When managing their capital, banks care for risk-based capital, which is the real appropriate amount of capital necessary to cover all risks and ensure solvency of the bank and its survival in case of large unexpected losses. In financial literature the term economic capital is used for such kind. All the requirements for minimum capital under Basel Accords, however, refer to regulatory capital which represents the amount of capital legally required by regulators to cover such losses. There is a slight difference in the definition but there can be a big difference in the actual amounts of both capitals. This is due to different approaches to its calculation (there

are predefined approaches to calculate regulatory capital while it is up to every bank which method it uses for its own calculation of economic capital).

The difference between regulatory and economic capital used to be even bigger under the first Basel Accord with its simpler and less flexible calculation of capital adequacy. It is one of the biggest contributions of Basel II to the bank capital management that it decreases the difference between both types of capital. Basel II brings regulatory capital closer to the economic one especially by increasing its risk sensitivity. Adding supervisory review process and market discipline also contributes to the reduction of existing gap.

2.2. BANK PERFORMANCE DURING FINANCIAL CRISIS

Before introducing new rules proposed under the Basel III framework we have to take a short look on performance of banks during the crisis. Problems of banks during the financial turmoil were the main factor shaping the new regulatory and supervisory framework. Banks all over the world have experienced problems and many studies claim that increased risk sensitivity of Basel II rules has its share in the depth of the crisis.

This thesis concentrates on banking sector of the countries of Visegrád Group, namely on the Czech Republic, Slovakia, Poland and Hungary. This sector is characterized by high intermediation as well as very high share of foreign investors, visible on the Figure 2.3.

As we can see, the percentage of foreign owned banks is in some countries almost 100% and has not been very affected by the crisis. This offers to certain extent a shield to local subsidiaries of the banks, which can turn to their international parent company as to the lender of last resort. Dominating international groups are:

- KBC Group including ČSOB in Czech Republic and Slovakia, K&H in Hungary and Kredyt Bank in Poland

- Unicredit, operating through Bank Pekao in Poland

- Erste Group, covering Česká Spořitelna in the Czech Republic and Slovenská Sporiteľňa in Slovakia and not operating in Poland

- Raiffeisen Bank, operating through Tatra Banka in Slovakia

- Societe Generale, covering Komerční Banka in Czech Republic and Eurobank in Poland, not operating in Slovakia and Hungary

Figure 2.3: Share of foreign banks the total number of institutions in the banking sector (in %)
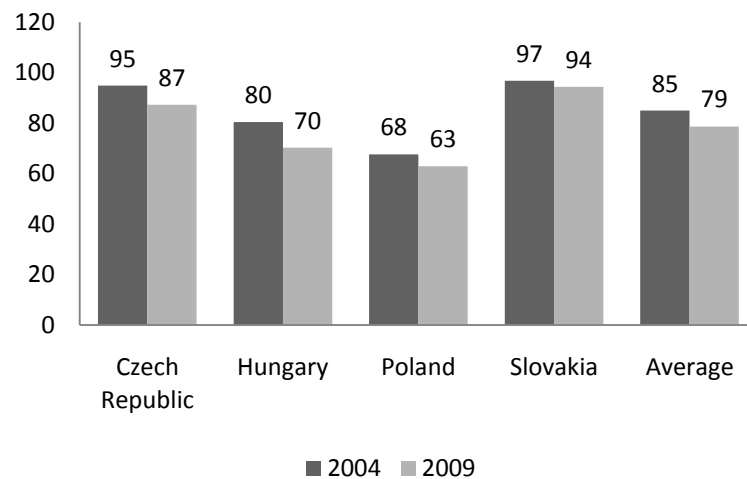
Source: IMF (2010)

Banking sector of the region was not immediately affected by the crisis. During the whole year 2007 it displayed outstanding growth. However, the US mortgage crisis spilled over to other parts of the Central European economies and contaigon effect ultimately hit the banking sector as well. The growth ratios of the first months of 2008 were lower but the sector was still thriving. Because of liquidity contraction banks concentrated mainly on deposits. They also had to cope with large financial instrument portfolios, which were dominated by debt instruments. This was a result of high profitability of the last years.

If 2007 was a good year for Central European banking sector then situation changed markedly in September 2008 with the bankruptcy of Lehman Brothers.

Financial panics spread through the whole financial world leaving its impact on the banks of the CE region as well. Investments decreased immediately and the whole sector became more risk averse. For banks this meant decrease in liquidity and increase of non-performing loans (see Figure 2.4).

Figure 2.4: Development of non-performing loans (NPL) 2004-2009 (% of total loans)
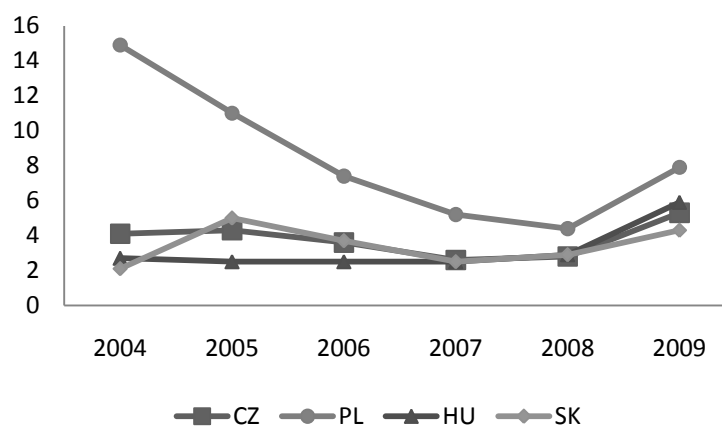
Source: IMF (2010)

Banks introduced stricter credit policies and shifted their scope more on deposits. Deleveraging, efficiency and cost cutting became the mottos of the period. In November 2008 Hungary became one of the first countries from the whole region of Central and Eeasten Europe to ask the International Monetary Fund for financial help. It was granted a rescue package worth €20 billion.

Confidence in banking sector improved partially in April 2009 after the G-20 summit in London which guaranteed assurance that no country of the region will be left to bankruptcy. The scope shifted from liquidity problems to the quality of assets and credit. Deterioration of asset quality meant also higher risk cost. This was accompanied by further increase in NPLs as we can see on the Figure 2.4 above.

Although banking sector of Central Europe has definitely conceived implications of global financial crisis, it has not been hit so severely as some other

countries. Figure 2.5 reflects the resiliency of the CE banking sector in the sense of more or less stable number of market players throughout the whole period of crisis.

Figure 2.5: Number of banks 2004-2009
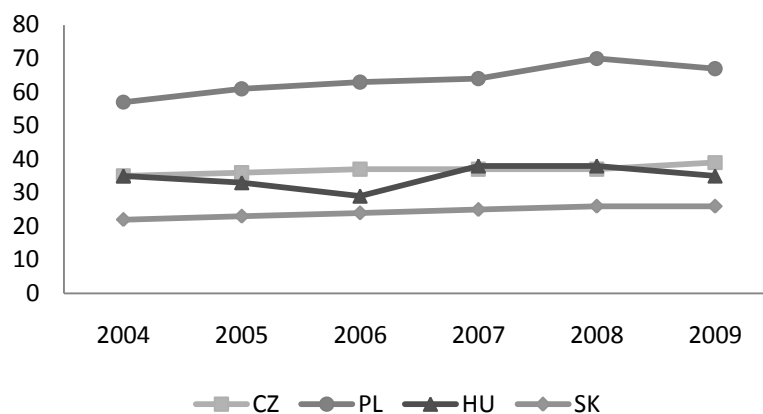
Source: IMF (2010)

Banks in the whole region also managed to hold appropriate level of capital adequacy throughout the crisis as we can see on Figure 2.6

Figure 2.6: Capital Adequacy (% of RWA)

Source: IMF (2010)

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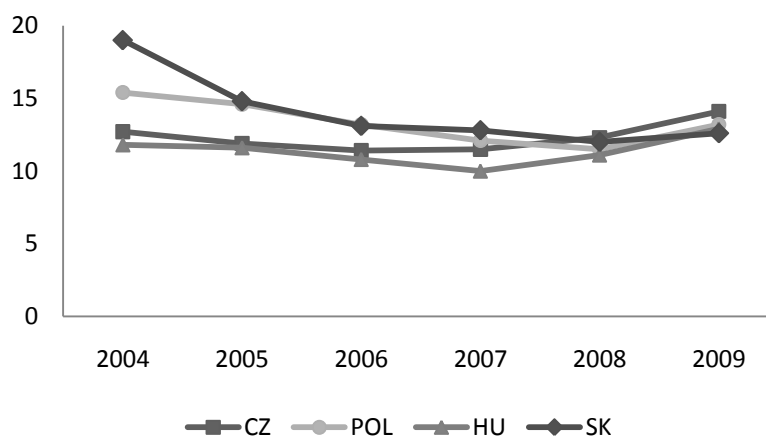
Rising levels of capital adequacy ratio after 2008 clearly demonstrate the risk sensitivity of Basel II framework. Banks of the region adopted the new Basel II rules shortly before the crisis and were now required to increase the holdings of capital in response to increased risk of economy. Another factor, the attempt of the banks to secure themselves in financially critical times, also added to increased capital ratios and may have added to the procyclicality

Important sign of bank performance is profitability of the banking sector. This can be measured by two ratios, Return on Assets (ROA) defined as a proportion of earnings to total assets and Return on Equity (ROE) which is measured as the share of earnings to stockholders equity. Development of both ratios is depicted in Figure 2.7 and Figure 2.8 respectively. Both charts show the same pattern with Czech Republic being the only country showing profitability of banks in 2009. This corresponds with the results of banking study published by Raiffeisen Bank in 2010. This study observed 11 international banking groups and their profitability. In 2008 only one bank (in Poland) was in red numbers while in 2009 there was substantial increase in banks with negative profitability totaling to 10 banks. Only one of them was in the Czech Republic.

Figure 2.7: Return on Assets (ROA) 2004-2009
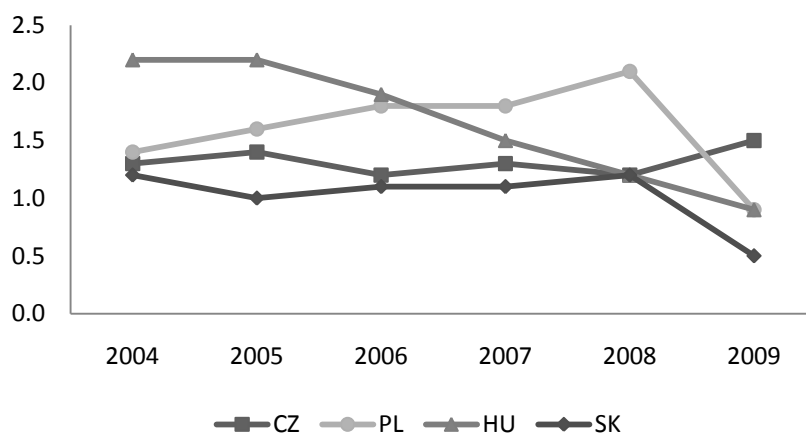
Source: IMF (2010)

On the profitability charts we can also clearly follow the development of single countries. Except for 2009, Poland is the most growing country in the region. Due to robust banking sector Poland was the only country with positive growth ratios and demonstrated almost no signs of crisis although the Polish currency zloty was the worst hit currency from the whole CEE at the end of 2008. Hungary, on the other hand, experienced problems even before the crisis fully hit the region. Even with the financial support from the IMF, the EU and the World Bank in November 2008 the country had to face loss of confidence in banking sector which they tried to boost with guarantees declaration. In order to meet its budget target, Hungary also became the first country to propose tax on banks in the amount of 0.5 % of banking assets, which is extremely high. Czech Republic remained quite liquid and stable throughout the whole period. Despite facing contraction of lending growth it retained the lowest loan-deposit ratio in the region (under 80%). Slovakia demonstrated strong dynamics caused by euro adoption but the banking sector had to face two challenges at once: transition to eEuro as well as the financial crisis.

Figure 2.8: Return on Equity (ROE) 2004-2008
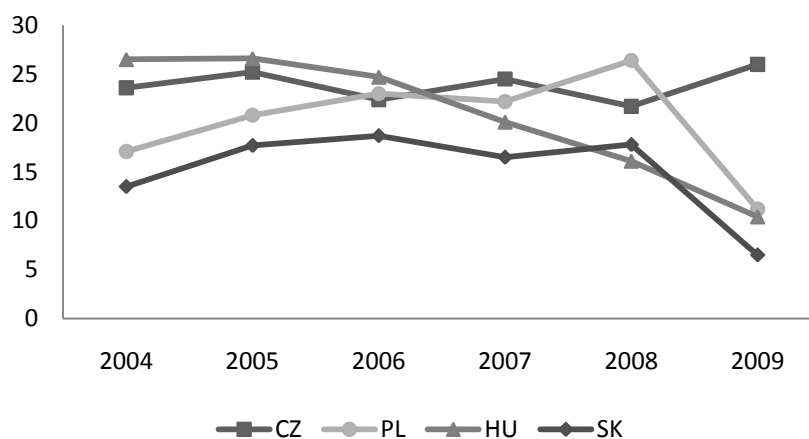
Source: IMF (2010)

Although not supported by data in this study, 2010 brought increase in profitability for the banking sector while Poland remaining the strongest country. The dominating topic of the year was regulatory regime with BCBS proposing new regulatory framework, Basel III.

2.3. BASEL III

2.3.1. From Basel II revisions to Basel III proposal

As we evidenced on the Central European data, financial crisis hit the banking sector severely. That of course influenced the perception of Basel II, which was in the middle of implementation period when the financial crisis started. During 2008 the banking world witnessed many discussions on the topic of how much would the banking sector be hit if the regulatory rules proposed by Basel II would already have been fully in force. Prevailing was the opinion that rules of Basel II are not sufficient and that the financial crisis has revealed many shortcomings which should be corrected as soon as possible.

Besides its tendency to procyclicality which might be even amplifying the crisis, Basel II was criticized especially for its low orientation on liquidity and high reliance on credit rating agencies which were losing creditworthiness (Economist, 2008). It was argued that better approach should be designed, rather principles based than rules based. The banking sector was also dissatisfied with the course of implementation process, especially because of problems with implementation in the US which meant different regulation for banks worldwide, problems for subsidies and their supervisors and time lag in implementation of new rules (Economist, 2006).

The Committee started revising the newly established Framework almost immediately. Already in September 2008 the document *Principles for Sound Liquidity Risk Management and Supervision* was published. This was the first reaction to one of the main shortcomings of Basel II which is insufficient treatment of the liquidity risk and risk management. As of the date this thesis was published this document remained and obtained important references in revised Basel II framework as well as in newly published Basel III. It introduced liquidity risk management tools (for example comprehensive cash flow forecasting limits or liquidity scenario stress testing) and suggested banks should maintain sufficient reserve of high-quality liquid assets to be able to meet their liquidity needs together with developing more elaborate funding plans. The document also introduced more substantial board and senior management oversight.

In July 2009 BCBS published the final version of its mending efforts, a document called *Revisions to the Basel II Market Risk Framework*. It included tools to promote capital buffers for periods of stress, to improve the quality of bank capital and it also introduced a leverage ratio. All these tools later became an important part of Basel III framework and we discuss them in detail in the next chapter. In this revised framework each of the three pillars underwent improvement. The upgrades in Pillar 1 (Minimum Capital Requirements) focused on securitization and (in order to capture its risk better) it assigned higher risk weights for securitization and re-securitization exposures and ordered banks to implement more rigorous credit analysis for securitization exposures that are rated externally. Under Pillar 2 (The Supervisory Review Process) the Revision Framework provided supplemental guidance for risk management practices which revealed many insufficiencies during the crisis. The *FSF Principles for Sound Compensation Practices*, issued in April 2009 by the Financial Stability Forum, were incorporated in the second pillar as well. Regarding Pillar 3 (Market Discipline) the upgraded Framework introduced enhancements to disclosure requirements in order to reduce uncertainties of market participants. Pillar 1 and Pillar 3 enhancements should have been implemented until the end of 2010 while Pillar 2 upgrade came into force immediately in July 2009.

However, during autumn 2009 the tendencies moved from revisions of Basel II towards compilation of new framework and first consultative proposals for Basel III were introduced. There were two main documents: *Strengthening the Resilience of the Banking Sector* coped with the capital adequacy and risk coverage while *International Framework for Liquidity Risk Measurement, Standards and Monitoring* covered solely proposals to enhance liquidity. The key areas on which Basel III proposals focused were:

1. Higher quality, transparency and consistency of the capital base with stricter criteria for Tier 1 capital.

2. Stronger risk coverage through trading book and securitization reforms and stronger requirements for counterparty credit risk.

3. Extra layer of protection in form of Leverage Ratio as a supplement to the risk-based capital requirements.

4. Introduction of minimum liquidity standards with short-term and long-term requirements.

And from the point of view of this paper especially

5. Measures promoting the build-up of capital buffers, reserves built in times of prosperity and available for use in times of crisis including measures that reduce procyclicality of the framework.

After their introduction both documents were subject to analysis within the whole financial sector and periods of consultation and calibration followed together with studies assessing possible economic and financial impacts of proposed framework. On December 17, 2010 the Final Report on the Assessment of the Macroeconomic Impact of the Transition to Stronger Capital and Liquidity Requirements was published together with (as of today) final version of Basel III framework.

2.3.2. Basel III framework

In the same manner as the proposal from December 2009 the final version of Basel III is divided into two documents. Those are

1. *Basel III: A global regulatory framework for more resilient banks and banking systems* and

2. *Basel III: International framework for liquidity risk measurement, standards and monitoring*.

2.3.2.1. The Global Regulatory Framework

The main reason for replacing Basel II with new framework was to respond to the financial crisis with tightening regulatory and supervisory rules. The BCBS developed the new framework to improve the ability of banking sector to absorb shocks and to reduce spillovers as well as to address lessons of the financial crisis. According to the Committee the crisis was caused by deterioration of capital base both in quantity and quality, by insufficient liquidity buffers and excessive leverage and by procyclicality of the deleveraging process. The institutions in banking sector

are tightly interconnected and when the market lost confidence in banking sector, liquidity and credit availability contraction inevitably followed.

The new framework is therefore built on fundamental reforms aimed to address those failures. It works on both micro- and macro-prudential level. On micro-prudential level it strives for higher resilience of individual banks while from macro-prudential point of view the focus is on system-wide risks. The framework is based on the three pillars introduced in Basel II but strengthened. It addresses the key areas that were first introduced under the 2009 proposal document *Strengthening the Resilience of the Banking Sector.*

First key area amounts higher quality, consistency and transparency of capital base. Capital under Basel II consisted of Tier 1, Tier 2 and Tier 3 part. Basel III redefines Tier 1 capital, harmonizes Tier 2 and completely eliminates Tier 3. The dominant part of Tier 1 should be common equity consisting of common shares and retained earnings and there are conditions for additional Tier 1 capital. Basel III also sets more restrictions of both categories of capital towards risk-weighted assets. Total capital requirements remain unchanged at 8% but Tier 1 ratio has increased under Basel III from 4% to 6% and the ratio for Common Equity Tier 1 from 2% to 4.5%. We can see the transitional arrangements for incremental increase as well as the final values in the Figure 2.9.

Figure 2.9: Transitional arrangements for capital requirements under Basel III (in %)

	Common Equity Tier 1	Tier 1 Capital	Total Capital
currently	2.0	4.0	
2013	3.5	4.5	
			8.0
2014	4.0	5.5	
2015	4.5	6.0	

Source: BCBS (2010)

Higher risk coverage is the second key area of Basel III. This area has already been discussed in reforms of July 2009. The new framework includes more explicit requirements for banks which use internal model methods as well as stronger requirements regarding counterparty credit exposures (arising for example from derivatives or repo operations). As a consequence of credibility loss during the crisis Basel III also lowers possible reliance on external ratings. Here the Committee has incorporated Code of Conduct Fundamentals for Credit Rating Agencies compiled by International Organization of Securities Commissions (IOSCO), the BCBS partner in the Joint Forum of financial regulators. Supervisors should refer to this document when testing the criteria for using data from external credit rating agencies.

The third key area is the capital conservation buffer. The main idea is to motivate banks to build up enough capital reserves in times of prosperity which can then be used in times of crisis. The minimum limit for capital conservation buffer is 2.5% of Tier 1 capital. This percentage cannot however be counted into regulatory minimum capital. Banks first have to keep 6% of Tier 1 and 8% of total capital adequacy and only then can use the excessive capital to build the conservation buffer.

There is also a second type of buffer defined under Basel III. It is a countercyclical buffer, extension to the capital conservation type. The buffer was designed with the aim to reduce procyclicality. As we have already discussed the financial crisis has revealed the effect of procyclical amplification supported among others through accounting standards and handling of leverage. Therefore Basel III developed countercyclical measures to enhance shock absorption instead of transmission and amplification. It serves also as a tool against the trade-off between risk sensitivity and cyclicality. As we know the more the regulation is risk sensitive the higher is the procyclicality effect. This trade-off was already known when developing Basel II framework but the measures taken to deal with were not sufficient. This may be due to one of the main criticisms of Basel II. It was developed in times of prosperity and the rules were not adequate for crisis times. Now BCBS suggests stronger provisioning (such as effort to change accounting standards and adjust regulatory rules accordingly which will be further discussed in

Chapter 4), further conservation of capital which can be used in times of crisis and mechanisms which would adjust capital buffer when signs of excessive credit growth would be identified.

As the Basel III guidance for operating the countercyclical buffer claims, the aim of the buffer is not solely to ensure solvency of individual banks. The countercyclical buffer aims on building up resources which would protect banking sector in aggregate against economic cycles. The decision making will be, however, transferred onto national jurisdictions. Entrusted national authorities will be monitoring credit growth and they will be responsible for deciding when the buffer should be imposed, when it should be released and how it should be adjusted over time. The buffer can range between 0% and 2.5% of RWA dependent on the level of systemic-wide risk and every revision has to be preannounced 12 months prior to the change so that banks have enough time to adjust their capital levels.

Although the power of decision-making lies in the hands of national authorities, there is a common reference guide which provides principles for the treatment of capital buffers. Buffers should be imposed in times of excess credit growth which might increase the systemic-wide risk. Such credit growth will be monitored via the credit-to-GDP ratio. Credit-to-GDP guide is, however, just a common reference point. It can work differently in diverse jurisdictions and therefore national authority always has to use its own judgment. Credit-to-GDP ratio even does not need to be the dominant information used; the authorities are free to use other indicators competent to assess systemic-wide risk as long as they supplement it with acceptable explanation. Basel III framework draws to attention many factors that could distort the information provided by credit-to-GDP ratio. Regulators should take into account various asset prices, funding spreads and CDS spreads, credit conditions or real GDP growth. The authority also has to decide, whether it is better to release the buffer gradually or promptly. This depends on the type of recession the economy is in. For mildly proceeding downturns gradual release of buffers might be sufficient, however many crises call for an immediate release.

Basel III sets the rules for each bank on how to set the buffer with respect to their jurisdiction. For internationally active banks the principle of juridical

reciprocity applies. This means that a bank has to obey the decisions of an authority of the country where the bank operates. Banks should subsequently calculate weighted average of buffers of all jurisdictions, where they file credit exposure.

The responsibility of home authority of an internationally active bank is to ensure that bank calculates the buffer correctly. Home authority can further increase the buffer if it considers current level insufficient or set the buffer entirely when host authority does not do so.

Most of the key areas of Basel III put requirements on Tier 1 as well as on total capital. For better orientation Figure 2.10 provides summary of those requirements. As we can see the adequacy ratio for total capital remained unchanged at 8%. However, when adding the requirement for Conservation buffer (consisting purely from common equity Tier 1 capital) the total capital requirements rise to 10.5%.

Figure 2.10: Summary of capital requirements under Basel III (in %)

	Common Equity Tier 1	Tier 1 Capital	Total Capital
Minimum	4.5	6.0	8.0
Conservation buffer	2.5		
Minimum plus conservation buffer	7.0	8.5	10.5
Countercyclical buffer	0 - 2.5		

Source: BCBS (2010)

New component of the Basel framework is the leverage ratio. It offers an extra layer of protection and supplements the risk-based capital requirements. The aim is to limit built up leverage because subsequent deleveraging process destabilizes the economy. The Tier 1 leverage ratio has been set to 3% in the December 2010 final version of Basel III but it will be subject to testing during the parallel period from January 2011 to January 2017 and possible changes in its level may occur.

Basel III also addresses systemic risk and interconnectedness of financial institutions trying to reduce spillover effects and developing approaches that will identify systemically important banks and adjust their loss absorbing capacities accordingly.

2.3.2.2. The Framework concerning liquidity

For better coping with shocks and reducing the spillovers BCBS introduced new liquidity requirements. Liquidity was namely realized as a serious problem during the financial crisis as banks experienced serious difficulties despite maintaining adequate capital levels. Here again one of the main shortcomings of Basel II appears, the old framework was namely designed in relatively trouble free times and liquidity requirements were therefore not incorporated. But, as the crisis has shown, banks failed basic principles of liquidity risk management. Therefore in 2008 the Committee issued *Principles for Sound Liquidity Risk Management and Supervision* (also known just as *"Sound Principles"*) and required their full implementation by banks. With Basel III further strengthening of the rules came and liquidity issue earned its own document in the new regulatory framework: *Basel III: International framework for liquidity risk measurement, standards and monitoring.*

The liquidity framework concentrates on two complementary objectives differing in time frame. Short term resilience is covered by the Liquidity Coverage Ratio (LCR) and medium to long term resilience by the Net Stable Funding Ratio (NSFR). The minimum levels of liquidity for internationally active banks are based on specific, internationally harmonized parameters but regulators are free to set the ratios higher if they consider it necessary.

LCR, the short term ratio, was designed to instruct banks to keep adequate level of assets which can be turned into cash to cover liquidity needs for one month under the worst stress scenario. The ratio is defined in Equation 2.2.

Equation 2.2

$$\frac{high-quality\ liquid\ assets}{total\ net\ cash\ outflows\ over\ the\ next\ 30\ days} \geq 100\%$$

i.e. stock of liquid assets should be equal or higher than the cash outflows expected under the stress scenario. The stress scenario has to be set by supervisors and has to fulfill specific condition where many of them have been experienced during recent crisis.

There are of course requirements which stock of high quality liquid assets has to fulfill. It should have low credit and market risk and low correlation with risky assets, it should be easy to evaluate and listed on developed exchange markets. Similarly as Tier 1 capital high quality liquid assets are divided into two groups, Level 1 and Level 2 assets. Under Level 1 comes for example cash, marketable securities or reserves of central bank. Level 2 assets are limited to 40% of the total stock of high quality liquid assets.

Total net cash outflows, the denominator of Liquidity Coverage Ratio, is defined according to the Equation 2.3.

Equation 2.3

$$Total\ net\ cash\ outflows\ over\ the\ next\ 30\ days$$
$$= outflows - Min\{inflows; 75\%\ of\ outflows\}$$

The total outflows are calculated by taking the outstanding balances of different liability types and multiplying them by rates at which they are estimated to be drawn down. Cash inflows use the same approach, multiplying the receivables by rates at which they are expected to flow in but, as we can see, there is a cap of 75% of outflows for the total cash inflows.

It is necessary to point out that the level of LCR set by Basel III is the minimal level. Banks are expected to do their own stress testing and calculate levels of LCR suitable for their institutions specifically.

NSFR covers the long term resilience with the aim to motivate banks to use more stable sources of funding. It is defined in the time horizon of one year. To ensure medium and long term funding the ratio, defined as proportion of available

amount of stable funding to required amount of stable funding, should be bigger than 1 (as defined in Equation 2.4).

Equation 2.4

$$\frac{Available\ amount\ of\ stable\ funding}{Required\ amount\ of\ stable\ funding} > 100\%$$

Sources available must be higher than sources required to limit the over-reliance on short term sources of financing. The methods for calculating both amounts of stable funding are based on net liquid assets and cash capital methodologies used by banks worldwide. Available stable funding consists mainly of capital, preferred stock and liabilities with maturity over 1 year.

Regarding the implementation of Basel III the observation period starts in January 2011. By the end of the year all countries of G20 should commit to adopting rules of Basel III. By 2015 the Liquidity Coverage Ratio should be implemented and in 2018 the Net Stable Funding Ratio should follow. Similarly as for Basel II countries of G20 are expected to follow the rules set by the new framework while other countries worldwide are strongly encouraged to do so as well.

Chapter 3: EMPIRICAL ANALYSIS

As it was outlined in the previous chapter, procyclicality and its mitigation has played an important role in the history of Basel Accords and in the development of new regulatory rules. Our aim is to model the impact of changing rules on the economy and analyze the differences of Basel II and Basel III with respect to the amplification of the business cycle. In its work this paper builds on several core studies published in the area of procyclicality under Basel II.

3.1. LITERATURE REVIEW

In recent years many studies covering this topic with respect to Basel II have been published. Immediately after the release of Basel II many experts started to deliver analyses of the possible impact of more risk sensitive approach on the economy. All the studies were driven by the same concern emerging from the stronger link between risk exposure and capital. Should the loans during an economic downturn become more risky, banks would be required to hold more regulatory capital which would negatively affect their willingness to grant further credits and would deepen the recession. Such concerns further increased after the start of the crisis.

Before we present the papers that belong to the core in this field of procyclicality analysis practices and that have substantially influenced the methodology of this thesis it is necessary to explain the rating philosophies as the choice of rating has a tremendous impact on procyclicality. Varsanyi (2007) delivers such an explanation. There are two approaches to the rating of a portfolio. They both incorporate macroeconomic effects into the credit assessment but in different ways. They are the Point-in-Time approach (PIT) and the Through-the-Cycle approach (TTC). Under PIT the rating reflects current condition of a borrower and the predicted development over a certain period of time. TTC on the other hand takes into account borrowers characteristics over a longer time period incorporating the

effects of business cycle as well. Definitions of the TTC approach vary throughout the papers and economists sometimes define it with the stressed nature of PD (with unstressed PD belonging accordingly to the PIT approach). Varsanyi (2007), however, criticizes such definitions and argues that "the definition of TTC should refer to the information included in the calculations and not to stress conditions". Despite the definition problems there is a common consensus that TTC approach tends to be more stable throughout the business cycle while PIT ratings vary. Driving this characteristic into extreme we can compare the TTC approach to the Basel I rules which are not risk sensitive and do not vary over the cycle.

Having introduced the rating approaches we now present most important papers in the area of procyclicality analyses which had significant impact on the model presented in this thesis. The core study in the field, which affected the majority of later analyses, is the paper from Kashyap and Stein (2004). The authors argue that omission of lending function of banks in the field of capital regulation is the main force behind procyclicality of Basel II. To prove such procyclicality Kashyap and Stein (2004) develop three models which simulate the standard as well as the IRB approach to capital adequacy. Using the data from the period beginning December 1998 and ending December 2002 authors first compute probabilities for each of the three models, then apply "typical values" for the other variables included in the Basel formula (that are LGD, EAD and M) and using the formula they finally obtain the levels of required capital. Procyclicality is then deduced from the extent to which the required capital levels change throughout the cycle.

The first model is based on Standard and Poor's credit ratings. To every rating Basel II specifies corresponding risk weights. Despite this straightforward designation of PD the authors, who are working with fixed loan portfolio, deal with several methodological problems such as missing values, defaulting firms or survivorship bias (distortion of the information due to movement in portfolio which are not caused by defaults but by mergers, acquisitions, etc.). To incorporate those problems four methodologies are being used throughout the first model consisting of combinations of two main approaches to the methodological problems:

1. Either all firms at all times are used or defaulted firms are removed.

2. Either last rating observed is used or imputation for missing values is engaged in the process.

Kashyap and Stein (2004) observe number of firms with available ratings[1], convert those ratings into corresponding PDs and using the Basel formula they map the PDs into capital requirements. After computing mean capital charges for each year the authors are able to observe changes in the required capital during different periods of business cycle. In order to gain more precise information they finally split the loan portfolios and observe the differences with respect to geographical classification as well as differentiating between investment and non-investment portfolios. Although results differ depending on which of the four above mentioned methodologies is used the analysis based on S&P ratings brings significant evidence on additional procyclicality induced by Basel II.

For more advanced assessment of PD Kashyap and Stein (2004) employ a KMV model[2]. It is not entirely possible to compare the results from this model and the methodology based on S&P ratings as the authors engage substantially larger number of firms with higher share of non-investment grade portfolios[3]. Therefore Kashyap and Stein (2004) compare just the investment grade subsamples, where the differences are not as substantial as in the whole sample. Dealing with similar methodological problems as in the first model the authors again employ the four methodologies described above. Although distribution of the results among the methodologies shows the same pattern the KMV model results (for all four methodologies) in significantly higher levels of procyclicality than the model based on S&P ratings. This is due to the fact that KMV model employs rather PIT rating while rating agencies deliver more TTC ratings.

Third model Kashyap and Stein (2004) use to analyze procyclicality is based in internal credit ratings of Deutsche Bank. Such a dataset provides the most precise information for estimation of capital requirements; however, it makes the comparison

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[1] Kashyap and Stein (2004) start their analysis with 3599 firms in 1998
[2] KMV model is one of the standard models for estimation of PD, operated by Moody's. Unlike other models it does not engage VaR for capital estimation but is based on Expected Default Frequency (EDF). For more information, please, follow the link www.moodyskmv.com
[3] KMV model involves 17 253 firms with the share of non-investment grade being 58%.

with previous methods rather difficult as the data presented are comprised only of German firms. Despite all the caveats and methodological problems Kashyap and Stein (2004) present the core of procyclicality literature and have been the basis for many latter procyclicality analyses.

Repullo, Saurina and Trucharte (2009) deliver one of the most recent procyclicality studies. Their paper is of a high importance to us as it analyses potential procyclicality of Basel II on Spanish data from 1986 to 2007. Spain was namely on anticyclical provisioning regime since 2000 and experienced slightly different changes in banking sector with respect to regulatory capital than the rest of Europe. Its experience became an important topic of regulatory talks when designing Basel III as the dynamic loss provisions are of a similar format to the capital buffers proposed by Basel III. One of the authors addresses in a separate paper solely the topic of dynamic provisioning. Saurina (2009) declares that dynamic provisioning is the way how to deal with the excess procyclicality. Spain introduced the system in July 2000 after the period of credit growth and related increased credit risk of Spanish banks. The dynamic provisioning regime in Spain provides a formula for loan loss provisions, which are charged on the profit and loss account during the period of expansion and provide a fund that can be used in times of contraction. The provisions account for about 10% of the net operating income of banks. Saurina (2009) states that the provisions were not a popular tool among Spanish bankers but that they helped to accumulate sufficient buffers to deal with the onset of the financial crisis. The author however points out that it is not clear if the buffers will be sufficient enough to deal with the crisis, which has been proved by the recent development of Spanish economy.

Regarding the parallel between Spanish dynamic provisioning system and Basel III capital buffers the above mentioned paper of Repullo et al. (2009), which is employed on Spanish data, provides an interesting analysis. The authors work with the data from the Credit register of the Bank of Spain and to detect potential procyclicality they use a logistic model of one-year PDs. Estimates for probabilities of default (in a Point-in-time manner) are essential for the study as they allow to

calculate corresponding capital requirements[1] and thereby estimate credit risk profile of Spanish banks. Repullo et al. (2009) obtain PDs through a probability function based on risk profile of debtors, type of loan and a variable approximating macroeconomic conditions. The function operates with a probability that the debtor will default during following period (set as one year) and it is a standard logarithmic function. Once Probabilities of default are estimated they are set into Basel formula for capital requirements and required capital is computed. In line with other studies in this field Repullo et al. (2009) derive results supporting procyclicality of capital adequacy rules. Compared to GDP required capital displays high negative correlation.

The authors do not stop by demonstrating the procyclicality of Basel II rules. In the second part of their study they test procedures which were being discussed as a possible tool to mitigate procyclicality. They concentrate on two methods, namely using the Through-the-cycle approach for PDs and adjusting the output through business cycle multiplier, and compare both tools to previous results (smoothed with Hodrick-Prescott filter for a better comparison). The TTC manner of PDs has been achieved through averaging the macroeconomic variable in the probability function which originally worked with current values of the variable. The results again stand in line with other studies and discussions. TTC approach may not provide timely information but it is less procyclical than the PIT method. Analysis shows that when applying business cycle multiplier to the PIT series the procyclicality of capital requirements will be reduced as well. The results are however not as pronounced as for the TTC methodology.

Despite the results it is not a common belief than TTC probabilities of default should be used instead of PIT PDs. Gordy and Howells (2006) argue the suitability of TTC ratings in capital regulation. Their paper stands out as it pronounces the importance of Pillar 3. As it has already been mentioned in previous chapters Pillar 3 sets how the information about banks should be disclosed to the public. The public however cares more about economic capital and distinguishing between both capital types provides additional complications in already complicated banking sector.

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[1] Repullo et al. (2009) calculate with exogenous level of LGD set at 45%

Gordy and Howells (2006) analyze the three methods which were widely considered for procyclicality dampening before publication of Basel III. First they concentrate on Through-the-Cycle rating, then they analyze the possibility of flattening the Basel capital function and finally they consider the proposal to smooth directly the output of the capital function with a multiplier (a tool corresponding with the business cycle multiplier discussed by Repullo et al, 2009). Their smoothing rule supposes the minimum regulatory capital $\hat{C}_{it}$ to follow an adjustment process which can be described with following equation:

Equation 3.1

$$\hat{C}_{it} = \hat{C}_{i,t-1} + \alpha\left(C_{it} - \hat{C}_{i,t-1}\right)$$

When setting the multiplier α equal to 1 the equation represents Basel II rules. Basel 1 regulatory capital would correspond with α equal to 0. Gordy and Howells (2009) propose that in order to dampen procyclicality of capital regulation α should either stand between these two extreme values or be even time-varying and follow the relationship

Equation 3.2

$$\hat{C}_{it} = \alpha C_{it}$$

In accordance with other studies Gordy and Howells (2006) support their theses with first empirical evidence on Basel II procyclicality and by simulation for the three tools to dampen procyclicality. They state that all the three methods have similar effect from the Pillar 1 point of view, i.e. they dampen the procyclicality, but there are different implications with respect to Pillar 3. The smoothing parameter α applied to the minimum regulatory capital required by the Basel formula provides for the best results. Through-the-cycle manner of rating on the other hand does not serve well the purpose of Pillar 3 as it makes comparability impossible. The information provided by TTC rating is not timely adequate and unsuitable for management purposes. Gordy and Howells (2006) state that using TTC method the "changes in bank's capital requirements […] would be only weakly correlated with changes in

economic capital and there would be no means to infer economic capital from regulatory capital".

All the above mentioned studies have analyzed procyclicality on rather microeconomic level, employing data on particular debtors and bank loan portfolios. Although the methods have been to a great extent the same and they have obtained evidence on procyclicality of Basel II and supporting evidence for proposed anticyclical measures, the magnitude of such evidence and measures differs greatly. This is of course due to differences in sample and methods used. Kashyap and Stein (2004) pointed this fact as well and offer a summary of the most common issues that add to difference in estimation results. The main differences originate from

- construction of sample portfolio
- time periods and geographical regions
- default and migration probabilities
- version of the IRB formula used

Higher quality portfolios are namely more volatile, different countries have experienced different recessions and Basel formulae have been adjusted with every new issue of a Consultative Proposal. One should therefore always observe the results with a certain degree of distance.

The aim of this paper is, however, to analyze potential procyclicality rather on macroeconomic level. This has not been done by many studies. Among the existing ones, one of the most current is the paper from Gerali et al. (2009). They have set their study into a dynamic stochastic general equilibrium model (DSGE) that is into an equilibrium model which explains economic variables on macroeconomic level while being derived from microeconomic principles. As the name of the model suggests, DSGE explains the evolution of economic variables over time and takes into account random shocks. The main advantage of such model is that DSGE does not yield to the Lucas critique[1]. DSGE models incorporating

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[1] The Lucas critique, named after Robert Lucas, argued that models predicting effects of changes in monetary policy cannot be based entirely on aggregated historical data. They should rather be built on microeconomic foundations, taking into account preferences and constraints of individuals.

financial frictions have been first introduced at the end of 1990s[1] but have not actively included any financial intermediaries such as banks.

Gerali et al. (2009) contributed substantially to the DSGE literature as they provide first model which incorporates banking sector and therefore connect credit and financial markets. This allows to "understand the role of banking intermediation in the transmission of monetary impulses and to analyze how shocks originate in credit markets and are transmitted to the real economy" (Gerali et al., 2009). The model presented in the paper covers simple economy populated by households and firms and complemented by banks and central bank and introduces set of equations which describe basic relationships in the economy related to utility maximization, loan and deposit demand, interest rate setting and labor market. Linearized model of equations then uses the Bayesian approach to estimate its parameters. Authors use data from the years 1998 to 2008, de-trended by Hodrick-Prescott filter.

Gerali et al. (2009) further use the estimated parameters to study the dynamics of the model. They do so through the use of impulse response functions. Impulses induced to the model are monetary policy shock and technology shock.

Paper presented by Gerali et al. (2009) serves as a starting point to the paper from Angelini et al. (2010), who adopt this model and extend it with risk weights. Having calculated the required capital and corresponding risk weights the authors use regression to estimate risk sensitivity of risk weights on the business cycle. To approximate probabilities of default delinquency rates for US loans are used. The authors then compare the procyclicality of Basel I and Basel II with impulse response functions, testing the sensitivity of economy on positive technological shock as well as positive monetary policy shock. The functions are based on parameters of DSGE model estimated by Gerali et al. (2009). The results clearly show the pronounced procyclicality of Basel II when compared to economy under Basel I regulatory regime. However, the extent of added procyclicality obtained by Angelini et al. (2010) is not as large as expected.

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[1] Bernanke, Gertler and Gilchrist (1999)

When analyzing the proposed tools to mitigate procyclicality of Basel II the authors study impulse response functions for positive technology shock and expansionary monetary policy shock under the regime of passive countercyclical requirements with time varying capital ratio and alternative regulatory regimes.

3.2. METHODOLOGY

Our model is partially based both on Angelini et al. (2010) and Gerali et al. (2009). Both studies have incorporated banking sector into the DSGE framework and Angelini et al. (2010) included risk weights to analyze the impact of Basel II capital regulation. We adopt the economy settings presented in those papers. The aim of the thesis is to broaden the model to incorporate Basel III changes and compare the procyclicality of both regulatory frameworks.

Throughout the model we approximate the cyclical conditions with the changes in GDP. Such an approximation is reflected in the formulation of the hypotheses the thesis has stipulated. Our hypotheses are as follows:

Hypothesis 1: *For Basel II there will be strong negative correlation between GDP and the risk weighted assets.*

This hypothesis covers the expected procyclicality of Basel II with the business cycle being approximated by the GDP development. If Basel II is procyclical the risk weights will grow with decreasing GDP.

Hypothesis 2: *The correlation between GDP and risk weighted assets will be less negative for Basel III framework.*

This hypothesis reflects the assumption of lower procyclicality of Basel III in comparison to Basel II.

Hypothesis 3: *Effect of Basel proposals on procyclicality will differ among the countries.*

Given the knowledge about recent economic development and policies in the countries observed we assume that the procyclicality and its change will not be the same among all countries of the region.

As it has been already mentioned, setting the analysis into DSGE framework provides us with the opportunity to measure the impact of both Basel II and Basel III rules on macro level. It does not yield to the Lucas critique and connects the model to the real economy. There have been many studies published proving the procyclicality of Basel II. We are therefore focusing on comparison between Basel II and Basel III.

To start our analysis let us assume simple model within an economy with four key players:

- households (HH)
- firms (F)
- banks (B)
- and monetary authority.

There are two types of households which differ in their degree of patience. Patient households prefer future consumption and save money in form of deposits while impatient households prefer current consumption and take loans from banks.

Simple economy coheres with simple balance sheet of banks. The asset side of the banking sector is composed of loans to firms and impatient households while the liabilities side consists of household deposits and capital. The budget constraint of banks is captured in Equation 3.3:

Equation 3.3

$$L_t^H + L_t^F = D_t + K_t$$

Both Basel Accords set minimal capital-to-assets ratio v. When banks deviate from this ratio they face a cost in quadratic form given by the Equation 3.4:

Equation 3.4

$$\kappa \left(\frac{K_t}{w_t^{HH} L_t^{HH} + w_t^F L_t^F} - v \right)^2 K_t$$

where K_t measures the bank capital in time t and κ is the parameter assigned to the cost of deviating from optimal capital-to-assets ratio. The real capital-to-assets ratio is adjusted for risk weights separately for households and for firms and denoted as w^{HH} and w^F respectively. Both Basel II and Basel III let the risk weights vary over time in order to capture the changing risks in the economy. As Angelini (2010) points out, setting $w_t^{HH} = w_t^F = 1$ would approximate the risk insensitive setting of the original Basel 1 framework.

3.2.1. Basel II model

In order to assess the procyclicality of Basel II and Basel III we analyze the correlation between the risk weights and the business cycle. Let us assume that the risk weights are subject to a motion in form given by Equation 3.5:

Equation 3.5

$$w_t^i = \left(1 - \varrho^i\right)\chi^i(logY_t - logY_{t-4}) + \varrho^i w_{t-1}^i \qquad\qquad i = HH, F$$

Through this equation we presume the risk weights to be dependent on cyclical conditions approximated by the year-on-year change in output.[1] We also presume some persistence in the risk weights adjustment represented by the previous value of risk weights w_{t-1}^i. The parameter χ^i in the equations measures just the sensitivity to cyclical conditions which is of particular importance to our study. The parameter ϱ^i determines the level of persistence in the model as it multiplies the previous value of risk weights.

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[1] As it will be explained in the next part we are working with quarterly data. Therefore the year-on-year change in output is measured as $logY_t - logY_{t-4}$

Since Basel II has been effective only for short period of time there are no time series for risk weights that would satisfy our model. Therefore we have to calculate them based on the Basel formulae for capital adequacy. Both Basel II and Basel III specify exact formula to calculate required capital on loans as provided in the Equation 3.6

Equation 3.6

$$K^i = 1.06 * \left(LGD^i * \Phi\left(\frac{\Phi^{-1}(PD)}{\sqrt{1-\rho^i}} + \Phi^{-1}(0.999) * \sqrt{\frac{\rho^i}{1-\rho^i}} \right) - PD * LGD^i \right)$$

$$i = HH, F$$

According to the formula, the required capital is a function of probability of default PD, loss given default LGD and the correlation parameter ρ^i.[1] In both the Standard approach and the foundation IRB approach LGD is given by supervisors. We assume

$$LGD^{HH} = 20\%$$
$$LGD^F = 40\%$$

which is in accordance with Gerali et al. (2009). Regarding the correlation parameter Basel Accords specify its calculation depending on the size of the creditor. For firms we have used the formula for small and medium-sized enterprises (SMEs) which has the form given as in Equation 3.7.

Equation 3.7

$$\rho^F = 0.12 * \frac{1 - e^{-50PD}}{1 - e^{-50}} + 0.24 * \left(1 - \frac{1 - e^{-50PD}}{1 - e^{-50}} \right)$$

Households in this thesis follow the formula for retail exposures defined in Equation 3.8.

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[1] For simplicity and due to the fact that we build the model on macroeconomic level and do not work with portfolios of individual banks we neglect the effect of maturity.

Equation 3.8

$$\rho^H = 0.03 * \frac{1 - e^{-35PD}}{1 - e^{-35}} + 0.16 * \left(1 - \frac{1 - e^{-35PD}}{1 - e^{-35}}\right)$$

Under Basel II the capital adequacy ratio is set to 8%. Therefore we can finally compute risk weights as

$$w^i = \frac{1}{8\%} * K^i = 12.5 * K^i$$

This process provides us with time series of risk weights.[1] As we have already mentioned setting them up into regression we can estimate the sensitivity of the risk weights to the business cycle for both households and firms under the Basel II framework.

3.2.2. Basel III innovation

In previous chapter we have already introduced the countercyclical buffer developed in Basel III to mitigate the procyclicality of the current framework. To address the procyclicality of Basel III we will add the buffer into the previous model. According to BCBS (2010) the decision about imposition of the countercyclical buffer and its release is in hands of national authorities. However, the Committee sets some guidelines for such determination. Among the most important guidelines is the ratio of credits to GDP. To translate the ratio to the buffer we follow the steps described in BCBS (2010).

First we calculate the actual ratio of credits to private sector to the GDP. This ratio is then translated into trend using Hodrick-Prescott filter. BCBS (2010) sets the smoothing parameter λ to the value of 400.000 to capture the long term trend. [2] In our model λ is set to the value of 50.000 as we have data, that capture rather short

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[1] The literature usually defines the capital adequacy ratio as a ratio of capital to RWA. We would arrive to RWA as RWA=w*EAD.
[2] BCBS (2010) does not specify the appropriate time range for calculation of long-term trend. However, in its example for calculation of the buffer BCBS (2010) employs data for period 1963 to 2009.

period; ranging from Q1 1993 to Q1 2010. The actual level of buffer is derived from the gap between the ratio and its trend as in Equation 3.9.

Equation 3.9

$$GAP_t = \frac{CREDIT_t}{GDP_t} - TREND_t$$

To translate the gap into the buffer every national authority sets upper and lower value of the gap which will correspond with the upper and lower level of the buffer. The countercyclical buffer is defined in the range between 0 and 2.5%. The lower bound (L) is the level when a higher buffer than 0% should be imposed while the upper bound (H) signals that the highest buffer possible, 2.5% will be imposed. For our model L equals to gap of 5 and H is set to the gap equal to 15. This means that

- for $RATIO_t - TREND_t < 5$ the countercyclical buffer is set to 0%
- for $RATIO_t - TREND_t > 15$ the countercyclical buffer is set to 2.5%
- for $5 \leq RATIO_t - TREND_t \leq 15$ the countercyclical buffer varies linearly between 0 and 5%

As it was said before, the decision about the value of the bounds is in hands of national authorities. BCBS (2010) only observes that empirically the values of L=2 and H=10 have proven to be the most appropriate. Since we are working with data covering shorter period of time, we have shifted the values to L=5 and H=15.

When adding the buffer to the capital requirements we change the constant minimal capital-to asset ratio v to a variable one. The new minimal capital-to-asset ratio v' will vary between 8% and 10.5% and its variation will depend on the level of countercyclical buffer imposed.

Variable v' changes the calculation of risk weights in our model. For Basel III model we still follow the steps described with Equation 3.6, Equation 3.7 and Equation 3.8. The change follows when transforming the calculated capital into the risk weights.

For Basel II we had:

$$w^i = \frac{1}{8\%} * K^i = 12.5 * K^i$$

For Basel III we need to add the buffer and achieve time varying capital requirements. Therefore, the Basel III risk weights are to be calculated as follows:

$$w^i = \frac{1}{v'} * K^i = \frac{1}{8\% + \text{buffer}} * K^i$$

The new time series of risk weights obtained through employing Basel III countercyclical buffer are again analyzed for sensitivity to business cycles. The regression formula is identical with the regression formula for Basel II and formulated in Equation 3.10 below:

Equation 3.10

$$w'^i_t = \left(1 - \varrho'^i\right)\chi'^i(logY_t - logY_{t-4}) + \varrho'^i w'^i_{t-1} \qquad i = HH, F$$

The parameter χ'^i now stands for sensitivity of the Basel III risk weights to the business cycle. Comparing it to the Basel II sensitivity parameter χ^i provides us with the result to the question whether Basel III mitigates the procyclicality of the regulation.

3.3. DATA

The model of this thesis is based on data for the region of the Visegrád Group, that is for Czech Republic, Slovakia, Hungary and Poland. We analyze quarterly data ranging from the first quarter of 2002 to the first quarter of 2010. That allows us to observe the cyclical behavior of both Basel Accords during a period of

prosperity and growth as well as during a recession which is represented by the recent financial crisis.

The calculation of capital requirements and consequently risk weights is based on PD and LGD. As it has been mentioned in the methodological part we assume LGD to be given by the regulator and set its value in accordance with Gerali (2009) to $LGD^{HH} = 20\%$ and $LGD^F = 40\%$. As for the probabilities of default it is difficult to collect data that would represent PDs on macro level as each bank calculates its own values for PDs of its portfolio. Bearing in mind that default is actually a migration from performing to non-performing loans we approximate PDs with data on non-performing loans. NPL represents a loan which payments are overdue for 90 days or more. Our data represent the ratio of NPLs to total loans separately for households and non-financial corporations and were collected from Stability Reports of Central Banks of the region.

As for the output we employ quarterly data on nominal GDP in national currencies from the IMF database. Figure 3.1 compares the development of NPLs for both households and firms. Looking at the data suggests that there is a procyclicality effect for Czech Republic and Slovakia, more pronounced for firms than for households. This should be supported by negative correlation of GDP and risk weights in next section.

For Hungary and Poland the correlation is not to obvious due to different development of both countries during the period observed. While GDP of Hungary displays similar trend to GDP in the Czech Republic and Slovakia, the NPLs develop differently. Hungarian NPLs for both households and firms do not show the bowed shape typical for NPLs in the rest of the region as the levels of NPLs in both household and firms sector remain on low levels and do not start to rise until the financial crisis. However, after the onset of the crisis they rise more than in the rest of the region.

Poland, on the other hand, follows the trend for NPLs with high levels at the beginning of the observed period and again with the start of the crisis but its GDP does not display any stronger decrease as a consequence of the financial turmoil.

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Figure 3.1: Comparison of NPLs and GDP in the region from 4Q 2002 to 1Q 2010
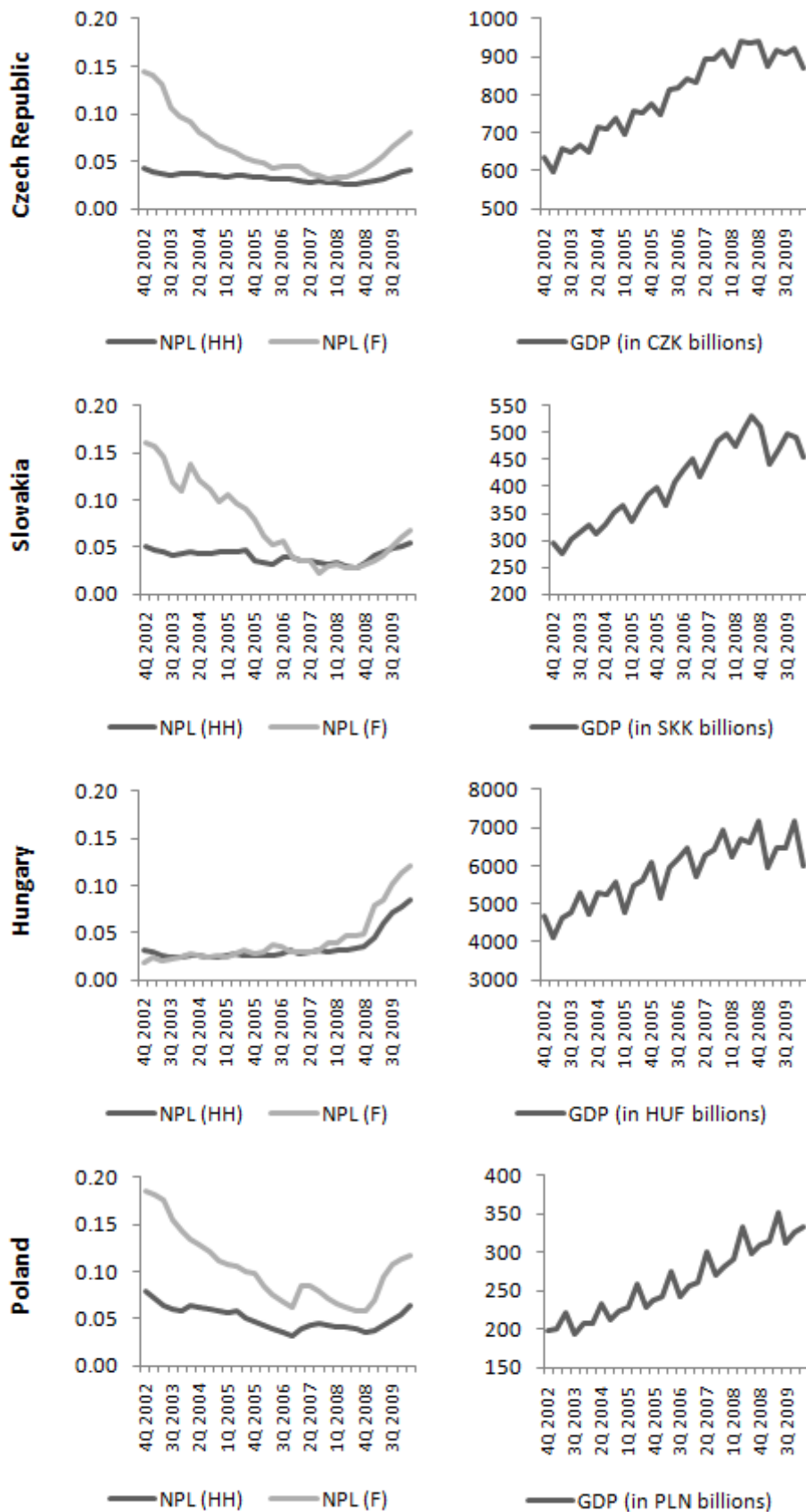
Source: Author's calculations

One last thing important to notice and which should be reflected in the estimation results is that Hungary does not display substantial differences between NPLs for households and for firms, except for the past couple of years.

For the second part of the model which is the calculation of capital buffer we use quarterly data on claims after private sector for the period 1Q 1993 to 1Q 2010. The chosen period is longer than the period examined in procyclicality in order to be able to capture trend in the evolution of the credit-to-GDP ratio.

Basel III procyclicality analysis proceeds as a simulation of Basel III rules on existing data. Therefore no new dataset is required. We develop our analysis with the data on NPLs and nominal GDP from 1Q 2002 to the 1Q 2010 amended by the countercyclical buffer which has been computed based on the data for claim after private sector and again nominal GDP for the period 1Q 1993 to 1Q 2010 to capture the trend

3.4. RESULTS

3.4.1. Procyclicality of Basel II

As the methodology suggests the first task was to obtain risk weights for both household and firm loans. Based on data for NPLs and using Basel II formula we have obtained time series of risk weights for households and corporations. When comparing the risk weights to non-performing loans (Figure 3.2), we can see that the trend is identical to comparison of GDP and NPL in Figure 3.1. This is a result of the fact that probabilities of default are the core item for risk weights calculation (and in our case PDs are approximated by NPLs).

Figure 3.2: Comparison of risk weights and GDP from 4Q 2002 to 1Q 2010

Source: Author's calculations

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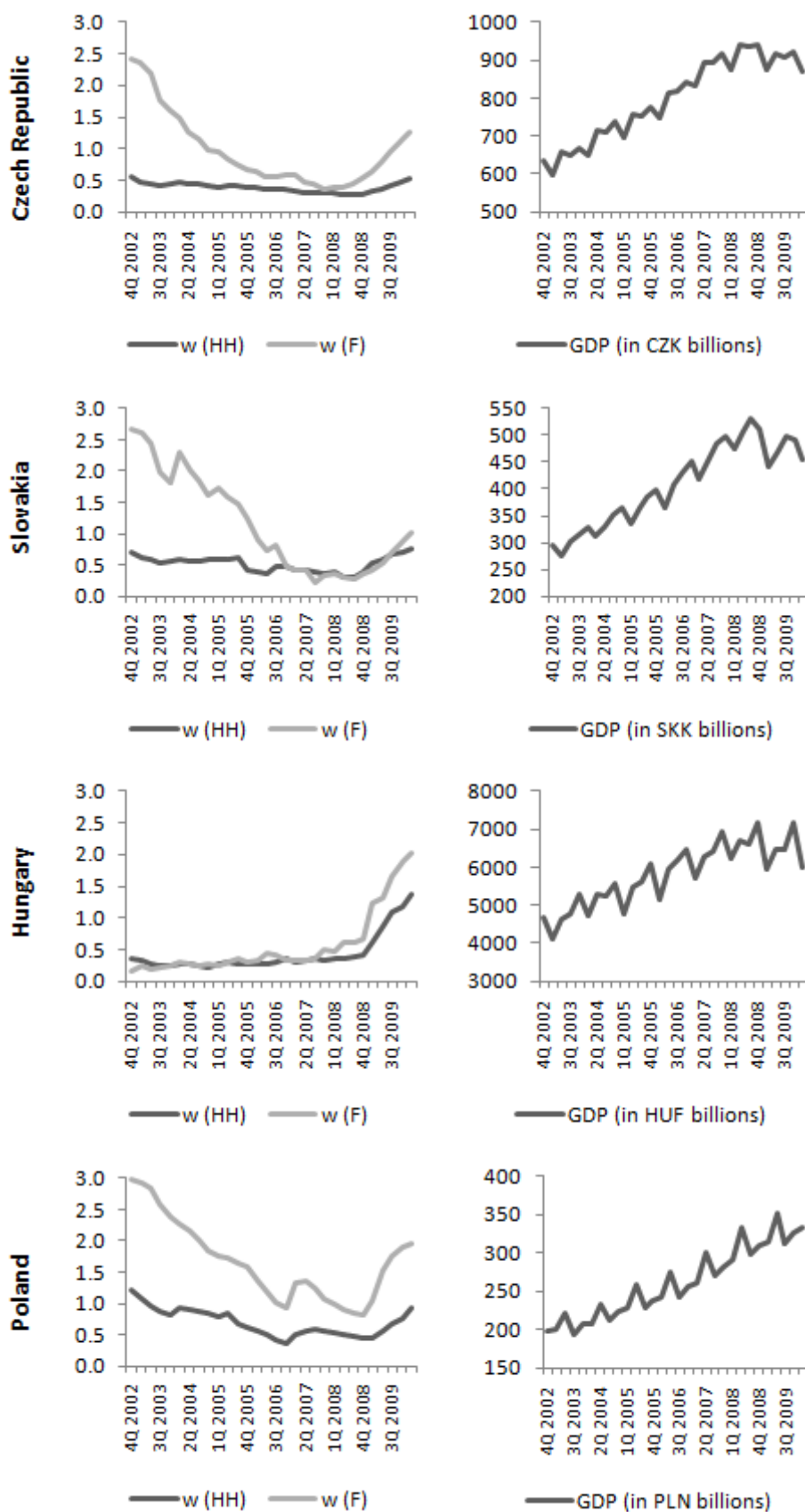
With risk weights following the same pattern as NPLs, our observations from the previous section about the development of variables in respective countries remains valid. Just looking at the Figure 3.2 there is a strong indication that the results for Hungary will differ from the rest of the region due the unique development of the country.

With the time series of risk weights we have then carried out the regression analysis for risk weights under Basel II. Results of the OLS estimation correspond to the observations we have made based on just visual comparison of the data for NPLs and GDP. The complete results with the exact regression output from the Gretl software together with tests for assumptions are enclosed in Appendix 1. The aim was to estimate the coefficient for sensitivity of risk weights to the business cycle for both households and firms model. The results of coefficient estimation for the household model are presented in Figure 3.3.

Figure 3.3: Estimation results for the household model under Basel II

	Czech Republic			Slovakia		
	coefficient	p-Value		coefficient	p-Value	
χ^{HH}	-4.14	0.00054	***	-3.03	0.00491	***
ϱ^{HH}	0.89	0.00001	***	0.81	0.00001	***
R^2	88.17%			77.14%		

	Hungary			Poland		
	coefficient	p-Value		coefficient	p-Value	
χ^{HH}	9.30	0.00021	***	-2.97	0.39682	
ϱ^{HH}	1.11	0.00001	***	0.81	0.00001	***
R^2	97.59%			85.40%		

Source: Author's calculations

With the exception of Hungary the estimation shows negative values of parameter χ^{HH} for all countries. The estimation displays high level of statistical significance for all countries except for Poland where the p-value is higher than 0.05. The coefficient of determination R^2 ranges from 77.14% to 97.59% suggesting a solid goodness of fit. As to the assumptions of the model, based on the test of White (1980) for heteroskedasticity the hypothesis of homoskedasticity is rejected for the Czech Republic. Heteroskedastic data should not have influence on the estimation values itself but could influence other statistics so the results about statistical significance have to be interpreted with some caution. The hypotheses of no collinearity and normal distribution of residuals cannot be rejected for any of the countries. Based on Durbin & Watson (1951) the Durbin-Watson statistics is sufficiently close to 2 for Slovak households and we cannot reject the hypothesis of no autocorrelation of disturbances. For the rest of the countries the Durbin-Watson statistics displays lower values. We have therefore checked the autocorrelation of disturbances with the Breusch-Godfrey test (Breusch 1979, Godfrey 1978). Again, we cannot reject the hypothesis that no autocorrelation is present. Exact results of the tests performed are stated in Appendix 1.

Such negative correlation between risk weights and business cycle proves the procyclicality of Basel II rules in Czech Republic, Slovakia and Poland. It namely shows that the lower is GDP (and through GDP the business cycle in our model) the higher are the risk weights. Higher risk weights are then reflected into higher levels of required capital which forces banks to withdraw their funds available for lending and further deepens the recession.

The positive result for parameter χ^{HH} in Hungary suggests that no such chain of causalities takes place there. While the GDP does not display substantial decrease after the crisis the risk weights jump significantly. The result reflects the fact that Hungary took measures to slow down the credit growth which resulted in private sector taking loans in foreign exchange. The loans were fixed to the development of exchange rate and as long as Forint, the Hungarian currency was strengthening, it was easier to repay the loans and levels of NPL have been quite low. After the crisis the ratio of non-performing loans increased significantly as the crunch affected the foreign exchange market. GDP does not reflect this development; the central bank

had to intervene to keep the exchange rate on a stable level. The development of both GDP and NPL therefore does not display procyclicality.

The estimates for our household model imply that the highest procyclicality in the region is in the Czech Republic with Slovakia and Poland showing about the same level of sensitivity to business cycle. This is little bit surprising when compared to Figure 3.2 which suggest that it is the Czech Republic and Slovakia who display the most similar pattern in both risk weights and GDP. We cannot, however, forget that the χ^{HH} estimation for Polish households seems to be not statistically significant.

The parameter ϱ^{HH} is statistically significant for all the four countries, estimating the inertia of the data to be around 0.8. Only for Hungary the parameter is higher than one which causes the risk sensitivity to reach positive value. Remember our regression equation to be

$$ w_t^{HH} = (1 - \varrho^{HH})\chi^{HH}(logY_t - logY_{t-4}) + \varrho^{HH}w_{t-1}^{HH} $$

It is evident that $\varrho^{HH} > 1$ changes the sign assigned to the business cycle sensitivity parameter.

`   In accordance with other studies[1] focusing on procyclicality of Basel II based on separate data for households and firms the procyclicality coefficient for firm model displays much higher values, as shown in Figure 3.4. For the Czech Republic and Poland this result was to be expected. When observing the trend for NPLs (Figure 3.1) and the trend for risk weights (Figure 3.2) we can see that the values of data on firms swing to a bigger extent than the values of household data.

For Slovakia the level of procyclicality does not increase that much when compared to the households model. This is due to the fact that the ratio of non-performing loans for households and corporations has reached about the same levels

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[1] See the section of literature review.

and therefore partially reduced the differences between procyclicality of households and corporations sector. However, the estimation shows that the sensitivity parameter is not statistically significant as its p-value reaches above 0.05.

The same as for the households, Hungary does not display any procyclicality for the firms' model. We can, however, observe similar trend as in our countries with the parameter reaching higher levels and suggesting stronger effects in the corporate sector.

In general, the sector of firms is subject to higher procyclicality as it is directly affected by the crisis and any turmoil spreads faster (for example in means of unpaid invoices which immediately cause the firm to be short of capital). In the household sector the swings of crisis are felt less directly, through the changes in employment, and the effects are dampened.

Figure 3.4: Estimation results for the firms model under Basel II

	Czech Republic			Slovakia		
	coefficient	p-value		coefficient	p-value	
χ^F	-16.30	0.00001	***	-10.26	0.17560	
ϱ^F	0.87	0.00001	***	0.92	0.00001	***
R^2	98.14%			94.32%		

	Hungary			Poland		
	coefficient	p-value		coefficient	p-value	
χ^F	41.02	0.00531	***	-17.68	0.03039	**
ϱ^F	1.04	0.00001	***	0.80	0.00001	***
R^2	96.41%			93.77%		

Source: Author's calculations

The parameter ϱ^F is again statistically very significant for all the countries. Only for Hungary it reaches above the value of 1 hinting on higher persistence of

previous values of risk weights and causing the business cycles sensitivity parameter χ^F to reach positive values.

Same as for the households' model the assumptions for functioning of the firms' model have been tested. Based on the White (1980) we cannot reject the homoskedasticity hypothesis for the Czech Republic and Slovakia but we have to reject it in Hungary and Poland. Here, again, we have to proceed with caution. Heteroskedasticity will not bias the parameter estimates, the statistics will, however, be affected. We also cannot reject the hypothesis of no collinearity. Normal distribution, however, has been rejected for all countries except Poland. Therefore, additional tests have been performed. For the Czech Republic and Slovakia the test for normal distribution introduced by Lilliefors (1967) does not reject the normality hypothesis and for Hungary both Lilliefors (1967) and Shapiro &Wilk (1965) do not reject the normality hypothesis. As to the autocorrelation of disturbances, the Durbin-Watson statistics is sufficiently close to 2 for all countries except for Poland. For Polish firms the Breusch-Godfrey test (Breusch 1979, Godfrey 1978) for autocorrelation up to order 4 has been performed and we cannot reject the hypothesis of no autocorrelation. For exact results of the tests, please, refer to Appendix 1. The model fits the data even better than for households as the coefficient of determination reaches for all countries levels over 90%.

3.4.2. Credit-to-GDP ratio

In order to address the changes in Basel III regarding procyclicality we have incorporated Credit-to-GDP ratio into our model as described in the methodology section. The actual ratio was calculated dividing the total claims to private sector with the nominal GDP for given period. The ratio was then compared to its trend (see Figure 3.5) obtained through Hodrick-Prescott filter with the smoothing parameter equal to 50.000. As we can notice on Figure 3.5 the trend is growing for Hungary and Poland while it is decreasing for the Czech Republic and Slovakia. This result is a consequence of monetary crisis which hit the Czech Republic and Slovakia around 1997 and in our model is reflected in higher values for the Credit-to-GDP ratio.

Figure 3.5: Credit-to-GDP ratio vs. trend comparison (in %)
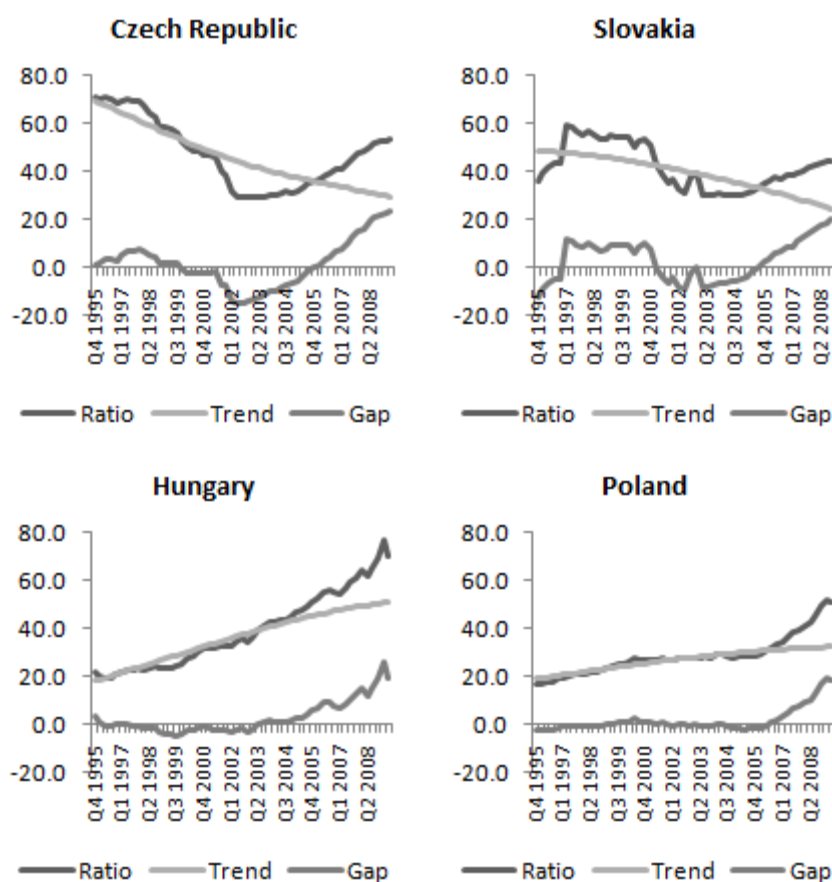
Source: Author's calculations

The gap between ratio and trend has been translated into countercyclical buffer as depicted on Figure 3.6. As the figure suggests, the countercyclical buffer should be employed once the gap between credit-to-GDP ratio and its long-term trend reaches certain level, in our case level L=5. The maximum value of the buffer is 2.5% of RWA. The highest buffer will be employed of the gap between ratio and trend reaches the level of H=15.

Analyzing Figure 3.6 we can see that again the Czech Republic and Slovakia display almost identical behavior of the economy. According to the setting of this thesis the buffer should have been employed in years 1996 to 1999 which is around the time of the above mentioned monetary crisis in both countries. Poland suggests a short period of buffer around the year 2000 while Hungary remains almost the whole observed period of time buffer-less.

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But the most important and for all the four countries the same is the impulse to build countercyclical buffer after 2006 when the ratio of credit to GDP started to rise significantly above its long-term trend. This thesis does not work with the potential use of the buffer as this does not directly influence the risk weights. It is, however, to be assumed that such buffer would serve as a source of capital in the critical years and smooth the procyclical effect of changes in capital adequacy.

Figure 3.6: Credit/GDP gap translated into countercyclical buffer (as % of RWA)
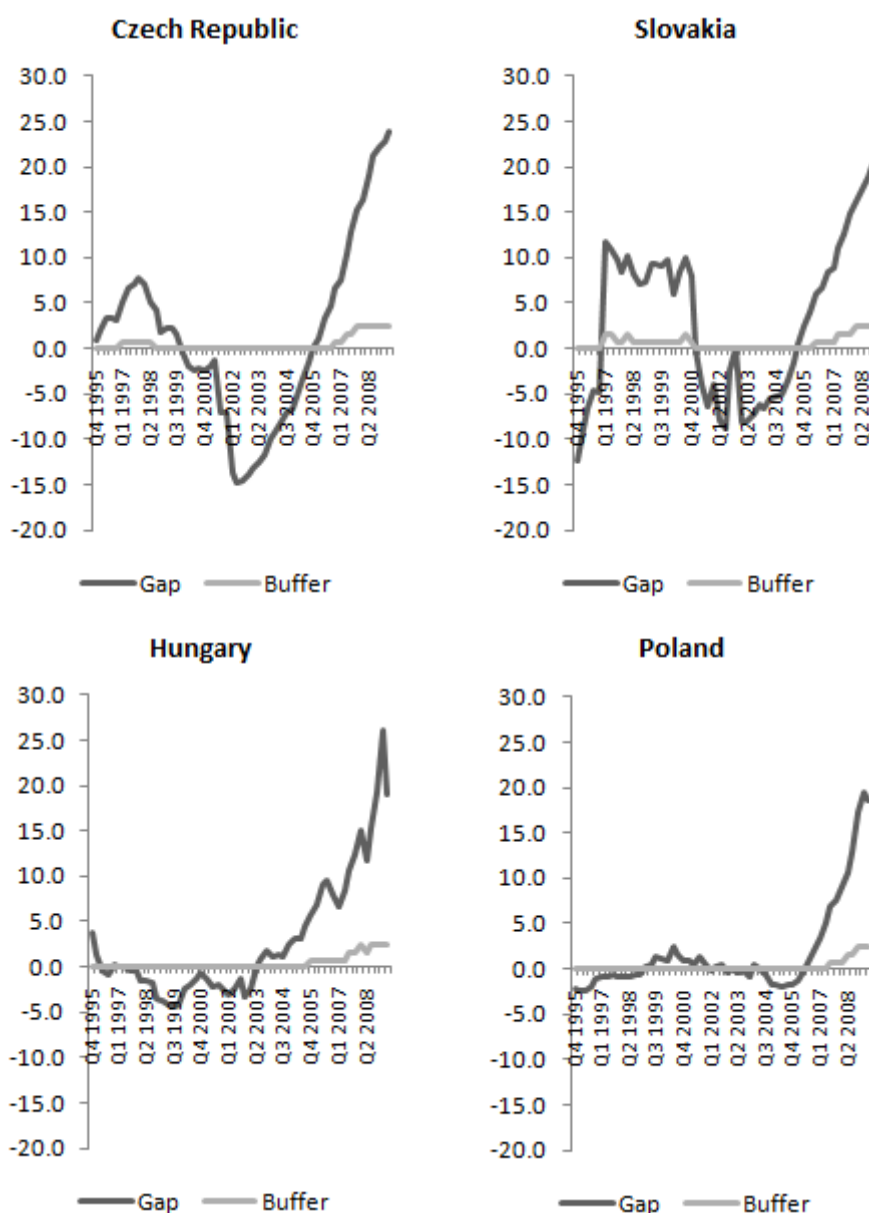
Source: Author's calculations

3.4.3. Procyclicality of Basel III

Adding the countercyclical buffer to the capital requirements we have obtained time varying capital requirements and a new set of risk weights. The comparison between Basel II and Basel III risk weights for both households and firms is depicted on the Figure 3.7.

Under the settings of this thesis the countercyclical buffer would be imposed for both the Czech Republic and Slovakia in the second half of 2006 when the credit growth exceeded the threshold given by the Credit-to-GDP ratio for both households and firms. This would affect the risk weights for both sectors. As we can see on the Figure 3.7 the risk weights decrease less after 2006 building a buffer and the amplitude is less pronounced.

Figure 3.7: Comparison of Basel II and Basel III risk weights for households and corporations (in %)
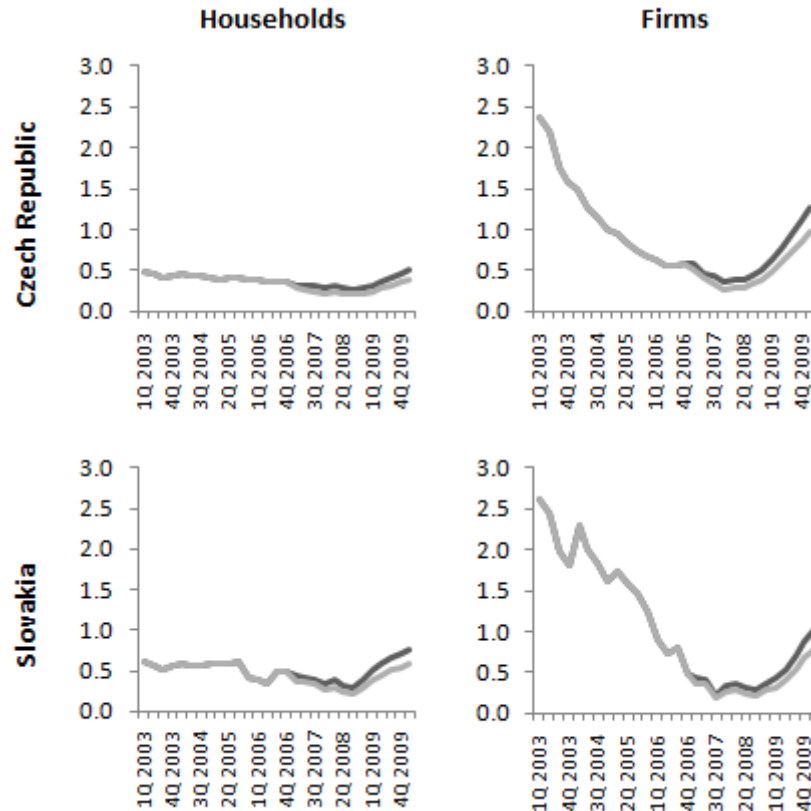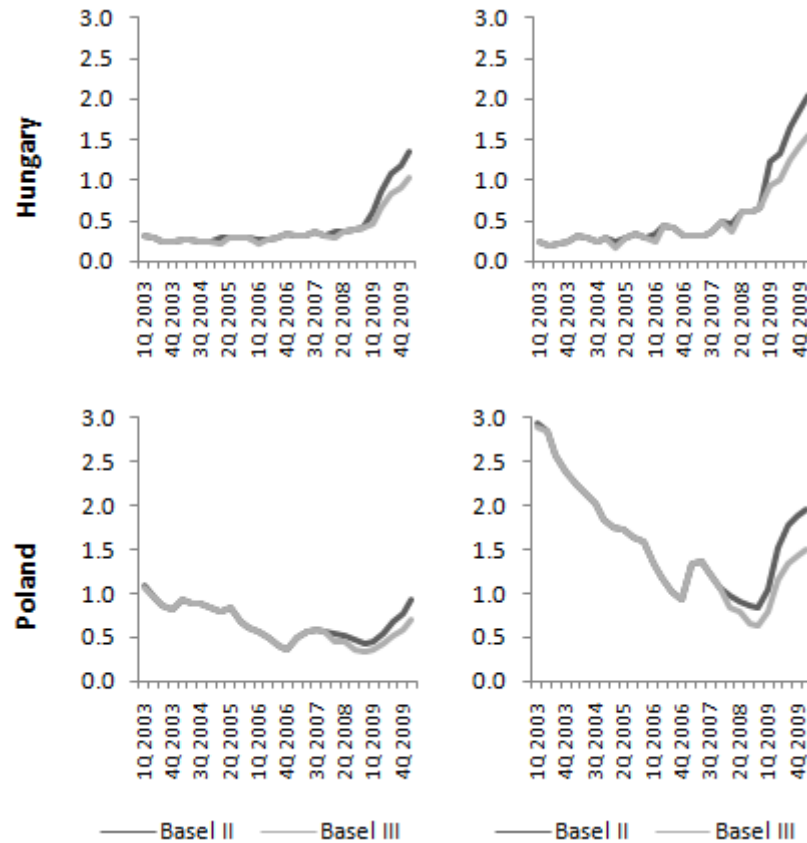
Source: Author's calculations

Hungary and Poland display the same effect for both sectors as the Czech Republic and Slovakia but the imposition of the countercyclical buffer happens later, for Poland in the second half of 2007 and for Hungary not until 2008.

The new risk weights time series have been added to the original regression equation to estimate the sensitivity of Basel III risk weights to the business cycle. The complete results with Gretl outputs for Basel III are enclosed in Appendix 2. Figure 3.8 presents the estimation results for Basel III household model.

The estimation shows procyclicality for all countries except for Hungary, with χ^{HH} reaching negative values. However, the results are again not very statistically significant for Poland. In general the model fits the data well with coefficient of determination R^2 over 75% for all countries. The inertia of previous values of risk weights (defined by ϱ^{HH}) is similar to Basel II model, with $\varrho^{HH} > 1$

for Hungary switching the Hungarian business cycles sensitivity parameter into positive values.

Figure 3.8: Estimation results for the households model under Basel III

	Czech Republic			Slovakia		
	coefficient	p-value		coefficient	p-value	
χ^{HH}	-5.51	0.00385	***	-2.63	0.05088	*
ϱ^{HH}	0.93	0.00001	***	0.85	0.00001	***
R^2	92.82%			77.99%		

	Hungary			Poland		
	coefficient	p-value		coefficient	p-value	
χ^{HH}	5.60	0.01366	**	-3.12	0.34487	
ϱ^{HH}	1.11	0.00001	***	0.82	0.00001	***
R^2	94.82%			89.29%		

Source: Author's calculations

As to the assumptions of the model, tests have been again performed to ensure proper functionality of the regression model. Possible heteroskedasticity has been tested with the test of White (1980) and the test could not reject the hypothesis of no heteroskedasticity present for any of the countries. Based on other tests we also cannot reject the hypothesis of no collinearity. Normality of residuals had to be rejected at first but control tests (Shapiro-Wilk (1965), Lilliefors (1967) and Jarque-Bera (1987)) do not reject normality of residuals for Slovak households' model. The autocorrelation of disturbances has been tested with the Durbin-Watson statistics (Durbin & Watson 1951) showing values sufficiently close to 2 for Slovakia and Hungary. For Czech and Hungarian households model possible autocorrelation has been further tested with the Breusch-Godfrey test for autocorrelation (Breusch, 1979 and Godfrey, 1978) up to order 4 and the hypothesis of no autocorrelation could also not be rejected.

As we can see in Figure 3.8 transforming the model under Basel III rules did not resolve the problem of Hungarian data and the results still do not correspond with the rest of the region.

Adding the countercyclical buffer to the firms' model we obtain estimations of parameters as depicted in Figure 3.9.

Figure 3.9: Estimation results for the firms model under Basel III

	Czech Republic		Slovakia	
	coefficient	p-value	coefficient	p-value
χ^F	-14.54	0.00005 ***	-9.99	0.23022
ϱ^F	0.88	0.00001 ***	0.93	0.00001 ***
R^2	98.57%		95.06%	

	Hungary		Poland	
	coefficient	p-value	coefficient	p-value
χ^F	24.59	0.07088 *	-17.93	0.02742 **
ϱ^F	1.04	0.00001 ***	0.83	0.00001 ***
R^2	93.99%		95.47%	

Source: Author's calculations

With coefficient of determination R^2 around 95% for all countries the estimated model fits the data very well. The estimates for parameter χ^F show again higher procyclicality of the firms sector than the households sector due to reasons we have discussed with the Basel II results. The estimates are statistically significant except for Slovakia where the p-value is significantly higher than 5%. The parameter ϱ^F again suggests strong persistence of the risk weights, with Hungarian ϱ^F above 1.

The tests do not suggest presence of heteroskedasticity or collinearity. The Durbin-Watson statistics is close to 2 for all countries except Poland where the

possible autocorrelation has been tested with the Breusch-Godfrey test up to order 4. The hypothesis of no autocorrelation cannot be rejected. The test for normality of residuals has rejected normality of residuals for Czech Republic and Slovakia. After performing additional tests the normality of residuals has not been rejected for Slovak firms under the Lilliefors test. However, all tests have rejected the normality hypothesis for the Czech Republic.

3.4.4. Comparison of Basel II and Basel III results

Although Basel II and Basel III results are interesting on their own, for this thesis the most important is the comparison of the procyclicality under Basel III and Basel II. For household sector such comparison is depicted on Figure 3.10.

Figure 3.10: Basel II and Basel III procyclicality for the household sector (as a % response to 1% change in business cycle)
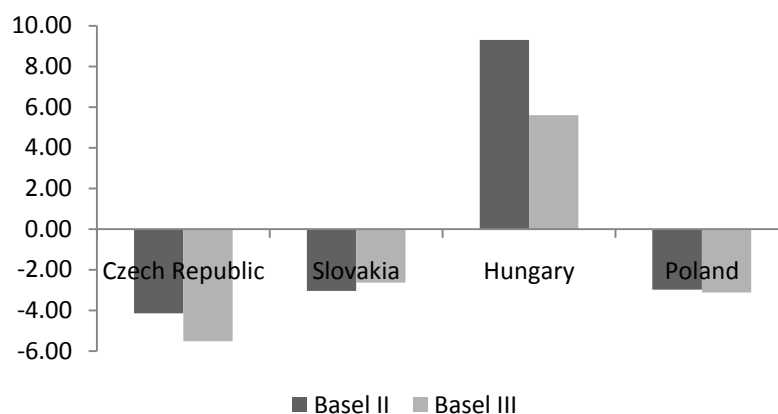
Source: Author's calculations

We have already proven that procyclicality means negative correlation between the risk weights and the business cycle and therefore negative values of the parameter χ^{HH}. It is clear from the Figure 3.10 that changes in the regulatory framework have affected the cyclicality of Basel Accords. The results are, however, ambiguous. For households the procyclicality decreases with Basel III innovations only for Slovakia. For Poland it stays around the same level while for the Czech Republic the results display even higher procyclicality under Basel III for the households sector. When

considering the cyclicality in general (given by the absolute value of the parameter) we can see decrease in cyclicality even for Hungary.

For the firms sector the results are more in favor of the original goal of Basel III as it is depicted on Figure 3.11. The procyclicality is mitigated under the new framework for Czech and Slovak firms while for Polish firms the level of sensitivity to business cycle stays again around the same. As we already know from the previous section, Hungarian model does not correspond with the rest of the region at all. But if we again take the cyclicality in absolute values, it will be decreased under Basel III even for Hungarian firms.

Figure 3.11: Basel II and Basel III procyclicality for the firm sector (as a % response to 1% change in business cycle)
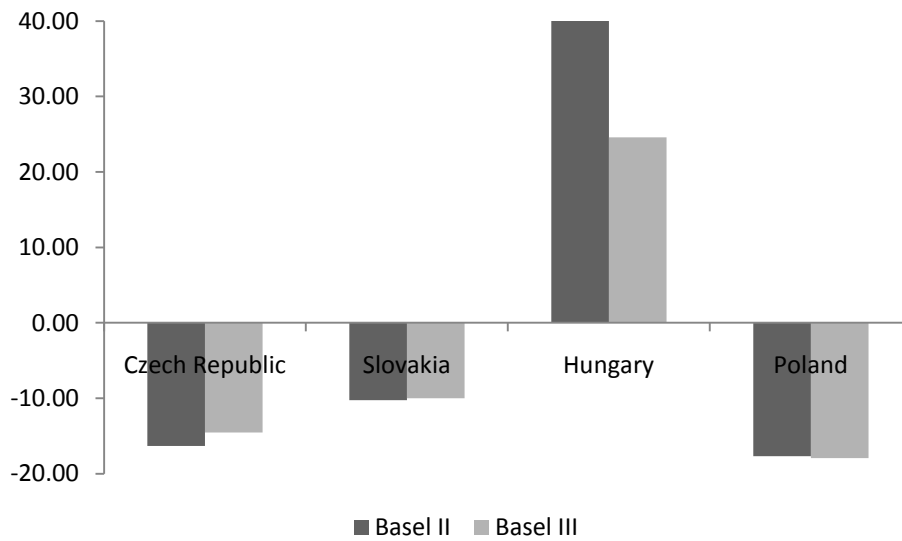
Source: Author's calculations

The fact that the results for the firms sector show stronger mitigation of procyclicality speaks also in favor of Basel III. As it was already mentioned, firms are the first sector to feel the swings of business cycles. Recalling the amplitude of NPL or risk weights movement (see Figure 3.1 or Figure 3.2) the firms sector oscillates on much larger scale. Therefore, the mitigation of procyclicality for firms might have more effect than mitigation for households where the sector is more stable and less elastic.

Chapter 4: ACCOUNTING ISSUES

To complete our study of procyclicality and its treatment under Basel II and Basel III let us now discuss the problem from the accounting point of view. The accounting standards are of course not primarily responsible for the crisis but many experts claim that they may have contributed to the procyclicality of the system great deal. There are two main issues discussed regarding the cyclical nature of accounting standards. Those issues are

1. Shift to the Fair Value Accounting
2. Treatment of provisions

This chapter will analyze both issues, their contribution to the procyclicality and reforms proposed to mitigate the procyclical nature.

4.1. FAIR VALUE ACCOUNTING

4.1.1. From Historical Cost to Fair Value Accounting

Recent decades have been characterized by the change in bank capital. Increased importance of capital markets, rapid innovations and creation of new financial instruments together with higher exposure of bank capital to market volatility triggered the need for adjustment of accounting standards. In order for accounting to better record the financial information a shift in valuation standards was proposed.

Originally the balance sheet items were recorded under the historical cost. As the name of the method suggests the Historical Cost Accounting (HCA) records the original value of an item. Should there be any change in the value of the item, it will not be reflected in the balance sheet and the value recorded would differ from the real value of the item. Such an inaccuracy was the main source of criticism and led the International Accounting Standards Board (IASB) in 2004 to a creation of new

standard, the IAS 39 concerning the recognition and measurement of financial instruments. One year later IAS 39 was updated and introduced the concept of Fair Value Accounting (FVA).

According to the definition provided by IAS 39, fair value is "the amount for which an asset could be exchanged, or a liability settled, between knowledgeable, willing parties in an arm's length transaction" (IFRS, 2009). Such accounting provides timely and more transparent information. On the other hand it is more exposed to the volatility of the market. The determination of the fair value is not always straightforward. Actively traded instruments are valued at the market price (through mark-to-market accounting) but for instruments which are not being traded actively other valuation techniques are necessary. IAS 39 defines three levels of instruments to determine the fair value:

- Level 1: actively traded instruments which are marked directly;
- Level 2: instruments to be priced using comparable instruments or using models with observable inputs;
- Level 3: not traded instruments or instruments with thin markets; such instruments have to be marked according to a model.

It is obvious that the higher is the level of the instrument, the less reliable is its fair value. FVA also classifies the instruments according to their intended purpose. It used to be difficult to reclassify once the instrument is allocated, this rigidity has, however, been changed in 2008 due to the crisis.

4.1.2. Procyclicality of FVA

From the above provided definition of FVA one can easily conclude that the shift in the standards has increased the share of assets and liabilities valued at the market value. Such valuation is, however, subject to market conditions and therefore more volatile. Changes in the asset prices are being immediately recognized. With the asset prices being procyclical on their own it is clear that FVA is procyclical.

In the Literature Review section of Chapter 3 we have discussed the two rating philosophies, PIT and TTC, with the conclusion that PIT enhances

procyclicality. Figure 4.1 presents two types of FVA which are based on the same principle.

Figure 4.1: Types of FVA

FVA	Volatility	Time delay
Point in time	Maximum	Minimum
Average	Minimum	Maximum

Source: Angelini et al. (2009)

Using the Average FVA would, similarly to the TTC rating approach, mitigate the procyclicality when compared to Point in time FVA. It is, however, not so much used in reality as its application is bound to several difficulties. It is disputable which period should be used when calculating for the average FVA. There is also the question of which weights should be given to which information throughout the period. Should the most up-to-date information be considered more important and given higher weights? Therefore the point in time FVA is used. The time delay of such accounting information is minimal but this transparency is counterbalanced by its increased volatility.

4.2. TREATMENT OF PROVISIONS

Besides the Fair Value Accounting the treatment of provisions is another accounting issue which is interconnected with the business cycle and might have an effect on cyclicality. In general, provisions should cover expected losses while the unexpected ones have to be covered by capital. However, IAS 39 works on the principle of incurred losses and allows creation of provisions only for loans that are more than less likely to be lost. In Figure 4.2 they are presented as specific provisions.

Figure 4.2: Overview of provisioning systems
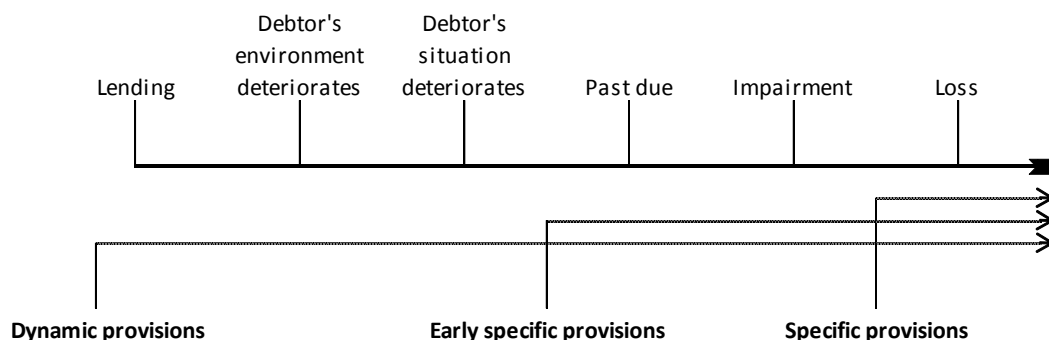
Source: Banque de France (2001)

As mentioned before, specific provisions are created on the basis of incurred loss. That means that there is conclusive evidence that the loan will be lost. Such evidence is, however, not present until economic downturn. Specific provisions are therefore created only in the times of recession while in booms there is no such initiative. The provisioning system obviously contains a cyclical component. The fact that banks create provisions in procyclical manner has been analyzed and confirmed by many studies[1].

Figure 4.2 depicts another provisioning system as well which is the system of dynamic provisioning. When the financial crisis started the system of dynamic provisioning has been discussed as a possible tool to mitigate procyclicality. On basis of the Spanish experience the economists argued that dynamic provisioning would create a buffer which would serve as a source of capital in bad times. Recent development has shown that the Spanish system was not successful either. The buffer allowed the banks to feel relatively safe but once the resources were spent there was a huge fall. The system of dynamic provisioning namely still accounts for the losses in one day instead of spreading them in longer period.

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[1] For the countries of our analyzed region see for example Frait & Komárková (2009).

4.3. OTHER PROCYCLICAL COMPONENTS

Except the two main issues discussed above there are other components in the accounting standards that affect the procyclicality of the economy. The following section provides the overview of the most important procyclical components. One should, however, keep in mind that sometimes there are more the results of business practices than pure accounting effects.

One of the procyclical components is the level of discretionality. To a certain extent it is up to the decision of a bank how it will provide its accounting information. Through appropriate choice of holding intents for its assets, through classification of instruments or through the use of different mark-to-model methodologies for Level 3 assets banks can misinterpret the accounting information they provide. Lower transparency makes the market players less comparable and increases the uncertainty on the market. The uncertainty has further reducing effect on liquidity on the market and can deepen financial crises.

The treatment of risks is another additional source of procyclicality. According to IAS 39 all risks have to be covered in one valuation of an instrument which can distort the information. The issue gets even bigger when we account for the effects of FVA on risk estimates. FVA provides optimistic estimates during financial booms and accentuates the risks during recessions which is a clear procyclical behavior.

The effect of FVA on procyclicality is on the forefront of accounting issues discussion. But the cycle is affected also by the fact that most liabilities are valued at the historical cost. The inconsistency in valuation of assets and liabilities causes the changes to be accounted only as changes in assets and not in liabilities as well. As a consequence the accounting presents higher profits in booms and lower profits in recessions.

And finally, the accounting standards also do not allow accounting for generic costs. Generic costs are provisions against hypothetical liabilities which are

larger than impairment losses. Would they be allowed they would serve as a cushion for bad times and mitigate the procyclicality in the same manner as buffers. Generic costs are now prohibited in the name of higher transparency which perfectly illustrates the basis for disagreements between accountants and regulators. The regulators point out that accounting standards can enhance procyclicality. The accountants, however, argue that accounting should in the first place provide transparent information and it is the task of regulation to set such prudential tools and rules that would deal with the procyclicality of the system.

4.4. CORRECTIVE ACTIONS

The discussions among regulators and accountants have resulted in planning of reform which would upgrade or replace the IAS 39 standard. The BCBS even formulated principles which should be followed when replacing IAS 39.

The Committee above all warns that the new standards should not further enhance the FVA approach. As BCBS (2009a) states, the new standards should especially

- Allow earlier recognition of loans which would allow creation of solid provisions
- Take into account that fair value measurement is not effective for illiquid or dislocated markets
- Permit easier reclassifications from the fair value category to amortized cost in the presence of events that strongly affect the business cycle (such as financial crisis)
- Promote cooperation across jurisdiction.

At the end of 2009 a new standard was introduced, IFRS 9. The accountants have to follow this standard beginning 2013 for all assets and there are few countries which applied it even for the financial statements for 2009.

The main change of IFRS 9 is a shift from the incurred loss system to the expected loss approach, which is being supported in Basel III as well. Already Basel II has discussed the expected loss approach. It has, nevertheless, worked only with expected losses for 12 months. IFRS 9 proposes a concept of expected losses where the provisions will be accounted for continuously and throughout the whole portfolio span. When the losses will be identified the provisions will shift into the current model. Such system should ensure that the development of provisions will be smoothed and only follow the business cycle instead of amplifying it.

When looking back at the BCBS principles which the improved accounting standard should follow IFRS 9 is in compliance with all of them. Even the cooperation among jurisdictions has been enhanced with the US considering to abandon US GAAP and join the IFRS. In order to ensure transparency the procyclical effects of FVA are not easy to mitigate. The Expected Loss model of IFRS 9 should, however, soften the procyclical component. There is only one issue, similar to the problem of countercyclical buffers, which has to be yet monitored. It is namely quite difficult to recognize that an economy is on the bottom of the business cycle. According to the Expected Loss model the accountants will create high provisions. The question remains when exactly such high provisions should be released in order to boost the economy.

Chapter 5: CONCLUSION

The aim of this thesis was to investigate the level of procyclicality under the two most recent regulatory frameworks, Basel II and Basel III. The recent financial crisis has revealed many shortcomings of the second Basel Accord and the amplification of the business cycle has been one of them. When creating improved framework, Basel III, the Basel Committee on Banking Supervision sought to incorporate tools that would mitigate the procyclical nature of Basel II.

Concentrating on the countries of the Visegrád Group, that is on the Czech Republic, Slovakia, Hungary and Poland, our aim was to compare the procyclicality of both regulatory frameworks in the region and find out whether the mitigating tools are effective. The exact hypotheses we sought to analyze supposed evident procyclicality in Basel II (measured as negative correlation between the business cycle and Basel risk weights) and decreased procyclicality in Basel III. We have also stipulated final hypothesis that the countries of the region will react differently to the both Basel Accords as they have been differently affected by the crisis.

Using the OLS estimation method we have analyzed separate models for households and corporations under Basel II based on the stable capital adequacy ratio of 8%. For Basel III we have incorporated the time varying countercyclical buffer into the model. The results of our estimation immediately and clearly showed that we cannot reject the Hypothesis 3: different impact of Basel Accords in the region. The figures we have obtained for Hungary differ greatly from the rest of the region as Hungary has shown a completely different pattern in the input data. This is due to the fact that until recently the Hungarians have obtained many loans in foreign exchange. Our data on non-performing loans was therefore distorted by the foreign exchange development.

When refraining from Hungary, the expected procyclicality of Basel II has been confirmed by our model and Hypothesis 1: procyclicality of Basel II could not be rejected. The sensitivity to the business cycle has been higher for the firms than

for the households, which is in line with other studies analyzing Basel II. It is to be expected as the firms are the first ones to directly feel the consequences of a crunch. The household sector is somewhat less elastic and the effects of a crisis take longer to fully develop. Our model has, however, shown ambiguous results for Basel III, mitigating the procyclicality for some sectors and countries while increasing it for others. Therefore we have to reject the Hypothesis 2.

If we would take into account Hungarian results as well we would have to reject both Hypothesis 1 and Hypothesis 2 as the country displays no procyclicality at all. But what all the countries have in common is a strong persistence of the data as the risk weights are above all dependent on its previous values. Such inertia has to be taken into account when considering any change in the rules.

Our final analysis went to the discussion of the cyclical effects from another point of view. The Committee has namely, besides its own reforms of the regulatory framework, called for amends in the accounting standards as there are several accounting issues affecting the business cycle. Certain changes have been made and the accounting standards are in the process of upgrading. It is, however, not possible to omit the procyclical factors altogether. The accounting should above all provide transparent information and it is the task of regulators with the prudential tools to deal with any procyclicality that might come as a side effect of the transparency.

If the task has been completed through Basel III remains an open question. Although the model of this thesis has been simplified and is certainly omitting several important factors it still employs data which serve as the basis for capital adequacy calculation under both Basel Accords. Therefore it suggests an important problem of the Accords, namely that the rules cannot be applied generally for all countries. And although our reference region is not a typical representative of countries hit by the financial crisis, the analysis conducted on its members indicates that the effect of Basel III might not be as convincing as many experts hope.

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APPENDIX 1

BASEL II RISK WEIGHTS

A1.1. Results for households

Czech Republic

Regression model:

$$CZE\_W\_HH = (1 - \varrho^{HH})\chi^{HH}(CZE\_CHANGE\_lnY) + \varrho^i * CZE\_LY\_W\_HH$$

Regression results:

Model 1:OLS. using observations 2003:1-2010:1 (T = 29) Dependent variable: CZE_W_HH					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.0679776	0.0258769	2.627	0.01426	**
CZE_CHANGE_lnY	-0.473643	0.120165	-3.9416	0.00054	***
CZE_LY_W_HH	0.88557	0.0654365	13.5333	<0.00001	***
Mean dependent var	0.381399		S.D. dependent var	0.066544	
Sum squared resid	0.014674		S.E. of regression	0.023757	
R-squared	0.88165		Adjusted R-squared	0.872546	
F(2. 26)	96.84373		P-value(F)	8.94e-13	
Log-likelihood	68.89089		Akaike criterion	-131.7818	
Schwarz criterion	-127.6799		Hannan-Quinn	-130.4971	
rho	0.307864		**Durbin-Watson**	**1.126595**	

Testing the assumptions

- **White's test for heteroskedasticity**
  - Null hypothesis: Heteroskedasticity not present
  - Test statistic: $TR^2 = 14.412221$, with p-value = P(Chi-square(5) > 14.412221) = 0.013192

- **Multicollinearity test**
  - Values > 10.0 may indicate a collinearity problem
  - CZE_CHANGE_lnY   1.003
  - CZE_LY_W_HH   1.003

- **Normality of residuals**
  - Null hypothesis: error is normally distributed
  - Chi-square(2) = 3.052, with p-value 0.21740

- **Breusch-Godfrey Test for autocorrelation up to order 4**
  - Test statistic: LMF = 1.261266, with p-value = $P(F(4,22) > 1.26127) = 0.315$
  - Alternative statistic: TR^2 = 5.409743, with p-value = $P(\text{Chi-square}(4) > 5.40974) = 0.248$
  - Ljung-Box Q' = 6.63745, with p-value = $P(\text{Chi-square}(4) > 6.63745) = 0.156$

Slovakia

Regression model:

$$SVK\_W\_HH = (1 - \varrho^{HH})\chi^{HH}(SVK\_CHANGE\_lnY) + \varrho^i * SVK\_LY\_W\_HH$$

Regression results:

Model 3:OLS. using observations 2003:1-2010:1 (T = 29) Dependent variable: SVK_W_HH					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.140052	0.0547162	2.5596	0.01664	**
SVK_CHANGE_lnY	-0.571062	0.185751	-3.0743	0.00491	***
SVK_LY_W_HH	0.811804	0.0983586	8.2535	<0.00001	***
Mean dependent var	0.50575	S.D. dependent var	0.121373		
Sum squared resid	0.094296	S.E. of regression	0.060223		
R-squared	0.771392	Adjusted R-squared	0.753807		
F(2. 26)	43.86589	P-value(F)	4.66e-09		
Log-likelihood	41.91567	Akaike criterion	-77.83134		
Schwarz criterion	-73.72945	Hannan-Quinn	-76.54668		
rho	0.006724	**Durbin-Watson**	**1.919666**		

Testing the assumptions

- **White's test for heteroskedasticity**
  - Null hypothesis: Heteroskedasticity not present
  - Test statistic: TR^2 = 1.324306, with p-value = $P(\text{Chi-square}(5) > 1.324306) = 0.932411$

- **Multicollinearity test**
  - Values > 10.0 may indicate a collinearity problem
  - SVK_CHANGE_lnY   1.025
  - SVK_LY_W_HH   1.025

- **Normality of residuals**
  - Null hypothesis: error is normally distributed
  - Chi-square(2) = 3.052, with p-value 0.21740

Hungary

Regression model:

$$HUN\_W\_HH = (1 - \varrho^{HH})\chi^{HH}(HUN\_CHANGE\_lnY) + \varrho^i HUN\_LY\_W\_HH$$

Regression results:

Model 5:OLS. using observations 2003:1-2010:1 (T = 29) Dependent variable: HUN_W_HH					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.0498862	0.0294981	1.6912	0.10276	
HUN_CHANGE_lnY	-1.02023	0.236756	-4.3092	0.00021	***
HUN_LY_W_HH	1.10974	0.0460158	24.1166	<0.00001	***
Mean dependent var	0.426903		S.D. dependent var	0.300647	
Sum squared resid	0.061007		S.E. of regression	0.04844	
R-squared	0.975895		Adjusted R-squared	0.974041	
F(2. 26)	526.3097		P-value(F)	9.28e-22	
Log-likelihood	48.2298		Akaike criterion	-90.4596	
Schwarz criterion	-86.35771		Hannan-Quinn	-89.17494	
rho	0.229422		**Durbin-Watson**	**1.431075**	

Testing the assumptions

- **White's test for heteroskedasticity**
  - Null hypothesis: Heteroskedasticity not present
  - Test statistic: TR^2 = 10.722630, with p-value = P(Chi-square(5) > 10.722630) = 0.057165

- **Multicollinearity test**
  - Values > 10.0 may indicate a collinearity problem
  - HUN_CHANGE_lnY   1.467
  - HUN_LY_W_HH   1.467

- **Normality of residuals**
  - Null hypothesis: error is normally distributed
  - Chi-square(2) = 1.697, with p-value 0.42796

- **Breusch-Godfrey test for autocorrelation up to order 4**
  - Test statistic: LMF = 1.485775, with p-value = $P(F(4,22) > 1.48578) = 0.241$
  - Alternative statistic: TR^2 = 6.167888, with p-value = $P(\text{Chi-square}(4) > 6.16789) = 0.187$
  - Ljung-Box Q' = 8.30373, with p-value = $P(\text{Chi-square}(4) > 8.30373) = 0.0811$

Poland

Regression model:

$$POL\_W\_HH = (1 - \varrho^{HH})\chi^{HH}(POL\_CHANGE\_lnY) + \varrho^{i} * POL\_LY\_W\_HH$$

Regression results:

Model 7:OLS. using observations 2003:1-2010:1 (T = 29) Dependent variable: POL_W_HH					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.161946	0.0859494	1.8842	0.07077	*
POL_CHANGE_lnY	-0.572147	0.664107	-0.8615	0.39682	
POL_LY_W_HH	0.807452	0.0766716	10.5313	<0.00001	***
Mean dependent var	0.674979		S.D. dependent var	0.198145	
Sum squared resid	0.160484		S.E. of regression	0.078565	
R-squared	0.854015		Adjusted R-squared	0.842786	
F(2. 26)	76.05038		P-value(F)	1.37e-11	
Log-likelihood	34.20519		Akaike criterion	-62.41038	
Schwarz criterion	-58.30849		Hannan-Quinn	-61.12572	
rho	0.503612		**Durbin-Watson**	**0.981101**	

Testing the assumptions

- **White's test for heteroskedasticity**
  - Null hypothesis: Heteroskedasticity not present
  - Test statistic: TR^2 = 6.077351, with p-value = $P(\text{Chi-square}(5) > 6.077351) = 0.298765$

- **Multicollinearity test**
  - Values > 10.0 may indicate a collinearity problem
  - POL_CHANGE_lnY   1.268
  - POL_LY_W_HH   1.268

- **Normality of residuals:**
  - Null hypothesis: error is normally distributed

- Chi-square(2) = 1.422, with p-value 0.49105

- **Breusch-Godfrey test for autocorrelation up to order 4**
    - Test statistic: LMF = 2.049766, with p-value = $P(F(4,22) > 2.04977)$ = 0.122
    - Alternative statistic: TR^2 = 7.873517, with p-value = $P(\text{Chi-square}(4) > 7.87352)$ = 0.0963
    - Ljung-Box Q' = 7.50382, with p-value = $P(\text{Chi-square}(4) > 7.50382)$ = 0.112

A1.2. RESULTS FOR FIRMS

Czech Republic

Regression model:

$$CZE\_W\_F = (1 - \varrho^F)\chi^F(CZE\_CHANGE\_lnY) + \varrho^i CZE\_LY\_W\_F$$

Regression results:

Model 2:OLS. using observations 2003:1-2010:1 (T = 29) Dependent variable: CZE_W_F					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.198971	0.0340503	5.8434	<0.00001	***
CZE_CHANGE_lnY	-2.12817	0.381857	-5.5732	<0.00001	***
CZE_LY_W_F	0.869457	0.0238433	36.4654	<0.00001	***
Mean dependent var	0.920106		S.D. dependent var	0.534331	
Sum squared resid	0.148445		S.E. of regression	0.075561	
R-squared	0.981431		Adjusted R-squared	0.980003	
F(2. 26)	687.0962		P-value(F)	3.12e-23	
Log-likelihood	35.33593		Akaike criterion	-64.67185	
Schwarz criterion	-60.56996		Hannan-Quinn	-63.38719	
rho	0.008471		**Durbin-Watson**	**1.786953**	

Testing the assumptions

- **White's test for heteroskedasticity**
    - Null hypothesis: Heteroskedasticity not present
    - Test statistic: TR^2 = 9.955310 with p-value = $P(\text{Chi-square}(5) > 9.955310)$ = 0.076511

- **Multicollinearity test**
    - Values > 10.0 may indicate a collinearity problem

- o CZE_CHANGE_lnY   1.001
- o CZE_LY_W_F   1.001

- • **Test for normality of residuals**
  - o Null hypothesis: error is normally distributed
    - ▪ Chi-square(2) = 12.337, with p-value 0.00209
  - o Lilliefors test = 0.126941, with p-value ~= 0.26

Slovakia

Regression model:

$$SVK\_W\_F = (1 - \varrho^F)\chi^F(SVK\_CHANGE\_lnY) + \varrho^i * SVK\_LY\_W\_F$$

Regression results:

Model 4:OLS, using observations 2003:1-2010:1 (T = 29) Dependent variable: SVK_W_F					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.0985503	0.0670956	1.4688	0.15388	
SVK_CHANGE_lnY	-0.878888	0.585894	-1.5001	0.14564	
SVK_LY_W_F	0.923093	0.0456142	20.237	<0.00001	***
Mean dependent var	1.096409		S.D. dependent var	0.742689	
Sum squared resid	0.876897		S.E. of regression	0.183649	
R-squared	0.943222		Adjusted R-squared	0.938855	
F(2, 26)	215.9637		P-value(F)	6.37e-17	
Log-likelihood	9.58137		Akaike criterion	-13.16274	
Schwarz criterion	-9.060852		Hannan-Quinn	-11.87808	
rho	-0.133983		**Durbin-Watson**	**2.219487**	

Testing the assumptions

- • **White's test for heteroskedasticity**
  - o Null hypothesis: Heteroskedasticity not present
  - o Test statistic: TR^2 = 6.705187, with p-value = P(Chi-square(5) > 6.705187) = 0.243505

- • **Multicollinearity test**
  - o Values > 10.0 may indicate a collinearity problem
  - o SVK_CHANGE_lnY   1.097
  - o SVK_LY_W_F   1.097
- • **Normality of residuals**
  - o Null hypothesis: error is normally distributed
    - ▪ Chi-square(2) = 13.445, with p-value 0.00120

Hungary

Regression model:

$$HUN\_W\_F = (1 - \varrho^F)\chi^F(HUN\_CHANGE\_lnY) + \varrho^i HUN\_LY\_W\_F$$

Regression results:

Model 6:OLS, using observations 2003:1-2010:1 (T = 29) Dependent variable: HUN_W_F					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.136666	0.0565496	2.4168	0.02298	**
HUN_CHANGE_lnY	-1.60741	0.52839	-3.0421	0.00531	***
HUN_LY_W_F	1.03919	0.0560778	18.5313	<0.00001	***
Mean dependent var	0.575673		S.D. dependent var	0.518622	
Sum squared resid	0.269999		S.E. of regression	0.101905	
R-squared	0.964149		Adjusted R-squared	0.961391	
F(2, 26)	349.611		P-value(F)	1.62e-19	
Log-likelihood	26.66195		Akaike criterion	-47.3239	
Schwarz criterion	-43.22201		Hannan-Quinn	-46.03924	
rho	-0.24191		**Durbin-Watson**	**2.475122**	

Testing the assumptions

- **White's test for heteroskedasticity**
  - Null hypothesis: Heteroskedasticity not present
  - Test statistic: TR^2 = 25.192261, with p-value = P(Chi-square(5) > 25.192261) = 0.000128

- **Multicollinearity test**
  - Values > 10.0 may indicate a collinearity problem
  - HUN_CHANGE_lnY   1.651
  - HUN_LY_W_F   1.651

- **Normality of residuals**
  - Null hypothesis: error is normally distributed
    - Chi-square(2) = 7.244, with p-value 0.02673
  - Shapiro-Wilk W = 0.934104, with p-value 0.0703174
  - Lilliefors test = 0.14038, with p-value ~= 0.15

Poland

Regression model:

$$POL\_W\_F = (1 - \varrho^F)\chi^F(POL\_CHANGE\_lnY) + \varrho^i * POL\_LY\_W\_F$$

Regression results:

Model 8:OLS. using observations 2003:1-2010:1 (T = 29) Dependent variable: POL_W_F					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.529404	0.185259	2.8576	0.00829	***
POL_CHANGE_lnY	-3.44831	1.50594	-2.2898	0.03039	**
POL_LY_W_F	0.804916	0.0585491	13.7477	<0.00001	***
Mean dependent var	1.619346		S.D. dependent var	0.598987	
Sum squared resid	0.626316		S.E. of regression	0.155207	
R-squared	0.937655		Adjusted R-squared	0.932859	
F(2. 26)	195.5175		P-value(F)	2.15e-16	
Log-likelihood	14.46113		Akaike criterion	-22.92227	
Schwarz criterion	-18.82038		Hannan-Quinn	-21.63761	
rho	0.453861		**Durbin-Watson**	**1.070866**	

Testing the assumptions

- **White's test for heteroskedasticity**
    - Null hypothesis: Heteroskedasticity not present
    - Test statistic: $TR^2 = 16.498633$,
    - with p-value = $P(\text{Chi-square}(5) > 16.498633) = 0.005556$

- **Multicollinearity test**
    - Values > 10.0 may indicate a collinearity problem
    - POL_CHANGE_lnY   1.670
    - POL_LY_W_F   1.670

- **Normality of residuals**
    - Null hypothesis: error is normally distributed
    - Chi-square(2) = 1.707
    - with p-value 0.42591

- **Breusch-Godfrey test for autocorrelation up to order 4**
    - Test statistic: LMF = 2.155484, with p-value = $P(F(4,22) > 2.15548) = 0.108$
    - Alternative statistic: $TR^2 = 8.165262$, with p-value = $P(\text{Chi-square}(4) > 8.16526) = 0.0857$
    - Ljung-Box Q' = 10.2263, with p-value = $P(\text{Chi-square}(4) > 10.2263) = 0.0368$

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APPENDIX 2

BASEL III RISK WEIGHTS

A2.1. Results for households

Czech Republic

Regression model:

$$CZE\_W\_HH = (1 - \varrho^{HH})\chi^{HH}(CZE\_CHANGE\_lnY) + \varrho^{HH} * CZE\_LY\_W\_HH$$

Regression results:

Model 1: OLS, using observations 2003:1-2010:1 (T = 29) Dependent variable: CZE_W_HH					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.042408	0.0177005	2.3959	0.02407	**
CZE_CHANGE_lnY	-0.406852	0.128203	-3.1735	0.00385	***
CZE_LY_W_HH	0.926183	0.0510524	18.1418	<0.00001	***
Mean dependent var	0.346932		S.D. dependent var	0.086705	
Sum squared resid	0.015121		S.E. of regression	0.024116	
R-squared	0.928164		Adjusted R-squared	0.922638	
F(2, 26)	167.9673		P-value(F)	1.36E-15	
Log-likelihood	68.45556		Akaike criterion	-130.9111	
Schwarz criterion	-126.8092		Hannan-Quinn	-129.6265	
rho	0.18265		**Durbin-Watson**	**1.403484**	

Testing the assumptions

- **White's test for heteroskedasticity**
  - Null hypothesis: Heteroskedasticity not present
  - Test statistic: $TR^2 = 10.325954$, with p-value = P(Chi-square(5) > 10.325954) = 0.066509

- **Multicollinearity test**
  - Values > 10.0 may indicate a collinearity problem
  - CZE_CHANGE_lnY   1.108
  - CZE_LY_W_HH   1.108

- **Normality of residuals**
  - Null hypothesis: error is normally distributed
  - Chi-square(2) = 3.345, with p-value 0.18781

- **Breusch-Godfrey test for autocorrelation up to order 4**
  - Test statistic: LMF = 0.629471, with p-value = P(F(4,22) > 0.629471) = 0.647

- Alternative statistic: TR^2 = 2.978179, with p-value = P(Chi-square(4) > 2.97818) = 0.561
- Ljung-Box Q' = 3.6728, with p-value = P(Chi-square(4) > 3.6728) = 0.452

Slovakia

Regression model:

$$SVK\_W\_HH = (1 - \varrho^{HH})\chi^{HH}(SVK\_CHANGE\_lnY) + \varrho^{HH} * SVK\_LY\_W\_HH$$

Regression results:

<table>
<tr><td colspan="6">Model 3: OLS, using observations 2003:1-2010:1 (T = 29)
Dependent variable: SVK_W_HH</td></tr>
<tr><td></td><td>Coefficient</td><td>Std. Error</td><td>t-ratio</td><td>p-value</td><td></td></tr>
<tr><td>const</td><td>0.0930455</td><td>0.0429996</td><td>2.1639</td><td>0.03984</td><td>**</td></tr>
<tr><td>SVK_CHANGE_lnY</td><td>-0.385978</td><td>0.188547</td><td>-2.0471</td><td>0.05088</td><td>*</td></tr>
<tr><td>SVK_LY_W_HH</td><td>0.853292</td><td>0.0890335</td><td>9.5839</td><td><0.00001</td><td>***</td></tr>
<tr><td>Mean dependent var</td><td>0.459298</td><td></td><td>S.D. dependent var</td><td>0.125575</td><td></td></tr>
<tr><td>Sum squared resid</td><td>0.097162</td><td></td><td>S.E. of regression</td><td>0.061131</td><td></td></tr>
<tr><td>R-squared</td><td>0.779944</td><td></td><td>Adjusted R-squared</td><td>0.763017</td><td></td></tr>
<tr><td>F(2, 26)</td><td>46.07586</td><td></td><td>P-value(F)</td><td>2.84E-09</td><td></td></tr>
<tr><td>Log-likelihood</td><td>41.48149</td><td></td><td>Akaike criterion</td><td>-76.96298</td><td></td></tr>
<tr><td>Schwarz criterion</td><td>-72.86109</td><td></td><td>Hannan-Quinn</td><td>-75.67832</td><td></td></tr>
<tr><td>rho</td><td>0.005954</td><td></td><td>Durbin-Watson</td><td>1.952904</td><td></td></tr>
</table>

Testing the assumptions

- **White's test for heteroskedasticity**
  - Null hypothesis: Heteroskedasticity not present
  - Test statistic: TR^2 = 1.569611,
  - with p-value = P(Chi-square(5) > 1.569611) = 0.904900

- **Multicollinearity test**
  - Values > 10.0 may indicate a collinearity problem
  - SVK_CHANGE_lnY   1.025
  - SVK_LY_W_HH   1.025

- **Normality of residuals**
  - Null hypothesis: error is normally distributed
    - Chi-square(2) = 8.514, with p-value 0.01416
  - Shapiro-Wilk W = 0.956253, with p-value 0.264946

- Lilliefors test = 0.107916, with p-value ~= 0.51
- Jarque-Bera test = 4.96173, with p-value 0.0836709

Hungary

Regression model:

$$HUN\_W\_HH = (1 - \varrho^{HH})\chi^{HH}(HUN\_CHANGE\_lnY) + \varrho^{HH} * HUN\_LY\_W\_HH$$

Regression results:

Model 5: OLS, using observations 2003:1-2010:1 (T = 29) Dependent variable: HUN_W_HH					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.0194848	0.035017	0.5564	0.58267	
HUN_CHANGE_lnY	-0.639	0.241542	-2.6455	0.01366	**
HUN_LY_W_HH	1.1141	0.0677602	16.4418	<0.00001	***
Mean dependent var	0.377039		S.D. dependent var	0.209792	
Sum squared resid	0.063873		S.E. of regression	0.049565	
R-squared	0.948170		Adjusted R-squared	0.944183	
F(2, 26)	237.8194		P-value(F)	1.95e-17	
Log-likelihood	47.56401		Akaike criterion	-89.12801	
Schwarz criterion	-85.02613		Hannan-Quinn	-87.84335	
rho	-0.028208		**Durbin-Watson**	**1.967903**	

Testing the assumptions

- **White's test for heteroskedasticity**
    - Null hypothesis: Heteroskedasticity not present
    - Test statistic: TR^2 = 7.805007,
    - with p-value = P(Chi-square(5) > 7.805007) = 0.167315

- **Multicollinearity test**
    - Values > 10.0 may indicate a collinearity problem
    - HUN_CHANGE_lnY   1.459
    - HUN_LY_W_HH   1.459

- **Normality of residuals**
    - Null hypothesis: error is normally distributed
    - Chi-square(2) = 2.755, with p-value 0.25223

Poland

Regression model:

$$POL\_W\_HH = (1 - \varrho^{HH})\chi^{HH}(POL\_CHANGE\_lnY) + \varrho^{HH} * POL\_LY\_W\_HH$$

Regression results:

Model 7: OLS, using observations 2003:1-2010:1 (T = 29)					
Dependent variable: POL_W_HH					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.141472	0.0698267	2.0260	0.05314	*
POL_CHANGE_lnY	-0.57076	0.593248	-0.9621	0.34487	
POL_LY_W_HH	0.817275	0.0621768	13.1444	<0.00001	***
Mean dependent var	0.634457		S.D. dependent var	0.214127	
Sum squared resid	0.137522		S.E. of regression	0.072728	
R-squared	0.892880		Adjusted R-squared	0.884640	
F(2, 26)	108.3594		P-value(F)	2.45e-13	
Log-likelihood	36.44417		Akaike criterion	-66.88834	
Schwarz criterion	-62.78645		Hannan-Quinn	-65.60368	
rho	0.374448		**Durbin-Watson**	**1.206670**	

Testing the assumptions

- **White's test for heteroskedasticity**
  - Null hypothesis: Heteroskedasticity not present
  - Test statistic: TR^2 = 2.050418,
  - with p-value = P(Chi-square(5) > 2.050418) = 0.842126

- **Multicollinearity test**
  - Values > 10.0 may indicate a collinearity problem
  - POL_CHANGE_lnY   1.180
  - POL_LY_W_HH   1.180

- **Test for normality of residuals:**
  - Null hypothesis: error is normally distributed
  - Chi-square(2) = 1.905, with p-value 0.38579

- **Breusch-Godfrey test for autocorrelation up to order 4**
  - Test statistic: LMF = 1.563337, with p-value = P(F(4,22) > 1.56334) = 0.219
  - Alternative statistic: TR^2 = 6.418605, with p-value = P(Chi-square(4) > 6.41861) = 0.17
  - Ljung-Box Q' = 7.85182, with p-value = P(Chi-square(4) > 7.85182) = 0.0972

A2.2. RESULTS FOR FIRMS

Czech Republic

Regression model:

$$CZE\_W\_F = (1 - \varrho^F)\chi^F(CZE\_CHANGE\_lnY) + \varrho^F * CZE\_LY\_W\_F$$

Regression results:

Model 2: OLS, using observations 2003:1-2010:1 (T = 29) Dependent variable: CZE_W_F					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.147829	0.0287182	5.1476	0.00002	***
CZE_CHANGE_lnY	-1.7124	0.350565	-4.8847	0.00005	***
CZE_LY_W_F	0.882218	0.0208653	42.2816	<0.00001	***
Mean dependent var	0.855571		S.D. dependent var	0.558208	
Sum squared resid	0.124728		S.E. of regression	0.069262	
R-squared	0.985704		Adjusted R-squared	0.984604	
F(2, 26)	896.3443		P-value(F)	1.04e-24	
Log-likelihood	37.86003		Akaike criterion	-69.72006	
Schwarz criterion	-65.61817		Hannan-Quinn	-68.43540	
rho	-0.029797		**Durbin-Watson**	**1.849730**	

Testing the assumptions

- **White's test for heteroskedasticity**
    - Null hypothesis: Heteroskedasticity not present
    - Test statistic: TR^2 = 11.047179,
    - with p-value = P(Chi-square(5) > 11.047179) = 0.050453

- **Multicollinearity test**
    - Values > 10.0 may indicate a collinearity problem
    - CZE_CHANGE_lnY   1.004
    - CZE_LY_W_F   1.004

- **Test for normality of residuals**
    - Null hypothesis: error is normally distributed
        - Chi-square(2) = 17.761,
        - with p-value 0.00014
    - Shapiro-Wilk W = 0.855824, with p-value 0.00100431
    - Lilliefors test = 0.170134, with p-value ~= 0.03
    - Jarque-Bera test = 42.0987, with p-value 7.21729e-010

Slovakia

Regression model:

$$SVK\_W\_F = (1 - \varrho^F)\chi^F(SVK\_CHANGE\_lnY) + \varrho^F * SVK\_LY\_W\_F$$

Regression results:

Model 4: OLS, using observations 2003:1-2010:1 (T = 29) Dependent variable: SVK_W_F					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.0680968	0.0627908	1.0845	0.28810	
SVK_CHANGE_lnY	-0.711019	0.578712	-1.2286	0.23022	
SVK_LY_W_F	0.928824	0.0432361	21.4826	<0.00001	***
Mean dependent var	1.048688		S.D. dependent var	0.777320	
Sum squared resid	0.835675		S.E. of regression	0.179280	
R-squared	0.950605		Adjusted R-squared	0.946806	
F(2, 26)	250.1868		P-value(F)	1.04e-17	
Log-likelihood	10.27955		Akaike criterion	-14.55910	
Schwarz criterion	-10.45721		Hannan-Quinn	-13.27444	
rho	-0.130707		**Durbin-Watson**	**2.221294**	

Testing the assumptions

- **White's test for heteroskedasticity**
    - Null hypothesis: Heteroskedasticity not present
    - Test statistic: TR^2 = 7.200039,
    - with p-value = P(Chi-square(5) > 7.200039) = 0.206183

- **Multicollinearity test**
    - Values > 10.0 may indicate a collinearity problem
    - SVK_CHANGE_lnY   1.123
    - SVK_LY_W_F   1.123
-
- **Test for normality of residuals**
    - Null hypothesis: error is normally distributed
        - Chi-square(2) = 14.361,
        - with p-value 0.00076
    - Lilliefors test = 0.138668, with p-value ~= 0.16

Hungary

Regression model:

$$HUN\_W\_F = (1 - \varrho^F)\chi^F(HUN\_CHANGE\_lnY) + \varrho^F HUN\_LY\_W\_F$$

Regression results:

Model 6: OLS, using observations 2003:1-2010:1 (T = 29) Dependent variable: HUN_W_F					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.084649	0.0588974	1.72	0.16258	
HUN_CHANGE_lnY	-0.947767	0.503232	-1.8834	0.07088	*
HUN_LY_W_F	1.03855	0.0730158	14.2236	<0.00001	***
Mean dependent var	0.500024		S.D. dependent var	0.376723	
Sum squared resid	0.238652		S.E. of regression	0.095807	
R-squared	0.939943		Adjusted R-squared	0.935323	
F(2, 26)	203.4616		P-value(F)	1.32e-16	
Log-likelihood	28.45142		Akaike criterion	-50.90285	
Schwarz criterion	-46.80096		Hannan-Quinn	-49.61819	
rho	-0.391302		**Durbin-Watson**	**2.775708**	

Testing the assumptions

- **White's test for heteroskedasticity**
  - Null hypothesis: Heteroskedasticity not present
  - Test statistic: TR^2 = 2.917756,
  - with p-value = P(Chi-square(5) > 2.917756) = 0.712664

- **Multicollinearity test**
  - Values > 10.0 may indicate a collinearity problem
  - HUN_CHANGE_lnY   1.694
  - HUN_LY_W_F   1.694

- **Test for null hypothesis of normal distribution:**
  - Null hypothesis: error is normally distributed
  - Chi-square(2) = 0.860
  - with p-value 0.65056

Poland

Regression model:

$$POL\_W\_F = (1 - \varrho^F)\chi^F(POL\_CHANGE\_lnY) + \varrho^F * POL\_LY\_W\_F$$

Regression results:

Model 8: OLS, using observations 2003:1-2010:1 (T = 29) Dependent variable: POL_W_F					
	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	0.418023	0.145814	2.68	0.00811	***
POL_CHANGE_lnY	-2.96588	1.26919	-2.3368	0.02742	**
POL_LY_W_F	0.834591	0.0463945	17.9890	<0.00001	***
Mean dependent var	1.528366		S.D. dependent var	0.634103	
Sum squared resid	0.510553		S.E. of regression	0.140131	
R-squared	0.954652		Adjusted R-squared	0.951163	
F(2, 26)	273.6688		P-value(F)	3.43e-18	
Log-likelihood	17.42436		Akaike criterion	-28.84871	
Schwarz criterion	-24.74682		Hannan-Quinn	-27.56405	
rho	0.340680		**Durbin-Watson**	**1.304202**	

Testing the assumptions

- **White's test for heteroskedasticity**
  - Null hypothesis: Heteroskedasticity not present
  - Test statistic: TR^2 = 4.621061, with p-value = P(Chi-square(5) > 4.621061) = 0.463851

- **Multicollinearity test**
  - Values > 10.0 may indicate a collinearity problem
  - POL_CHANGE_lnY   1.455
  - POL_LY_W_F   1.455

- **Test for normality of residuals**
  - Null hypothesis: error is normally distributed
  - Chi-square(2) = 3.720. with p-value 0.15564

- **Breusch-Godfrey test for autocorrelation up to order 4**
  - Test statistic: LMF = 2.748114, with p-value = P(F(4,22) > 2.74811) = 0.0541
  - Alternative statistic: TR^2 = 9.662246, with p-value = P(Chi-square(4) > 9.66225) = 0.0465
  - Ljung-Box Q' = 14.6516, with p-value = P(Chi-square(4) > 14.6516) = 0.00548