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Edited by Jan Frait

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SYSTEMIC RISK IN POST-CRISIS FINANCIAL MARKETS

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* The views presented are those of the authors and not necessarily those of the Czech National Bank or other non-academic institutions.

Foreword

The global financial crisis that started in 2007 represented a striking example of underestimating risks of systemic nature. Both the academic research and the financial market regulation had overly focused on individual institutions' risks in pre-crisis years. However, they had underestimated the risks across individual markets and financial institutions as well as their potential impact on asset prices. Moreover, risks were underestimated in terms of the macro-economically and financially stable economic environment, i.e. low-volatility and prosperous economic environment. This had resulted in strong risk appetite, and low risk aversion leading to overly low risk premiums, consequently causing optimistic expectations with regard to the future development of returns and general economic performance.

Both international and national authorities responded to global financial crisis by plethora of regulatory changes. Systemic risk was acknowledged and macroprudential policies were instituted (for details see Frait et al., 2016). The contribution of this book is the proposal for the framework for the application of macroprudential policy tools in practice. It applies primarily to the countercyclical capital buffer (Chapter 2) and liquidity regulations (Chapter 3). Next, the book focuses on the new sources of systemic risks that emerged pro the policy responses to the global financial crisis aftereffects. It concerns primarily accommodative monetary policies of central banks. These new sources of systemic risks have become apparent only recently and new research on their substance and the ways of mitigation is needed (Chapters 1, 4, 5, 6). And finally, although the regulatory and economic/political response to the crisis addressed number of issues, it likely failed to address the sources of systemic risk stemming from the non-banks. We start from the observation that the regulatory overhaul focused primarily on the banking sectors opening thus avenues for systemic risk in other sectors. We therefore investigate in to risks in insurances, pension funds and investment funds (Chapters 1, 7, 8 and 9).

The book is structured as follows. Chapter 1 describes the sources of systemic risk associated with indebtedness of both private and public sectors and with cyclical patterns in provision of financial services. Chapter 2 focuses on the ways of detecting credit cycles and on approaches to setting countercyclical capital buffer in banking sector. Chapter 3 turns attention from credit risk to liquidity risk in banks and the approach to its testing. Chapter 4 describes developments of monetary policies in advanced economies after the crisis that contribute to sources of systemic risk. Chapter 5 looks at the risk of contagion in the foreign exchange market while Chapter 6 explores risks associated with the transition to fixed exchange rate regimes. Chapter 7 investigates into the measurement of credit risk using the data from capital markets. Chapter 8 studies the behaviour of insurance-linked securities and Chapter 8 sums up the sources of systemic risk in insurance sector.

This book can be of interest of researchers, university teachers, financial analysts and policy makers. It is the output of research activity supported by The Czech Science Foundation with project no. 16-21506S *New Sources of Systemic Risk in the Financial Markets*. Some chapters deliberately provide simplified and less technical presentation of research outputs so that we can address broader group of readers. We note that everything contained in this book represents their own views and not necessarily those of the institutions where they are employed. All errors and omissions remain entirely the fault of the authors.

Jan Frait (editor)

Prague, 1st December 2019

Content

Chapter 1

Debts, financial cycles and systemic risks

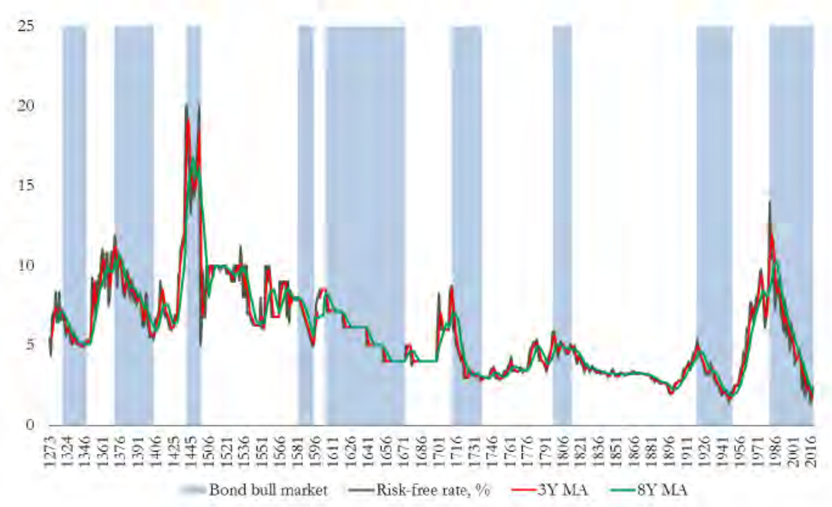
By Jan Frait

In response to the global financial crisis (GFC) that started in 2007, both international and national authorities initiated number of regulatory changes. These were addressing primarily the risks generated in the banking sectors and to some extent at the insurance industry and capital market. In particular, the Basel Committee on Banking Supervision (BCBS) introduced number of reforms to the international framework for measuring and mitigating solvency, liquidity, and market risks. Besides regulatory changes for functioning of individual institutions, macroprudential policies were instituted to address systemic risks (for details see Frait et. al (2016). The GCF has had dire consequences for macroeconomic dynamics and stability of global economy, the advanced economies in particular. Weak demand, partially associated with high indebtedness in number of economies, contributed to strong disinflationary pressures. Central banks have responded by exceptionally accommodative policies that created environment of exceptionally low interest rates (Section 1.3). Despite it, economic activity in most advanced economies remained subdued and disinflation pressures persisted. This chapter deals with the potential of adopted policies to create potential sources of systemic risk. It also discusses the risk of Japanisation of European economy and its financial sector (Section 1.2).

1.1 Introduction

Besides setting monetary policy rates to levels close to zero or even below, some central banks responded to post-GFC environment by quantitative easing that resulted in depressing long-term interest rates and yields of financial assets to exceptionally low levels (Chapter 5). Credit spreads and risk margins have been often depressed too. What originally appeared to be a temporary environment related to the necessary response to the GFC has become a longer-term structural factor. Liquidity injections, asset market purchases of public and private debt by central banks, exceptionally low nominal interest rates, and often negative real interest rates, supported global liquidity generation and "search for yield" (Shin, 2013). The outcome has been strong demand for riskier financial assets, residential and commercial real estate. Higher demand for foreign assets in advanced economies enabled large nonfinancial companies from advanced and emerging economies to tap large funds through corporate bond issues. Easy access to, and the low cost of, loans for house purchase, coupled with expectations of continued growth in house prices, have created a potential for spiralling between property prices and loans for house purchase. All this contributed to spreading of systemic risk in global financial system.

Figure 1–1 Historical development of world nominal interest rates
(in %)



Source: Schmelzing (2017)[1]

The understanding that the interest rates could stay very low for a long time globally owing to strongly accommodative monetary policies of the major central banks and other major central banks lead to intensive considerations how to combine monetary policy instruments with macroprudential policy tools so as to attain its price stability and financial stability objectives simultaneously. A fierce debate on the interaction of monetary and macroprudential policies erupted first in 2013 in connection with the accommodative monetary policy being pursued by the Federal Reserve, the ECB and the Bank of England coupled with a strong recovery in property markets and some financial market segments. Official commentaries were published on the contribution of the sustained easy monetary

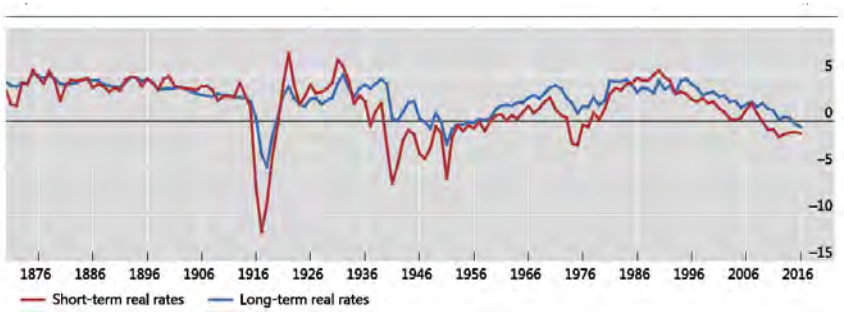
[1] This study provides a new and highly valuable dataset for the estimates of annual risk-free rate in both nominal and real terms going back to the 13th century. It also comes out with a bit speculative conclusion that there is a declining trend of nominal interest rates lasting centuries. The discussion of the conclusion goes beyond the scope of this chapter.

conditions to inflated prices of houses and some other assets, the greatly increased activity on the corporate bond market, inadequate risk assessment and the compression of yields on debt securities (BIS, 2014, p. 3). The prevailing conclusion of this debate was that the potential undesirable effects of easy monetary policy on the risks to financial stability could be largely mitigated by applying suitable macroprudential tools in good time. However, concerns were voiced that more aggressive use of such tools could neutralise the effects of accommodative monetary policy and foster deflationary pressures. The debate has not been resolved up now.

1.2 Low interest-rate environment and prospects of Japanisation

Nominal interest rates went to historical low levels in recent years (Figure 1–2). As to the real interest rates, there where periods characterized by lower rates compared to recent years. These were, however, present in war-time or post-war periods (owing to high inflation) or during the oil-induced inflationary shock in 1970s. In other words, we currently have post-war interest environment without a war.

Figure 1–2 Historical development of world real interest rates
(in %)



Source: Borio et al. (2017)

Sharp decline in government bond yields occurred over summer 2019.[2] The whole yield curve of German government bonds slipped to negative territory. Both government and private bonds equivalent to 18 bn. USD globally recorded negative yields. There were also plus expectations of short rates staying negative for a long time. All this lead to fears of Japanisation (or Japanification) of European economy and its financial sectors. Despite some increase in yields since such fears persist. According to popular and a bit misleading view "Japanification is the term economists use to describe the country's nearly 30-year battle against deflation and anaemic growth, characterised by extraordinary but ineffective monetary stimulus propelling bond yields lower even as debt burdens balloon" (Financial Times, 27 August 2019).

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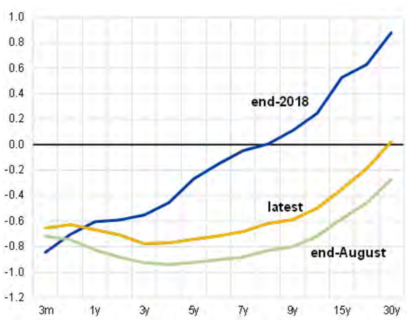
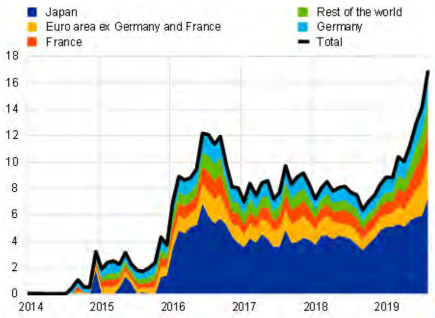
[2] The ECB's September 2019 statements raised expectations of a continued policy of zero or negative monetary policy rates in the years ahead and increased quantitative easing.

Figure 1–3 Yield curve of German Bunds in August 2019
(in %)



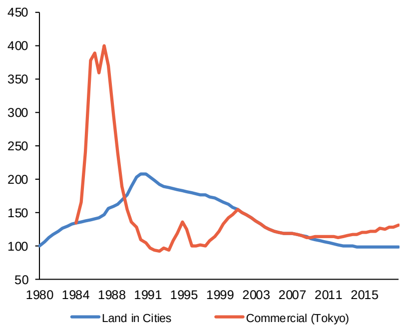
Source: ECB

Figure 1–4 Stock of bonds with negative yields
(in bn. USD)



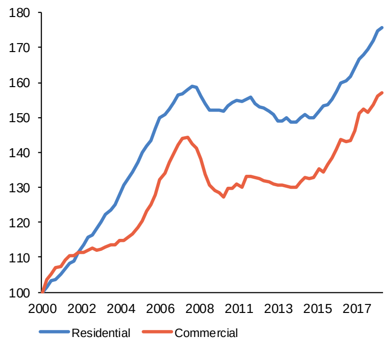
Source: ECB

Figure 1–5 Property prices in Japan



Source: BIS

Figure 1–6 Property prices in EA



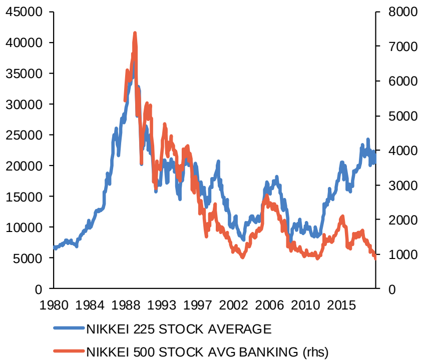
Source: BIS

Our comparison of Japan (1980s onwards) and euro area (2000 onwards) presented below shows that there are some common trends as well as major differences. Japan went through major bubbly boom in 1980s followed by spectacular bust. Drastic downward correction of perceived wealth[3] owing to asset prices collapse (Figures 1–5 and 1–7) contributed to decline of private sector demand. Firms and households responded to the shock by attempt to correct their balance sheet by saving more and lending less leading to balance sheet recession (a term popularized by economist Richard Koo). Monetary policy response initially cautions with no intention to restore previous asset prices levels and bail-out investors. Highly accommodative fiscal policy maintained aggregate demand.

[3] Wealth losses up to 2007 achieved 300% of initial yearly GDP.

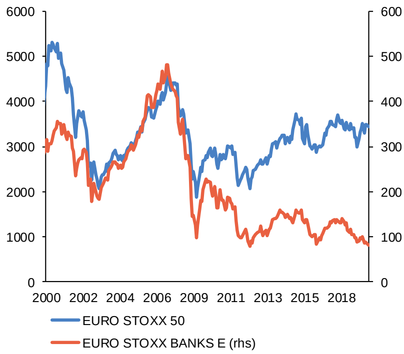
Euro area enjoyed bubbly boom after 2003 followed by a major shock to some economies after 2008. Asset prices were in most countries affected partially and temporarily (Figure 1–6). Monetary policy responded to the shock vigorously, private investors were often supported by public policies. Aggregate demand management has been done primarily through monetary policy while fiscal policies involvement only selective.

Figure 1–7 Stock prices in Japan



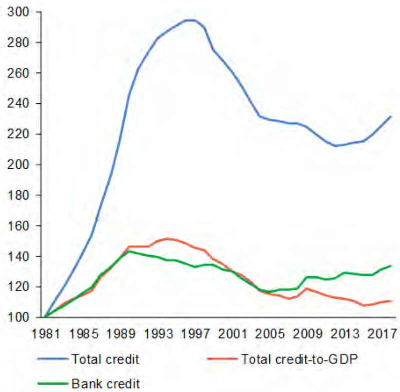
Source: Bloomberg

Figure 1–8 Stock prices in EA



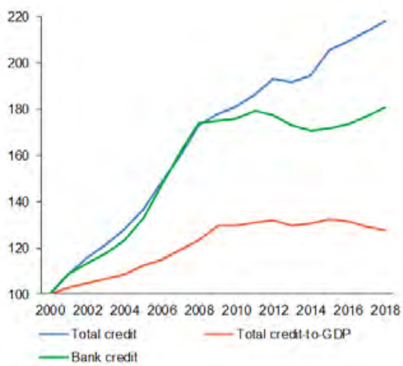
Source: Bloomberg

Figure 1–9 Credit to private non-financial sector in Japan



Source: Bloomberg

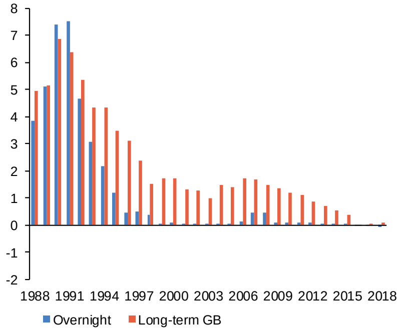
Figure 1–10 Credit to private non-financial sector in EA



Source: Bloomberg

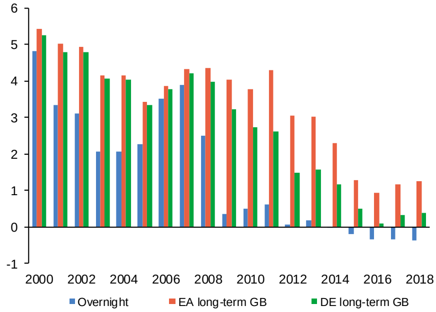
In Japan, property prices as well as stock prices in Japan never got back close to boom levels (Figures 1–5 and 1–7). In euro area current property prices often exceed peak levels in most cases thanks, among other things, the ECB policy. Stock prices recovered quite well (Figures 1–5 and 1–7) with the exception of the bank stocks that scored badly like in Japan. Japan experienced strong deleveraging with the non-financial firms' net borrowings negative for a long time (Figure 1–9). Deleveraging in euro area occurred in some countries only and was only mild (Figure 1–10). Japan's current consumer price level is only marginally higher than in 1990s owing to deflation in number of years. The euro area price level has been steadily growing, just slowly than implied by the ECB target.

Figure 1–11 Nominal interest rates in Japan



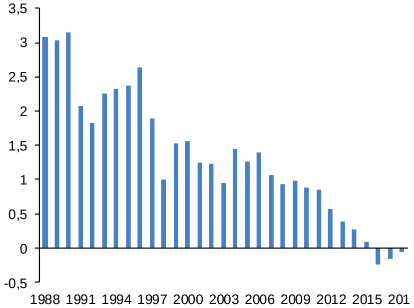
Source: Fred

Figure 1–12 Nominal interest rates in EA



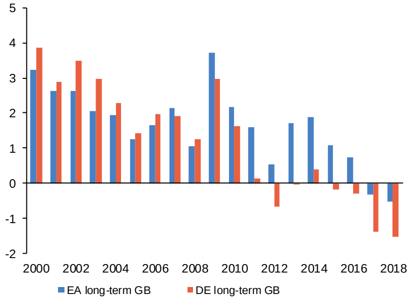
Source: Fred

Figure 1–13 Long-term real interest rates in Japan



Source: Fred

Figure 1–14 Long-term real interest rates interest rates in EA



Source: Fred

Note: Real interest rates based on CPI inflation, measured on ex post basis.

What is striking that interest rates and government bond yields were positive or close to zero most of the time in Japan while in the euro area the interest rates and some government bond yields (such as German) turned negative earlier than in Japan Figures 1–11 and 1–12). And Japanese real long-term bond yields were positive even during deflationary period, and turned negative after the GFC only

(Figures 1–13 and 1–14). In euro area the real rates and some bond yields were particularly low even during the pre-GFC boom. It could thus be justified not to talk about Japanisation of the European economy, but about Euroisation of Japan economy. Unfortunately, despite all differences, both economies slipped to sustained slow output growth. The "low-for-long" scenario used in international institutions' analyses in previous years can thus continue to be materialising.[4]

1.3 Risks stemming from low interest rate environment

The environment of low interest rates and yields is fostering a reduction in the risks stemming from the economic slowdown in the short term. In the medium term, however, the risks to financial stability – especially in the form of overvalued prices of market assets due to reduced risk premia and increasing indebtedness – are growing in this environment (Section 1.4). The low interest rates are creating favourable conditions for borrowers, as reflected in a drop in debt service costs. However, the low rates are simultaneously giving an impression of easy debt service and encouraging the acceptance of higher levels of debt. Both government and private sector debt are at historical highs in many countries. Significant debt growth has been recorded by emerging economies, China and selected euro area countries. High debt and a potential sizeable rise in losses on loans taken out in the optimistic phase of the cycle currently represent the main risk to global financial stability.[5] Potential economic slowdown and drop in borrowers' incomes, and the related deterioration in their ability to repay accumulated debts, could be the primary trigger of the materialisation of this risk.

An environment of very low interest rates can jeopardise the financial stability of individual financial market segments via two channels. The first is its negative effect on the profitability and, in turn, the resilience of financial institutions. The second is the resulting search for yield, reflected in investment in riskier assets, growth in leverage and concentration, more intense sectoral interconnectedness and hence greater vulnerability of the financial sector. Both channels may create – to a certain degree spurious – impulses for a shift from a banking-based financial system towards capital markets and to migration of financial activities into less regulated segments, which are generally more sensitive to market shocks.

This interest rate environment – reflected in a flat yield curve – squeezes banks' profitability via a decline in net interest rate margins. This applies especially to countries in which interest rates on client deposits are zero or even negative. In such a situation, banks often cannot respond to a drop in interest rates on loans by lowering their deposit rates. For many European banks, the room for cutting funding costs will be limited by the obligation to acquire further eligible liabilities to comply with the MREL requirement and raise regulatory capital.

[4] The ESRB's November 2016 report *Macroprudential policy issues arising from low interest rates and structural changes in the EU financial system* and the July 2018 analysis *Financial stability implications of a prolonged period of low interest rates* prepared by the Committee on the Global Financial System operating under the BIS in Basel.

[5] IMF (October 2019*): Global Financial Stability Report: Lower for Longer.*

Banks can try to reduce their operating costs, but this has its limits. Another option is to increase the volume of remunerated assets. However, this is difficult to do in economies where sectors are so indebted that demand for further loans is weak. Banks can partially relax their credit standards and invest in more profitable but potentially riskier assets. However, holdings of such assets are significantly limited by regulatory measures. The lower incentive to write off problem loans has an indirect negative impact on banks' profitability in the longer term. Cheap financing allows banks to hold such loans in their balance sheets for longer, but at the expense of new and potentially more lucrative clients.

Life insurance companies and pension funds providing defined benefit pension plans with guaranteed returns face similar risks. Their assets may have a shorter maturity than their liabilities, so a decline in interest rates increases the present value of liabilities more than that of assets. Specifically, this means that plans concluded 20 years ago, for example, were based on an assumption that government bond yields would fluctuate around 4%. If the environment of very low yields persists for an extended period, some providers of defined benefit pension plans may run into solvency problems, although more probably in the longer term. This risk is marginal for some European countries (such as the Czech Republic) but high for others. If it were to materialise, the problems could spill over to other sectors and cause a lack of confidence in the stability of the financial system as a whole. In addition, the current interest rate environment is discouraging financial institutions from providing products with guaranteed returns and generating incentives to transfer risks to clients.

The low interest rates are forcing insurance companies and pension funds to make riskier investments. As higher-yield bonds mature, they are having to choose between safe assets with low yields and assets with higher yields but riskier profiles. The share of funds invested in property, especially commercial property, is rising in many countries. The increased property exposures, which can be observed in almost all sectors, also mean higher exposures to credit, market and concentration risks. Property exposures are sensitive to changes in economic activity, interest rates and market sentiment. They are often subject to an increased risk of price overvaluation and a subsequent marked correction. If institutions were to suffer substantial losses, this could create a need for support using public finances. The costs would be borne mainly by the younger generation.

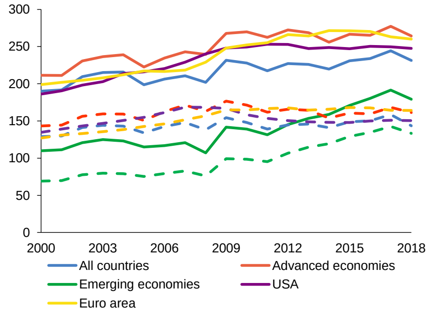
Investment funds are reacting to the decline in yields on safe assets by purchasing higher-yield investment-grade or speculative-grade corporate bonds and investing in alternative assets (property, private capital funds, funds investing in infrastructure assets etc.). The market liquidity of these assets is often low or uncertain. The share of highly liquid assets in portfolios is thus decreasing. In the event of a strong financial shock, many funds would probably have problems redeeming shares. Pressure on central banks to stabilise the situation could be expected to emerge. If investment funds were forced to react to requests to redeem shares by selling off assets on a larger scale, this could cause a drop in their prices and a spillover to other sectors. This risk also pertains to life insurance companies.

The existing recommendations for mitigating these risks are rather general. They focus mainly on strengthening the resilience of the riskiest segments through higher capitalisation and various types of buffers. In the case of banking, they concentrate on the use of macroprudential instruments to prevent a build-up of systemic risk. However, instruments for mitigating specific risks in the non-bank sector are mostly in the initial discussion phase. This is rather problematic since even after the GFC, the global financial system remained highly complex and interconnected. These qualities arise from mutual relations among individual entities of the given system that act as financial transaction counterparties. The complexity of the system translates into systemic risk, since interconnections within such system increases and individual effects may be mutually reinforcing. The substance of systemic risk consists in simultaneous adverse development of constituents within a financial system and subsequently within the real economy. The systemic risk arises from co-dependence[6] of potentially feasible individual risks and/or idiosyncratic events of the system agents (financial institutions, markets, products, and infrastructures).[7]

[6] Co-dependence in linear perception could be described as correlation; however, to consider co-dependence in linear perception would be inaccurate when talking about systemic risk.

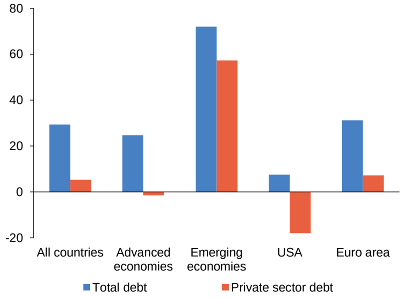
[7] Ceccheti et al. (2010) liken systemic risk to (negative) externality, such as pollution, as it occurs due to activities of certain entities and is transferred to other entities. It may take two forms: (i) joint bankruptcy of institutions within a certain period of time, due to their joint exposure to the same risks or due to mutual ties of intermediaries; (ii) procyclicality – it can be described as mutual interaction of the real economy and the financial system, multiplying each other, thereby contributing to cyclicality (boom and bust cycles) – potentially endangering stability of both the financial sector and the real economy.

Figure 1–15 Non-financial sector debt after 2000 (% of GDP)



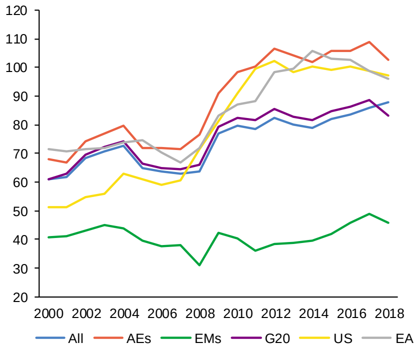
Source: BIS
Note: The solid lines denote total debt (including the government) and the dashed lines private non-financial sector debt.

Figure 1–16 Changes in non-financial sector debt (2008–2018, p.p.)



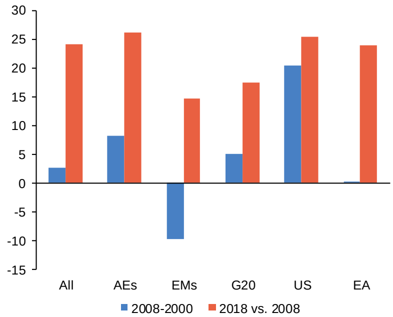
Source: BIS
Note: The data are for 43 countries covered by credit statistics available on the BIS website.

Figure 1–17 Total general government debt (in % of GDP)



Source: BIS
Note: Calculated indirectly as difference between total NF

Figure 1–18 Changes in general gov. debt levels (in p.p.)



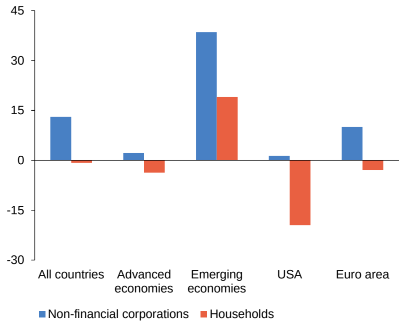
Source: BIS
Note: Calculated indirectly as difference between total NF

The financial system structure is not static constant, but it changes and forms over time – also as a consequence of financial innovations. There surely could be some welcome innovations even in the financial sector. Nevertheless, one can also find plenty of bad innovations in the financial industry in this and previous centuries. One particular area of systemic importance is mortgage financing. Dubious approaches like interest only schemes, deferred payment of interest and principle, extensive stretching of maturities and even not amortized mortgages. Their final outcome was that people that were buying houses and flats were taking much higher loans leading to high indebtedness and vulnerability to increase in debt-servicing costs. Altogether it created systemic risk with dire consequences in some countries. The high indebtedness of private sector, especially households, may have created a very challenging environment for monetary policy or other policies, or these policies even could be jointly trapped.

1.4 Debts and savings after the GFC

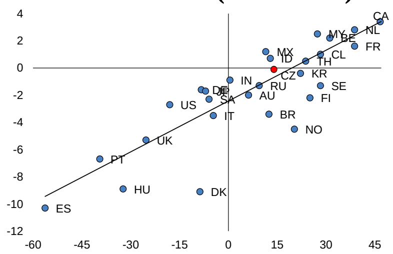
It was assumed that accommodative monetary policies would enable the private sector in particular to reduce its debt, which was regarded as one of the major causes of the crisis. Ten years on, we can say that no overall decrease in debt has been observed in advanced or emerging economies (Figures 1–15 and 1–16).[8] Advanced economies have mostly seen an increase in government debt, which in most of the countries has exceeded the stagnation or decline in private debt (Figures 1–17 and 1–18). In emerging economies, private sector debt has increased significantly. A reversal of the rising debt trend has occurred in recent years owing to higher economic activity being reflected in faster nominal income growth.

Figure 1–19 Changes in the debt of households and non-financial corporations (2008–2018)



Source: BIS
Note: The data are for 43 countries covered by credit statistics available on the BIS website.

Figure 1–20 Changes in the debt and debt service of the private non-financial sector (2008–2018)



Source: BIS
Note: The data are for 32 countries covered by debt service statistics available on the BIS website. Debt and debt service are expressed as a percentage of GDP. The Czech Republic is plotted in red.

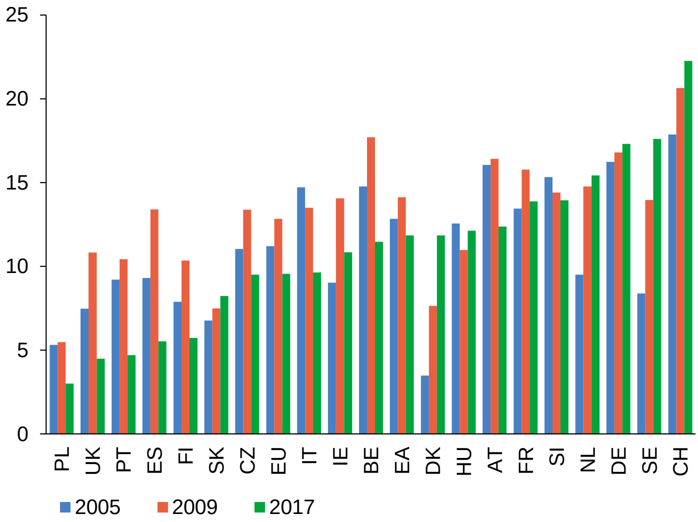
The debt trends have differed substantially across the countries monitored and between the sectors of households and non-financial corporations. In many advanced countries, including the USA, write-offs of non-performing loans after the global crisis, falling property prices and macroprudential measures focused on mortgage loans have been reflected in a decline in household debt (Figure 1–19).

[8] The data are from credit statistics available on the BIS website https://www.bis.org/statistics/ about_credit_stats.htm.

By contrast, cheap and available funding has motivated the corporate sectors in many countries to increase their leverage (Figure 1–19). In addition, private sector growth was replaced by public sector debt (Figures 1–17 and 1–18). Differently from the pre-GFC decade, the rise in private non-financial sector debt has often not been accompanied by a rise in debt service (Figure 1–20). On the contrary, debt service has fallen significantly in some of these countries (Figure 1–20, bottom-right quadrant). The main reason is a decrease in interest rates.

The low level of real interest rates and associated rise in debt levels is often explained by global savings glut (Bernanke, 2005). Should it be the case, the recent developments should not be viewed as an important source of risk. The data on household savings are generally available with some delay and are more reliable that the data on corporate savings. One of the reasons is that the household savings are typically the main domestic source of funds to finance capital investment, which is a major impetus for long-term economic growth. Still, saving rate indicators have to be assessed with caution since they often have residual features, may not be comparable across economies and are subject to major revisions. Looking at the data on households' gross rate of saving from disposable income (the portion of their disposable income that is not used for consumption), the European countries do not fit well into the story above (Figure 1–21).

Figure 1–21 Gross saving rates of households in EU countries
(% of gross disposable income)



Source: Eurostat

The decrease in saving rates in many countries in recent years can be considered risky from the long-term perspective. Household savings are one of the main sources of financial investment in the real economy, which is a key factor of economic growth. Besides their wealth, households generally use a substantial portion of their savings to buy and maintain owner-occupied housing. In particular, if house prices rise faster than households' income, the investment rate in the household sector may exceed the saving rate for a time. In such a case, households draw on the savings they have accumulated in the past, the savings of other sectors, or foreign sources. In cases where households invest largely in "overpriced" properties, inefficient utilisation of savings may occur. This, in turn, is usually reflected in sharp macroeconomic volatility and structural distortions in the economies concerned. Correctly conducted macroprudential policy helps to prevent such episodes from becoming excessive.

1.5 Conclusions

The response of most central banks in advanced economies to weak demand and disinflationary pressures after the GFC has created the environment of ultra-low interest rates. The side effect of this environment consists of the growth of asset prices and creation of incentives to invest into real estate and other risky classes of both real and financial assets. Asset price boom associated with increase in private and public sectors' debt could under some circumstances lead to bust ending up in massive loss of perceived wealth, balance-sheet recession and further drop in demand. Aggressive monetary policies attempting to avoid Japanese-lie scenario may thus at the end produce it. Having this in mind, there is growing reliance of advance economies on the active use of macroprudential policies. Some countries set relatively high countercyclical buffers and use the LTV, DTI and DSTI limits for limiting the risks associated with mortgages. The capital add-ons for systemically important banks have also become standard.

Central banks have price stability and financial stability objectives. For meeting them they have monetary policy and macro prudential policy tools at their disposal. Number of people in the central banking community and even more in academia think that each policy should be used fully separately to meet its specific objective. Nevertheless, once we start to think about transmission mechanisms of these policies, we will likely conclude that these policies are not independent, they are interlinked. Anything that affects the availability and price of credit (or assets in general) also affects the growth rate of these assets, their quality and profitability. Changes to both monetary policy tools and macroprudential tools act via channels working through credit supply and demand, the risk-taking of economic agents, the asset prices, the perceived actual and expected bank credit risk or the banks' profitability.

In some situations, the two policies can come into conflict because of a need for them to work in opposite directions, while in other situations it may be desirable for them to act in the same direction. Being aware of such connection, some central banks such as the Czech National Bank decided to set a framework for coordination of these policies (Frait et al., 2014). However, there are some other situations in which it is not that easy to coordinate and even find a proper mix. It is because the mix depends on the properties of two cycles, the financial cycle and business cycle. And because these cycles are rather different, sometimes is very difficult to tell what is the best approach or least problematic approach (Malovaná and Frait, 2017). The typical situation of this sort is right now in Europe. The prevailing view in the central banking community these days is that ultra loose monetary policies are necessary. As they produce risks, the macroprudential policy tools should do the job, prevent excessive credit growth and asset prices misalignments. The calls for a more holistic approach were played down for years. However, under the volatility and uncertainties that emerged in 2019, this view has become to be adopted more generally.

The complicating factor for number of economies is the high level of private and public debt. Very low interest rates help to keep debt servicing cost easily manageable. However, even relatively small increase in the level of lending rates could lead to much higher default rates, decline of consumer lending and disinflationary pressures. This also means that the protracted period of low interest rates could be self-enforcing. If this environment enables emergence of high debt, the central banks will get under pressure to keep policy rates low, because otherwise their economies would find at a risk. Also, in countries with high level of debts, macroprudential policy could become unwittingly a substitute for monetary policy. And if the central bank is not the macroprudential authority, and if such authority is constrained by political considerations, a trap may emerge.

And finally, the macroprudential policies could mitigate some risks, not all. Current macroprudential tools are developed for building buffers in banks and limiting residential real estate risks. Tools for mitigating the commercial real estate risks or the risks from other asset classes are untested or non-existent. Tools for life insurances, pension funds and investments funds are at the initial stage or developments. Further research in these areas is therefore much needed.

Chapter 2

Detecting credit cycle and setting countercyclical capital buffer

By Jan Frait, Jan Hájek and Miroslav Plašil

In the aftermath of the global financial crisis, the importance of the objective of financial stability across the world increased dramatically. Besides increased interest in financial stability analyses, the whole institutional framework of maintaining financial stability was strengthened by instituting the macroprudential policy. The main aim of this policy is to mitigate systemic risk, i.e. the risk of instability of the financial system as a whole.

Basel III regulatory framework established as one of the key macroprudential instruments in the banking sector a countercyclical capital buffer. This instrument is designed to reduce the consequences of worsened access of firms and households to banking credit in bad times. This chapter proposes comprehensive approach to the countercyclical capital buffer using the experience of the Czech National Bank. It describes its decision-making process from assessing the position of the economy in the financial cycle through detailed analysis of particular risks to setting the buffer rate. The approach that can be labelled discretion guided by multiple-factor analysis builds upon the signals from both individual and composite indicators of financial cycle and systemic risk. The chapter then describes the factors that the macroprudential authority takes into account when setting the specific countercyclical capital buffer rate.

2.1 Introduction

The countercyclical capital buffer (CCyB) is a pure macroprudential policy tool. It is designed to protect the banking sector against risks arising from its behaviour through the financial cycle, and in particular from excessive credit growth, which generates systemic risks and increases the potential for sharp swings in economic activity. A macroprudential policy authority should ensure that banks create a capital buffer during the financial expansion to enable them to absorb losses in the event of an adverse shock accompanied by elevated financial stress and growth in loan defaults. Use of the buffer at such a time should prevent a fall in the supply of credit to the sound part of the economy and stop the shock spreading from the financial sector to the real economy and causing the banking sector further losses.

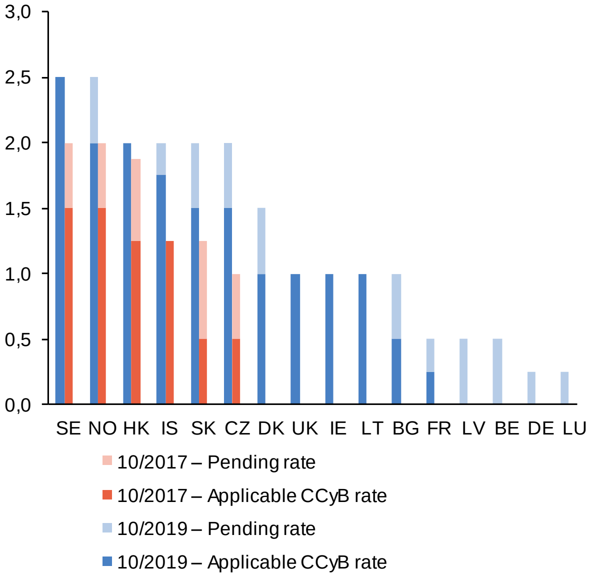
At first glance, the CCyB is a very simple tool. In reality, though, setting the CCyB rate is a complex task in terms of both decision-making and communication. It can be particularly difficult to justify the specific level at which it is set. This chapter aims to present key aspects of the CNB's approach to setting the CCyB rate, contribute to better formation of expectations about the future path of the rate and thereby facilitate capital planning for credit institutions. The chapter is structured as follows. Section 2.2 summarises the essence and purpose of the CCyB, describes the BCBS/ESRB methodology and points out some issues with its application to the Czech economy. Section 2.3 introduces the main indicators used to determine the position of the economy in the financial cycle. Section 2.4 details the CNB's approach to setting the CCyB rate and discusses its decision-making process, which draws on stress test results and known facts about the morphology of the financial cycle. Section 2.5 briefly discusses the approach to releasing the CCyB. The section 2.6 concludes.

2.2 CCyB essence and the BIS/ESRB guidelines

The recent financial crisis revealed that stress in the financial sector can easily spread to other sectors of the economy. Faced with capital shortages due to losses, banks in some countries severely curtailed the supply of credit even to sound non-financial corporations (a situation generally referred to as a "credit crunch"). In response to these funding constraints, some firms had to cut their production substantially. This led to rising unemployment, falling household incomes and, in turn, to a deepening recession. Inadequate capital creation by banks in the upward phase of the financial cycle was thus reflected in a downward spiral where falling aggregate demand due to difficulties in raising funds for viable projects led to further credit losses and further lending constraints. In some countries, public money had to be used to resolve the crisis in the banking sector. This was reflected in growth in long-term interest rates and also adversely affected the real economy.

To avoid a repeat of the spill-over effects of such shocks from the financial sector to the real economy, a countercyclical capital buffer (CCyB) has been incorporated into the macroprudential policy toolkit (BCBS, 2010). The CCyB is aimed at "protecting" banks against excessive impacts of the financial cycle, which banks themselves are involved in creating. In the spirit of this regulation, banks are meant to set aside a sufficient buffer in good times – characterised by rapid credit growth accompanied by relaxation of credit standards and growth in property prices – to cover losses arising from the switch to the downward phase of the financial cycle.

Figure 2–1 Countries with non-zero CCyB rates
(% of total risk exposure, October 2019)



Source: BCBS, ESRB

The buffer should be released when risk materialises, so banks should be able to apply a reduced capital requirement to maintain the supply of credit to the sound part of the real economy. As adverse shocks can occur unexpectedly, the macroprudential authority can set a new CCyB rate with immediate effect when deciding to release the buffer.[9] The addition of a CCyB rate to the overall capital requirement may help tame credit growth in the expansionary phase of the financial cycle; however, this can be regarded only as a positive side-effect of the CCyB and is not the main purpose of creating the buffer. The primary objective is still to boost the banking sector's resilience to adverse shocks at times of financial instability and to ensure smooth funding of the real economy through the financial cycle.

[9] There is no clear consensus across the economic community on whether the creation of a capital buffer will give rise to a reduction in the supply of credit by banks. Financial sector representatives often assert that higher capital requirements lead to a decrease in the supply of loans (see Admati et al., 2011). Based on an analysis of data for advanced countries, however, Gambacorta and Shin (2016) find that better capitalised banks have lower funding costs and are capable – especially in worse times – of lending more to the economy than banks with lower capitalisations. For that reason, efforts to constrain credit growth should not be the main motivating factor in CCyB rate decisions.

The CCyB is a new macroprudential tool and there is limited experience with its use so far. A limited number of countries have already set non-zero CCyB rate (Figure 2-1). A universally shared approach to the introduction of non-zero CCyB rates and the setting of their specific level has yet to emerge in the international regulatory community. Some macroprudential authorities view the CCyB as a tool that should only be applied in a strongly expansionary phase of the financial cycle when systemic risks are already clearly visible and tangible. Other macroprudential authorities prefer a more prudent approach in which the CCyB should be created right at the start of a credit recovery or at a certain level even in the neutral phase of the cycle.[10] Such approach is applied by the CNB as well. It repeatedly communicated that it was desirable to set a non-zero CCyB rate when cyclical financial risks are still close to their usual, standard levels and have not yet become significantly elevated. The aim of the standard rate concept is to ensure that the banking sector's resilience starts to be supported in a timely manner after the acute phase of a cyclical contraction, or even a financial crisis, has subsided. The CNB's detailed approach to setting and calibrating the standard CCyB rate is described in Plašil (2019).

The basic framework for applying the CCyB was formulated by the Basel Committee on Banking Supervision (BCBS) and subsequently introduced into EU regulatory practice through the CRD IV directive and its transposition into the Member States' national legislation. The European Systemic Risk Board (ESRB) further developed the core principles of the original framework in the form of a recommendation (ESRB, 2014). From the operational macroprudential policy-making perspective, though, the BCBS/ESRB methodology still represents only a very rough guide to when to introduce a buffer rate and what rate to set. For this reason, it needs to be further elaborated and tailored to the specifics of each national financial sector.

The BCBS/ESRB methodology can be summarised into four main steps (see the dark blue boxes in Figure 2-2). The first involves determining the deviation of the credit-to-GDP ratio from its long-term trend using the Hodrick-Prescott (HP) filter and then using that gap to set a so-called benchmark buffer rate. In the BCBS/ESRB methodology, this rate serves as a guide for setting the CCyB rate.[11]

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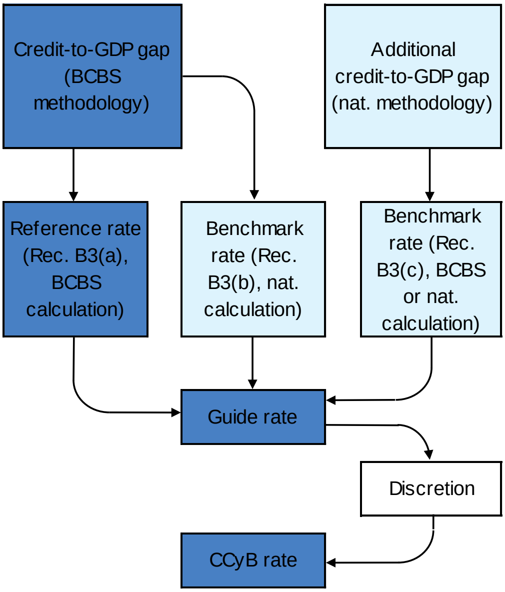
[10] An example might be the approach adopted in the UK. The local macroprudential authority (the Financial Policy Committee, FPC) reported that under normal conditions, when systemic risks are neither depressed nor elevated, the FPC will hold a rate of 1%. The FPC intends to adjust the buffer rate gradually to minimize the potential economic costs. By doing so, the FPC aims to reduce the probability of systemic risk rise to dangerous levels on one hand and on the other to allow banks to provide loans to households as well as businesses smoothly without major setbacks.

[11] Total credit comprises total loans to the private non-financial sector (households, non-financial corporations and non-profit institutions serving households) plus debt securities issued. The recommended smoothing parameter for the HP filter, λ, is 400,000. The benchmark buffer rate is 0% of risk-weighted assets if the gap is less than or equal to 2 pp and is greater than zero if the gap is larger than 2 pp. The equation used to calculate

EU Member States are required publish a credit-to-GDP gap and a benchmark buffer rate quarterly every time they set a CCyB rate. However, they are given discretion to calculate the CCyB guide rate using a different method not necessarily based on the BCBS methodology (see the light blue boxes in Figure 2-2).

Figure 2–2 The logic of the BCBS/ESRB regulatory framework for setting the CCyB rate



Note: Dark blue boxes indicate mandatory elements and light blue boxes voluntary elements of the ESRB (2014) methodology for setting the CCyB rate.

Source: BCBS, 2010, ESRB, 2014

This discretion is allowed because the original BCBS methodology would produce incorrect recommendations in many countries if applied mechanically (see, for example, Geršl and Seidler, 2011). This is true for the Czech Republic, where the use of this methodology would signal the need for non-zero CCyB rate from the start of the global financial crisis. This could be considered as dubious result as simple economic logic would suggest releasing the hypothetical buffer in case the crisis emerges (especially crisis of the extent of the one that spread out in 2008). A significantly non-zero benchmark buffer rate would also hold from 2011 Q2 and the maximum rate of 2.5% in 2013 Q2 (see the solid red line in Figure 2-3). During 2013, however, loans recorded only weak growth, property prices

the rate on the basis of the gaps is: benchmark buffer rate = 0.3125*(gap) – 0.625. The benchmark buffer rate is 2.5% if the gap is greater than or equal to 10 pp. The resulting benchmark buffer rate should be calibrated in steps of 0.25 pp or multiples thereof.

continued to fall in year-on-year terms (as they had done since 2009 Q1) and credit standards were tightened further. These conditions can hardly be interpreted as an expansionary phase of the financial cycle.

The main sources of the misleading results of applying the BCBS/ESRB methodology in the Czech economy are structural breaks in the time series related to the 1990s banking crisis, when bad loans were written off from banks' balance sheets. In addition, during early 2000s there was a structural change in the composition of credit to the private sector. Prior to period of the Czech banking crisis the main driver of the credit growth was credit to non-financial corporations whereas the main driver since then has been credit to households or related to housing.

In the case of other countries, misleading results would stem from different factors. ESRB provides the estimates of the credit-to-GDP gap data for all EU countries through ESRB Risk Dashboard since 2012. For the whole period, negative credit-to-GDP gap is estimated for most economies. The data in Figure 2-3 from December 2019 suggest that positive and significant gap applies for France, Germany, Sweden and Croatia only. Nevertheless, fast credit growth and expansionary stage of financial cycle are identified by authorities in number or countries including the Czech Republic. The credit-to-GDP gap thus provides a poor indication of desirable setting of the CCyB rate.

Figure 2–3 The credit-to-GDP gap and the hypothetical CCyB rate under the national and BCBS methodologies (CNB)

Source: ESRB Risk Dashboard, December 2019

Shifting from data-related issues, the use of the HP filter to determine trends in macroeconomic variables has some drawbacks as well. To begin with, a time series trend obtained by the HP filter is dependent to a significant extent on the length of the chosen time series and the calculation is very sensitive to the smoothing parameter (lambda). A big problem as regards practical application in macroprudential policy is the end-point bias, which generates a highly unreliable estimate of the trend at the end of the data period.[12] Macroprudential policy, which, by contrast, requires assessment of the trend on the basis of current (i.e. end-of-period) data, would therefore be reliant on indicators subject to a high degree of uncertainty. Moreover, in case of some economies characterized by relatively short time series (e.g. post-transition countries), the credit growth is automatically incorporated into the trend by the HP filter (Cottarelli et al., 2005). This implies the method's inability to take into account economic fundamentals which affect the equilibrium stock of loans.

There are other shortcomings from perspective of practical use. These are caused by unavoidable nature of the credit-to-GDP ratio because it fluctuates due to changes of both credit and GDP. In this sense, it might be quite difficult to interpret the underlying changes correctly. There are also considerable lags between changes in economic conditions and leverage adjustments. Another aspect is the filtering of credit-to-GDP may not be fully appropriate for converging economies or economies that previously experienced long-lasting credit boom. By filtering the trend in context of these economies, it is impossible to disentangle between financial deepening and credit bubble which is significant impediment.

The ESRB (2014) recommendation takes such cases into consideration and allows the gap calculation to be tailored partially to the specifics of the national economy. In line with this, the CNB calculates additional gaps that may be more appropriate for macroprudential decision-making (Hájek et al., 2017). One of these is a credit-to-GDP gap based on a shorter time series excluding the structural break that occurred in the 1990s. Another is based on the ratio of bank loans to GDP and disregards other sources of credit financing (unlike the BCBS/ESRB methodology). Restricting the calculation to bank loans is logical since the CCyB is a tool targeted at the banking sector and at ensuring stable bank lending.

In addition to gaps calculated using the HP filter, the authority can apply an alternative method for determining the deviation from the trend which eliminates some of the known issues with the said filtration technique. This method is based on analysis of local extremes in the time series.[13] This eliminates the problem of removal of old loans from banks' balance sheets after the late-1990s crisis and (unlike the HP filter) does not lead to changes in the trend estimate as new observations come in. The corresponding gap (referred to as the expansionary credit gap) is very different from the original signal and much closer to the true course of the financial cycle (see the solid blue line in Figure 2-4).

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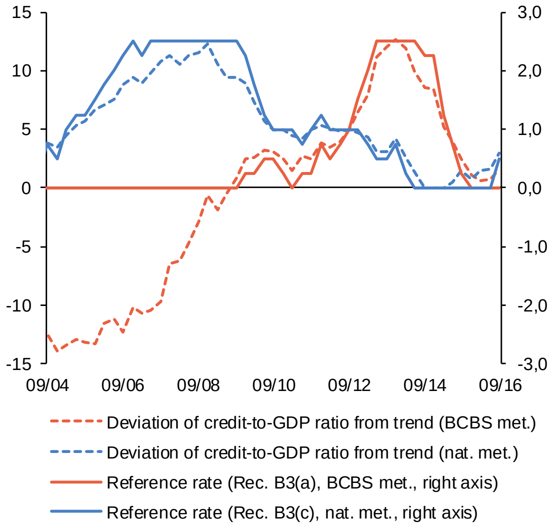
[12] One way of dealing with end-point bias is to extend the time series into the future by means of prediction. This, however, can introduce further uncertainty into the estimate linked with the quality of the prediction.

[13] To reveal extremes indicating credit expansion, the CNB uses the difference between the present value of the ratio and the minimum value achieved in the past eight quarters. Other time periods were tested but the results remained robust. This analysis is loosely inspired by the definition of the cycle proposed in Burns and Mitchell (1946) and by the unemployment recession gap (Stock and Watson, 2010).

Figure 2–4 The credit-to-GDP gap and the hypothetical CCyB rate under the national and BCBS methodologies



(deviation in pp; right axis: rate in % of RWA)

Note: The trend in the BCBS methodology is estimated using the HP filter, lambda = 400,000. The trend in the national methodology is estimated by analysis of local extremes.

Source: CNB

Regardless of the estimation technique, however, the credit-to-GDP gap can be only an initial guide to the position of the economy in the financial cycle. Although the credit-to-GDP ratio provides valuable information about indebtedness of the domestic private non-financial sector, there are several limitations that should be taken into account when drawing out conclusions for setting the CCyB rate. Probably the most important one is that credit-to-GDP is a lagging slow-motion variable staying above the historical norms during the initial stages of crisis. For example, a rapid decline in GDP during a recession increases the credit-to-GDP ratio and may indicate an excessive borrowing phase purely as a result of a more persistent credit cycle.[14] The credit-to-GDP ratio is therefore only a very rough measure of leverage in the economy, on the basis of which it is hard to identify turning points between phases of the financial cycle in a timely manner (for more details, see Frait and Komárková, 2012, pp. 14 and 22).

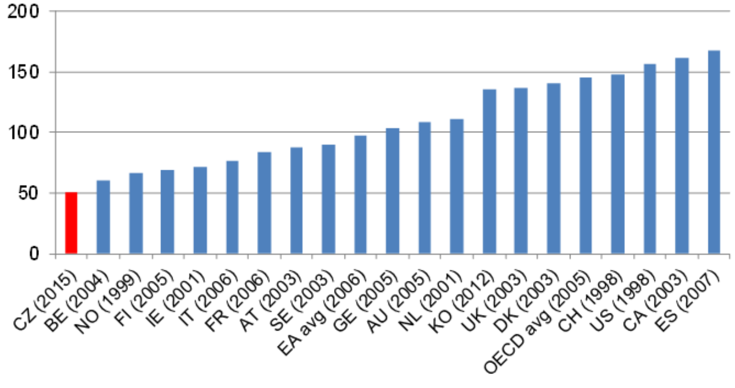
[14] The problem is partly mitigated if potential GDP, which is more stable, is used to calculate the credit indicator. However, the results for the Czech Republic are little changed in terms of identifying periods of excessive credit growth compared to the traditional calculation. For further details see Gersl and Seidler (2011).

2.3 Key indicators for the CCyB rate setting

For the reasons given in the previous section, the recommendation of the ESRB (2014) requires national authorities to take into account other variables indicating excessive credit growth and the build-up of system-wide risk when setting the CCyB rate. To this end, the macroprudential authority should use a wider range of indicators (including composite and simple indicators of financial cycle, credit dynamics and systemic risk changes) in order to answer several layers of fundamental questions. These questions investigate (i) whether the debt in the economy is too high, (ii) where we stand in the credit cycle, (iii) why amount of credit changes and (iv) what the appropriate CCyB rate is currently and what can be expected in the future.

To begin with, the question whether the debt in particular economy is too high or not, a cross-country comparison of combined debts of non-financial corporations and households could help. In such comparison, the Czech economy seems as the fourth least indebted country out of all EU member states, only Estonia, Lithuania and Romania has less indebted private sector. From a different perspective, the Czech Republic has lower level of credit-to-GDP than most advanced economies when compared at similar level of economic development measured by GDP per capita (Figure 2-5).

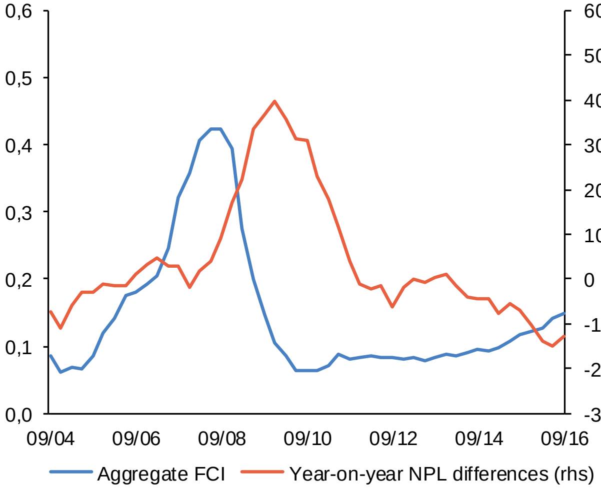
Figure 2–5 Credit-to-GDP for similar level of economic development
(GDP per capita, PPP current international USD, CZ 2015 = 32.000 USD)



Source: World Development Indicators, World Bank.

As to the stage in the financial cycle, the composite financial cycle indicator (FCI, Plašil et al., 2016) plays an important role in determining the position of the economy in the financial cycle in the CNB. The FCI was created in order to measure the accumulation of risks in the financial sector and to provide an early warning (6–8 quarters ahead) signal of the potential materialisation of such risks (see Figure 2-6). The FCI includes indicators covering a wide range of demand and supply factors which, according to earlier studies and expert judgement, well characterise the cyclical swings in financial risk perceptions.[15] Decomposing the FCI into individual factors allows the CNB to identify the determinants of the current evolution of the composite indicator and, where relevant, helps it choose the optimal macroprudential response.

Figure 2–6 The composite FCI and risk materialisation



(FCI value; right-hand scale: CZK billions)
Source: CNB

When determining the position in the financial cycle, the CNB also pays increased attention to the dynamics of bank loans with respect to both the stock (overall amounts) and flows (new business) of credit. The dynamics of the stock of loans provide information on the evolution of overall leverage, while the

[15] The indicators are credit growth, property prices, lending conditions, sustainability of the debt of non-financial corporations and households, asset prices and the adjusted current account deficit-to-GDP ratio. The IFC takes into account the changing cross-correlation structure and takes its highest values at times of rising synchronisation between all the input signals. The weights of the variables in the composite indicator are calibrated so that the indicator best predicts the loan impairment losses observed in the Czech banking sector (i.e. the risk materialisation phase).

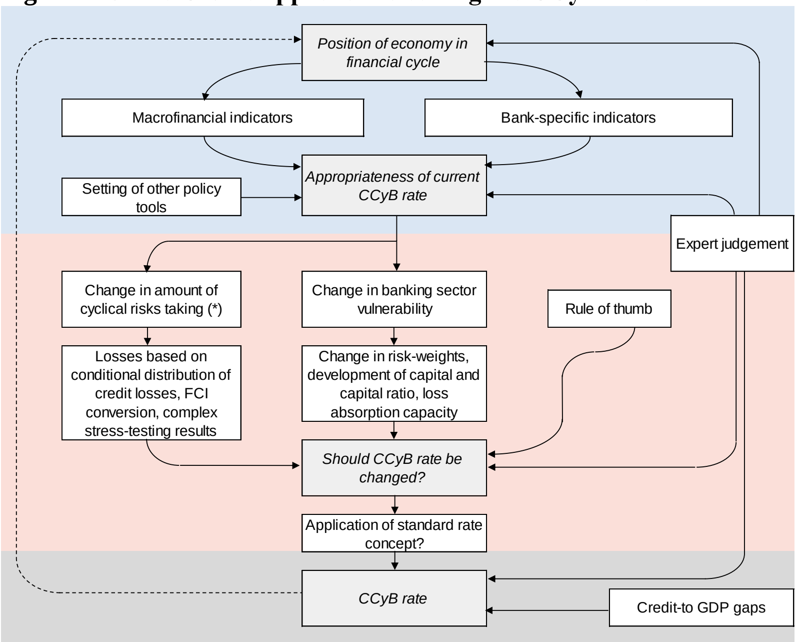
dynamics of new loans indicate current tendencies in risk-taking by households and non-financial corporations.

In addition to credit dynamics, the CNB focuses on other areas linked closely with lending, most notably the property market and the potential for a spiral between property price growth and growth in house purchase loans. Rising property prices can give the impression that the financial benefits of buying a house are increasing and can thus motivate other households to buy property financed by mortgage loans. Besides the annual rate of growth of property prices, the CNB tracks measures of overvaluation and sustainability relative to economic fundamentals (e.g. the price-to-annual wage ratio, the price-to-income ratio and other indicators presented in more detail in Hlaváček and Hejlová, 2015).

2.4 Deciding upon the CCyB rate

The CCyB rate decision-making process is largely formalised and has clearly defined rules. For the reasons described in detail in section 2, however, the CCyB rate cannot be set in a purely mechanical fashion. The CNB's approach is thus one of "guided discretion", requiring, in addition to regular assessment of the main indicators, a great deal of expert judgement on developments in the financial sector and the real economy. A similar approach to the CCyB setting is applied by other countries, such as Slovakia, Switzerland, Sweden or Norway.

Figure 2–7 The CNB's approach to setting the CCyB rate



Source: CNB

The entire process is illustrated in simplified form in Figure 2–7. In the initial phase, the CNB needs to judge whether the current CCyB rate is commensurate with the observed situation (the blue area in Figure 2–7). The CNB thus has to decide whether conditions in the economy necessitate the introduction of a non-zero rate and, if so, whether a tightening or easing of macroprudential policy is needed. This phase of the process is based on the CNB's assessment of the position of the economy in the financial cycle as well as other aspects such as the settings of other CNB tools whose effects might partially overlap with those of a non-zero rate. Given the complexity of the financial cycle, expert judgement is a necessary part of our considerations about the appropriateness of the current CCyB rate.

If the CNB concludes that the current CCyB rate is appropriate, it can confirm it at the current level. If, however, it feels that economic conditions call for a rate adjustment, be it a tightening or an easing, it moves to considering a change in the CCyB rate (the red area in Figure 2-7).[16] The aspects taken into account when changing the rate are described in more detail below in this section. Before the final decision is made, expert judgement enters the process once again, and the new CCyB rate is then set on the basis of all the available information (the yellow area in Figure 2-7).

Where application of the BCBS/ESRB methodology is not a suitable starting point for determining the rate (see above), other criteria must be taken into account in the decision-making process. The simplest guide for setting the rate is past historical experience and the known facts about the morphology of the financial cycle. The economic literature states that the average length of the financial cycle in advanced countries is around 15 years. The downward phase from the peak to the trough of the cycle is around half as long as the upward phase from the trough to the next peak (see, for example, Drehmann et al., 2012, 2013). Moreover, the upward phase can be divided into a recovery phase, when the subdued economy slowly emerges from the trough of the cycle, and an expansionary phase, when credit dynamics surge and systemic risk rises. The two phases are roughly equal in length (see Drehmann et al., 2012). On a general level, then, the observed historical experience implies that the economy is in the expansionary phase of the financial cycle for around five years on average. When there is a need to build up the CCyB during an expansionary phase, a simple rule of thumb based on the ratio of the assumed maximum rate (2.5%) to the assumed length of the expansionary phase (five years) can be used. This rule therefore states that the macroprudential authority should increase the CCyB rate by at least 0.5 pp in each year of the expansion phase. Despite being only a rule of thumb, this can be a useful guide for setting the rate given the difficulty of predicting a turning point in the financial cycle at a time when most indicators are not sending out negative signals.

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[16] CCyB rate decision-making here primarily refers to gradually increasing or decreasing the rate. The decision-making process on cancelling a non-zero rate in order to release the buffer can take the form of a rapid reaction to an unexpected shock or an event generating a risk to financial stability (see Figure 7 in Frait and Komárková, 2012, p. 22).

Another guide is based on the composite FCI (see section 2.3 for more details). Table 2-1 shows the indicative relationship between the FCI values and the CCyB rate. The presented relationship can be formally derived by adopting a set of assumptions, two of which exert a decisive influence on it. The first is that the maximum observed FCI value from the peak of the previous cycle in mid-2008 must correspond to a rate of 2.5%. The second is that the median of the sub-indicators entering the FCI calculation corresponds to a kind of "equilibrium" situation where the financial cycle is neither significantly subdued nor overheating. The FCI is constructed using a quadratic system of weights (for more details, see Plašil et al., 2016), so the relationship between the FCI values and the CCyB rate is non-linear. A consequence of this property is that the bands of FCI values are not necessarily of the same width for all the rates, and it does not hold that an increase in the FCI values leads to a proportional change in the rate.

Table 2–1 The indicative relationship between the FCI values and the CCyB rate

FCI values		CCyB rate
from	to	
0,00	0,09	0,00 %
0,09	0,11	0,25 %
0,11	0,13	0,50 %
0,13	0,16	0,75 %
0,16	0,19	1,00 %
0,19	0,23	1,25 %
0,23	0,27	1,50 %
0,27	0,32	1,75 %
0,32	0,37	2,00 %
0,37	0,43	2,25 %
0,42	1,00	2,50 %

Note: The financial expansion observed in the Czech economy just before the global financial crisis started was so strong that it would have necessitated setting the rate at least at the "upper limit" of 2.5% had the tool been available. For this reason, the historical maximum of the FCI is associated with a CCyB rate of 2.5%. The input data are normalised for the FCI calculation, so the historical FCI values constantly change as new data come in.

Note: The table is drawn up on the assumption that the CCyB rate would have been 2.5% during the last crisis. The input data are normalised for the FCI calculation. For this reason, the historical FCI values constantly change as new data come in.

Source: CNB

More formal approaches to setting the CCyB rate are based on the idea that the size of the CCyB should ensure that the total capital buffers are consistent with the potential losses that the banking sector as a whole may be exposed to in the event of future stress. A natural way of doing this is to link CCyB rate decision-making with bank stress testing. The crudest option is to compare the overall impact of the adverse shock with the sum of the capital conservation buffer (CCoB) and the CCyB. If the CCoB and the CCyB are not capable of absorbing the simulated decrease in capital at the sector level in the Adverse Scenario, the macroprudential authority may consider raising the CCyB rate to the level at which the capital buffers would be able to absorb it fully. The impact of the adverse scenarios in the CNB's macro-stress tests has fluctuated around 5 pp of the banking sector's capital ratio in recent years. If this rule were applied purely mechanically, this impact would imply a rate of 2.5% for both buffers. However, this is too crude an approach, among other things because it does not take into account the banks own prudent approach (e.g. provisioning). A more sensitive option is to compare the credit losses in the Adverse Scenario with the expected losses in the Baseline Scenario.

The point of the Adverse Scenario is to test the resilience of the banking sector to an exceptionally large and implausible stress. One could therefore argue that considerations about the CCyB rate should take into account the fact that the probability of such situations occurring varies across the phases of the financial cycle. For example, the probability of a crisis is much higher in a strongly expansionary phase of the cycle than when the subdued economy is just starting to recover. An estimate of the conditional credit loss probability distribution can be used for this purpose. In the case of the conditional distribution, the potential size of the losses (the variance and shape of the distribution) differs depending on the current phase of the cycle. In simplified terms, the risk of a crisis – and hence also the probability of greater cumulative losses in future – steadily increases as the economy moves into the expansion phase of the cycle. To ensure consistency with the most likely outcome, the conditional distribution is constructed in such a way that the expected size of the losses (the expected value of the distribution) always matches the losses in the Baseline Scenario.

Owing to the complexity of stress testing, the conditional loss distribution cannot be derived mathematically and must be estimated using simulation techniques. The principle consists in simulating a large number of alternative paths for the stress test input variables and calculating the corresponding cumulative losses for each of them. An empirical estimate of the probability distribution is then obtained by summarising the losses simulated in this way.

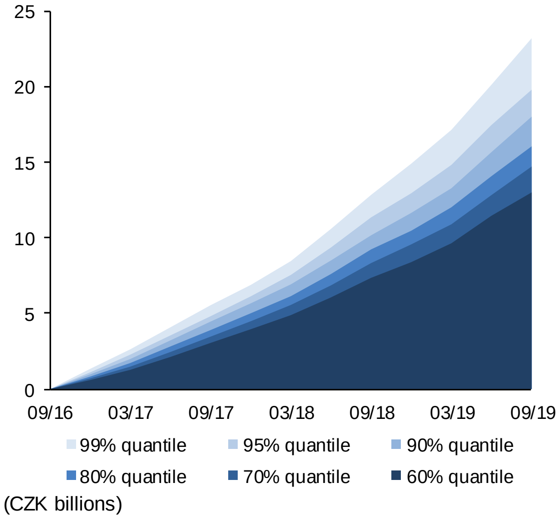
The technique for generating the alternative paths is based on the maximum entropy bootstrap method (see Vinod, 2006).[17] The size of the deviation of the simulated paths from the Baseline Scenario projection can be regulated by changing the settings of the input parameters of the chosen method. The degree of deviation is set by the CNB depending on the current phase of the financial cycle. The specific values of the time-varying parameters are obtained by solving an

[17] Unlike traditional bootstrap techniques, this method preserves the cyclical properties of the time series and is also suitable for directly simulating non-stationary series. A total of 1,000 bootstrap simulations with a time period of 12 quarters were performed for variables including PD, LGD and growth in bank loans for the sectors of non-financial corporations and households. The LGD values in the simulation are limited as follows: (i) non-financial corporations: 0.45–0.55; (ii) households – loans for house purchase: 0.2–0.3; (iii) households – consumer credit: 0.55–0.65.

optimisation problem taking into account, among other things, the size of the past differences between the losses in the Baseline Scenario and the actual losses.

When deciding on the rate, the macroprudential authority can then choose its own level of sensitivity to unexpected events. Like most macroprudential and supervisory authorities in other advanced countries, the CNB prefers a prudential approach, i.e. it tries to ensure that there are sufficient buffers in place to cover even relatively unlikely credit losses. This corresponds to the 99% quantile of the probability distribution (Figure 2-8).

Figure 2–8 The difference between expected credit losses and alternative quantiles of the credit loss probability distribution



Source: CNB

The need to raise the rate is naturally lower in the case of a less strict approach to setting macroprudential tools. For example, if the 60% quantile were used, the difference would be around CZK 7 billion and a CCyB rate of 0.5% would be sufficient to cover this level of credit losses in 2017. The relationship between the final rate decision and the stress test results is not entirely mechanical, but it does represent a logical enhancement of the forward-looking principle of macroprudential policy. This approach to applying stress test results to assess whether capital requirements are adequate is also being discussed in the context of the planned EBA guidelines on bank stress testing (EBA, 2015).

The final decision of the policy board on the CCyB rate setting is not mechanically based on the aforementioned approaches. Instead, it reflects a complex evaluation and discussion of systemic risks. For example, some authorities including the CNB began to consider the impact of accounting standard IFRS 9 on loss-bearing capacity of banks following its introduction in 2018. IFRS 9 was conceived to be beneficial to financial stability from the long-term perspective, because unlike the previous IAS 39 it creates conditions for early and sufficient provisioning against losses. However, it is found that IFRS 9 may have a procyclical effect in certain conditions.[18] In recession, the application of expected credit losses under IFRS 9 leads to temporarily stronger impacts on capital than under the previously applied IAS 39 methodology. These impacts are concentrated in the initial period of the adverse shock. Following a sudden change in economic conditions leading to a marked reassessment of macroeconomic fundamentals, banks need to create a large amount of new provisions. This sharp increase may in turn cause sizeable losses and a fall in capital and contribute to a credit crunch. The switch to the new IFRS 9 reporting standard thus increases the need for the macroprudential authority to react in time to cyclical risks so that sufficient resilience of the banking sector to adverse economic shocks is achieved. More specifically, it is necessary from the macroprudential perspective to build a sufficient capital buffer before the models of expected losses used under IFRS 9 lead to increased provisioning that could ultimately result in the credit supply to the sound part of the real economy being restricted. One of the potential ways how to do so is the CCyB.

2.5 Deciding upon the release of the CCyB

From the prudential perspective, and in order for its purpose to be fulfilled, the CCyB should be released in the phase when cyclical risks are subsiding. Credit risk accumulated in favourable phases of the cycle usually materialises in this phase and may be reflected in systemic losses of the banking sector. However, the emergence and size of systemic losses are not the sole criterion applied when deciding on releasing the CCyB. If banks are unable to absorb these losses by a sufficient margin using profit or capital, their capitalisation will decrease substantially and their spare lending capacity will fall. This may limit the banking sector's ability to lend to the real economy. A decrease in spare lending capacity may thus be viewed as an indication of a credit crunch and serve as an impetus to consider releasing the capital buffer.

Releasing the buffer at a time of declining cyclical risks may be considered even in the absence of systemic banking sector losses and/or a decline in spare lending capacity. The potential release of the buffer in such a situation would take into account the evolution of cyclical risks covered by the CCyB and would help reduce the uncertainty surrounding the future course of macroprudential policy. In such case, the release is contingent on a comprehensive assessment of all available information, especially as regards preserving the option to use the CCyB to cover accumulated credit risks which have not yet materialised. In this situation, the buffer should not be released in full but should rather converge to a rate of 1%, which the CNB considers to be the standard rate, taking into account the evolution of relevant factors. This creates room for manoeuvre in the event of lagged

[18] See ESRB: Financial stability implications of IFRS 9, July 2017.

transmission of credit risks to banks' results and also reduces the need to potentially rebuild the CCyB in the next phase of the cycle.

2.6 Conclusion

The decision-making process regarding the CCyB rate contains both systematic elements and expert judgement and takes the form of guided discretion. The first step is to assess the position of the economy in the financial cycle. Then the decision-making on the specific level of the CCyB rate has to take into account a wide range of factors, which, in addition to an assessment of the main indicators of the financial cycle, include stress test results and stylized facts about the financial cycle Such approach can be labelled discretion guided by multiple-factor analysis. Putting more weight on formal approaches can only be expected in the future dependent on the accomplishments of research in modelling the financial cycle. It is a major challenge for future research in the area.

Chapter 3

A liquidity risk stress–testing framework with Basel liquidity standards

By Hana Hejlová, Zlatuše Komárková and Marek Rusnák

This chapter describes a liquidity risk stress-testing framework for banks. The presented approach with a survival period of one year follows the main principles of the Basel standards the LCR and the NSFR. Besides the model takes into account the impact of both bank–specific and market–wide scenarios and includes second– round effects of shocks due to banks´ feedback reactions. The presented methodology is then applied to a sample of Czech banks. This allows to monitor the sensitivity of their liquidity position to the combination of shocks under consideration.

3.1 Introduction

In the period prior to the 2008-2009 financial crisis, the assessment of banks by the central bank and other supervisors was largely guided by a capital-focused micro-prudential approach. The crisis attests that the failure to adequately model the interrelationship between solvency and liquidity risk and interconnectedness through liquidity flows within and across financial system led to underestimation of risks to, and vulnerabilities of, financial systems in many economies. Motivated by the fact that capital cannot fully mitigate liquidity risk the Basel III introduced two requirements to strengthen bank liquidity management: a liquidity coverage ratio (LCR) and a net stable funding ratio (NSFR).[19] Both are based on assumptions about liquidity inflow and outflow rates, asset quality and liquidity,

[19] The LCR represents a requirement to hold sufficient liquid assets to cover net liquidity outflows over a 30-day period. The NSFR is defined as the amount of available stable funding relative to the amount of required stable funding. This ratio should be equal to at least 100% on an on-going basis.

and funding source stability over a given period (BCBS, 2013a, 2014). Those two requirements should be viewed as harmonised minimum standards that do not necessarily reflect all the national specificities of the banking sector.[20] It should also be emphasized that the LCR (considered as a short–term stress test) neither assumes any haircuts on high–quality domestic government bonds and may cause high concentration in balance sheet, nor does it include any second–round effects. For this and other reasons, it is essential to have an additional methodology being able to assess magnitude of liquidity risk within the banking sector, such as top-down stress tests.

The top-down liquidity stress tests are part of the prudential toolkit that are used to detect system-wide liquidity risk. Many of the first-generation liquidity stress tests were performed as a routine test where scenario shocks, such as haircuts on assets and liability run-off assumptions were applied to balance sheet positions. Thus liquidity risks were often tested independently of solvency risks. Later on range of modelling approaches has been developed evolving to macro stress test with the aim of establishing macrofinancial linkages and integrated frameworks to model dynamic and systemic effects. They draw on theoretical work on modelling financial crisis (Allen and Gale, 2000 or Cifuentes at al., 2005, for example). These advanced and highly sophisticated models are more suitable for financial systems with developed financial market as they are very often relied on financial market data.

This chapter describes a liquidity stress–testing framework that is based on parsimonious models with metrics similar to the two Basel liquidity regulatory standards the LCR and the NSFR.[21] The presented model takes into account the one year stress period with a gradual impact of a credit shock on banks´ liquidity position. Besides the test includes endogenous reactions of banks (so–called an adverse feedback loop) to the first round of initial shock, creating an additional liquidity shocks in the second round. On the one hand the framework ensures that a sufficient liquidity buffer of banks, solvency and liquidity interactions, and the degree of maturity mismatch are tested. On the other hand with less number of parameters or prediction variables. The methodology of models is based on van den End (2008), Aikman et al. (2009), Nier et al. (2008), Geršl et al. (2016) or Hejlová et al. (forthcoming). The framework described in this chapter is therefore more appropriate for economies with a less developed financial market, such as the Czech economy.

The structure of the chapter is as follows: Section 3.2 briefly discusses the related literature. Section 3.3 is devoted to the concept of the approach, while

[20] See Article 98 of the CRD and also EBA (2014): Guidelines on common procedures and methodologies for SREP (12/2014).

[21] A variation of this model is used at the Czech National Bank for its annual top-down liquidity stress-testing exercise (CNB, 2016a; Komarkova, et al., 2016). The model presented here have some differences from the official CNB model, therefore the results of the presented simulations differ from the results in official CNB publications.

Section 3.4 presents illustrative examples of the application of the methodology based on data for the Czech banking sector. Section 3.5 concludes the chapter.

3.2 Related literature

A range of top-down stress tests has been developed over the last decade, but a limited set of those now include liquidity risk (BCBS, 2015). The stress testing concept of banking sector liquidity and its interaction with solvency has been addressed extensively in the literature, especially since the fall of Lehman Brothers. Researchers have examined the interaction between the deposit outflow rate and the probability of default (Wong and Hui, 2009) and profitability (Komárková et al., 2011, Geršl et al., 2016). The effect of a credit shock generated by a macro–financial scenario on a bank's liquidity or funding sources is also tested; as a decrease in liquidity inflows due to growth in non–performing loans or the credit spread in the case of bonds (see, for example, Gauthier and Souissi, 2010). Some models also test the reverse linkage where increased funding costs and/or losses on fire sales of assets affect the solvency of banks via their profit and loss accounts (Cetina, 2015; Puhr and Schmitz, 2014; Schmieder et al., 2012). Close interlinkages between various solvency indicators and the rating of a bank and its funding costs have also been used (BIS, 2015).

The most advanced liquidity stress testing models are part of integrated frameworks that combine credit risk, liquidity risk and market risk. Nevertheless, more complex integrated frameworks are still used rarely. One of the earliest integrated model is the model of Central bank of Austria that integrates satellite models of credit and market risk with a network model to evaluate the probability of bank default (Boss et al., 2006). The next advanced model is also the Bank of England´s RAMSI model (Alessandri et al., 2009) that includes an interbank network model and an asset price function to simulate fire sales of assets and satellite models for credit risk. In most modelling approaches, the feedback effects are driven by the interaction between credit and liquidity risk. Shocks to banks' solvency and lower collateral value translate into limited market access, liquidity accumulation and liquidity run-off rates. These mechanisms are used in models of the Bank of Korea, 2012 or Central Bank of Austria (Schmieder et al., 2012). The next important mechanisms included in models are fire sales and liquidity runs causing stress and contagion across the financial system (the Bank of Mexico, BCBS, 2015). In some models as a part of feedback loop the liquidity effects of bank reactions affect the solvency position of other banks (the Central Bank of Norway). Both fire sales and market-wide effects resulting from banks' behavioural responses are used also by the Netherlands Bank (van den End, 2010, 2012) or Czech National Bank (Geršl et al., 2016, Komárková et al., 2016 and Hejlová et al., forthcoming).

3.3 The concept of the approach

The liquidity stress-test presented in this Chapter is built upon the approach in Hejlová et al. (forthcoming), Geršl et al. (2016), and van den End (2018). The test followed the methodology that covers the interaction between balance–sheet liquidity (concerning liquidity and maturity transformation function of a bank) and market liquidity (its ability to monetise its assets at a set price) and the banking sector's reactions. The model is a two– round one and we consider three successive steps. The banking sector is first hit by scenario–defined exogenous shocks on which banks react to under certain conditions. Those reactions increase the reputational risk of each reacting bank and the systemic risk in the banking sector as a whole (endogenous shocks). Banks have a limited ability to increase their balance–sheet totals over the entire test period. For example, they cannot raise additional funds by issuing securities, borrowing in money market or from central banks,[22] and funds are not deposited back in the bank once they have been withdrawn.

The main changes compared with the test presented by Geršl et al. (2016) and by van den End (2008) are as follows: (i) our liquidity test is linked to solvency macro–stress tests and scenarios, (ii) four three–month maturity bands are included, extending the stress period to one year, and (iii) metrics similar to the Basel LCR (calculation of the ratio) and the Basel NSFR (the maturity mismatch profile and the stress period) are included.

The approach focuses on testing whether a bank holds a sufficient buffer of liquid assets in relation to its maturity mismatch. To assess banks' resilience to liquidity risk we use a liquidity indicator defined as the ratio of the liquidity buffer to net expected liquidity outflows, i.e. the difference between liquidity outflows and inflows. The calculation of the liquidity indicator follows the LCR and the NSFR in some aspects. Like the LCR, the *LI* is used to test whether the liquidity buffer is sufficient to meet accumulated net outflows, nevertheless, across four three–month maturity bands (the feature of the NSFR). Unlike the LCR requirement with its one–month stress period, the *LI* with its one–year period allows us to take into account the rate of accumulation of maturity mismatch in the bank's balance sheet. Like the LCR, for the calculation of the LI the amount of inflows, that can offset outflows, is capped. However, haircuts, inflow rates and outflow rates are set in the presented approach differently to values (factors) introduced by Basel III (BCBS, 2013a and 2014). The main reason is that the presented approach is designed for a one–year horizon and uses four maturity bands (four quarters). In other words, we use four different values of haircuts, inflow rates and outflow rates entering equations below depending on the quarter being tested. Values of the haircuts and the inflow rates are empirically obtained from mutually consistent modelling simulations of the macro-financial scenario.[23]

[22] The methodology assumes no government assistance or central bank reactions in order to assess the ability and scope of banks to survive without support. As central bank tools are an element of lender-of-last-resort policy, application of those tools is not considered in the tests.

[23] For the purposes of this chapter, we use for projections of relevant parameters CNB models – macro–financial scenarios were created by the prediction model DSGE g3 (Andrle et al, 2009; Brázdik et al., 2011), by the satellite models for house prices

Merely the outflow rates are based on the factors from the LCR. The factors are set as floors that are increased by an add–on. The amount of add-on depends on the resulting capital adequacy ratio after applying the macro–stress test. Simply said, the greater the impact of macro–stress shock on the capital ratio, the higher add-on is applied.

The test can be summarised as follows. Exogenous shocks are applied to selected types of balance–sheet or off– balance–sheet items, outflows and inflows in each maturity band. In the second to fourth maturity bands, the items included in the liquidity buffer are additionally subjected to endogenous shocks caused by banks' reactions. The size of the reaction is determined by the difference between the liquidity outflow and inflow in each bank in the monitored bands. Two situations can arise: the bank has a sufficient liquidity buffer and reacts by using it to cover net outflows, the bank reacts by deploying its liquidity buffer, which, however, does not cover its net expected outflows due to excessive maturity mismatch in a balance sheet dominated by unstable funding sources. The liquidity buffer is deemed sufficient if the bank can meet its accumulated net outflows (across the four maturity bands) over a one–year period. A sufficient *LI* thus takes a minimum value of one.

In the first step of the stress test, we simulate three different types of exogenous shock expressed in terms of a haircut on the asset value (*h*), a haircut on the capped expected liquidity inflow (*p*) and a run–off rate or draw– down rate expressing the rate of liquidity outflow (*r*). The maximum haircut/rate is 100%. The liquidity indicator can then be expressed as:

$$LI_{Qt}^{b} = \frac{LR_{Qt}^{b}}{NetOut_{Qt}^{b}}, where\ t = 1,2,3,4 \tag{1}$$

$$\mathrm{LR}_{\mathrm{Qt}}^{\mathrm{b}} = \sum_{\mathrm{i}} \mathrm{LA}_{\mathrm{Qti}}^{\mathrm{b}} \left(1 - \mathrm{h}_{Q\mathrm{ti}}^{b}\right), where\ t = 1,2,3,4 \tag{2}$$

where, in the numerator (equation 1), the liquid asset buffer (*LR*) of each bank (b) is defined as the sum of the market values of assets (*LA*) easily and immediately converted into cash being subject to a haircut (*h*) applied according to the scenario (equation 2). Among these assets (*i*) we include cash, claims on the central bank excluding minimum reserves, unencumbered debt securities, stocks and collateral accepted. In baseline, securities included in the liquidity asset buffer are not differentiated in terms of credit quality, which means that they are not capped according to their credit risk instead all unencumbered tradable debt securities are recognised. The different credit quality of securities is expressed using appropriate haircuts specified in the stress scenario. In the denominator is the net liquidity outflow (*NetOUT*). The *NetOUT* is defined (equation 3) as the total expected cash outflows minus total expected cash inflows in the specified stress scenario for the subsequent 90 calendar days (*Q* as the relevant maturity band, where *Q1* is the first

(Hlaváček and Komárek, 2009), for credit growth, PD and LGD (Geršl et al., 2012), for yield curve (Kučera et al., 2019).

maturity band of 0–3 months, *Q2* of 3–6 months, *Q3* of 6–9 months, *Q4* of 9–12 months). The NetOut can be expressed by the following relation:

$$NetOUT_{Qt}^{b} = \sum_{k} OUT_{Qtk}^{b} - cap \sum_{l} IN_{Qt1}^{b} \left(1 - p_{Q1}^{b}\right), where\ t = 1,2,3,4 \quad (3)$$

Among outflows (*OUT*) we include liabilities due in the given band (e.g. retail deposits, wholesale funding and issued debt securities), credit line drawdowns and new loans. The run-off or draw–down rate of individual outflows (k) is given by parameter (r). Total expected cash outflows are calculated by multiplying the outstanding balances of various outflows (k) by the appropriate outflow rate (r). Expected contractual inflows including interest payments (*IN*) comprise contractual receivables (l) due in the given band, for some of which an inflow of only a part thereof is assumed ($1 - p$). To prevent bank from relying solely on expected inflow to meet their liquidity needs, and also to ensure a minimum level of liquid asset holdings, the expected inflows are under the scenario aggregately capped (cap).[24] Total expected inflows are calculated by multiplying the outstanding balances of various (l) by the appropriate inflow rates ($1 - p$) at which they are expected to flow in under the scenario up to an aggregate cap of scenario given percent of total expected cash outflows.

The haircuts (h) reflect the fall in market prices of assets (*LA*) and the lower proceeds that would come from selling/pledging them if they had to be monetised to cover a cash outflow. The haircuts are applied in the form of an interest rate shock to debt securities and as an equity shock. Two types of interest rate risk are taken into account. First, general interest rate risk that is defined as the risk of a change in the market price of an asset due to a change in the market interest rates used to value cash flows arising from ownership of the asset. Second, credit spread risk that is defined as the risk of a change in the market price of an asset due to a change in the risk premium of the asset as perceived by financial market. The impact of the materialisation of both interest rate risks on the value of debt securities is computed separately for the portfolio of debt securities issued by domestic/foreign government, credit institutions and other corporations, with differentiation of the currency of issue. The haircut concerning general interest rate risk is calculated separately for each issue in an available–for–sale portfolio and depends on the projected paths of the government yield curves in the scenario and on the average residual maturity. It generally holds that larger general interest rate haircuts are applied in the case of higher growth in the yield curve or longer residual maturities. The haircut concerning credit spread risk is also calculated separately for each issue in a whole portfolio. It depends on the projected paths of the swap curve and government yield curve in the scenario and also on the credit rating and residual maturity of the issue. Generally, a higher devaluation rate corresponds to lower rating and longer residual maturity. Details concerning calculation techniques of the interest rate risk can be found in CNB (2017b). Cash and claims on the central bank are not subject to haircuts.

[24] According to the Basel LCR the amount of inflows that can offset outflows should be capped at 75% of expected outflows in the standard. In other word, the minimum liquid asset buffer equals 25% of the total expected outflows (BCBS, 2013a).

The size of the haircut applied to the expected inflow (*p*) reflects the risk of the bank not receiving the full expected inflow. The haircuts are determined by counterparty and/or collateralisation of claims. Inflows from due mortgage loans and other inflows from due unsecured claims on households, non–financial corporations, credit institutions and other financial institutions are subject to other haircuts. The haircut applied to the inflow from unsecured loans to households and non–financial corporations is a function of the probability of default (PD) and the expected loss given default (LGD). PD and LGD are modelled using satellite models in bank solvency macro–stress tests. In those models, PD and LGD are a function of macroeconomic variables (for a detailed description, see Geršl et al., 2012). Claims on other banks are not subject to a haircut, as failure of the bank is implicitly assumed even in the event of partial default on such claims.

The run–off or draw–down parameter (*r*) reflects the fact that due liabilities or credit commitments do not always lead to an outflow to the full extent. The value of credit lines, debt securities issued by the bank, retail deposits and wholesale funding is multiplied by this parameter. Debt securities issued by the bank and due in the given band are included in the liquidity outflow to the full extent, i.e. their rate of outflow is equal to one. In simple terms, it is assumed in the model that this source will not be restored in the next period. So, all issued debt securities with maturities of up to one year gradually mature over the test horizon.

In determining the run–off rate, account is taken of the type of counterparty and the stability of this funding source. The presented test follows basic principles used in the Basel LCR and NSFR standards, under which longer–term, more stable and easier–to–restore funding sources are subject to a lower run–off rate. A prominent finding in the literature is that a deposit´s insurance status is the most important characteristic in determining the sensitivity of deposit flows (BCBS, 2013c). Therefore, the lowest rate we applied to insured retail deposits and the highest to unsecured wholesale funding. In the presented test, the run–off rate is composed of two values. The first is a benchmark. To set the benchmark we followed the outflow factors for the relevant liabilities applied in the LCR requirement, for instance for retail insured deposits the benchmark is set to 2.5%, for retail uninsured deposits to 5%, for secured wholesale funding to 10% (funding from central bank including), for the unsecured wholesale funding provided by non–financial corporation to 20% and for the unsecured wholesale funding provided by financial institutions to 25%. The second part of the value is an add–on linked to the capital ratio results from bank solvency macro–stress tests. The procedure is that the bank first undergoes a stress test of credit risk, which materializes and is reflected in a decrease in the capital ratio. The larger the decline in the overall capital ratio in the given quarter recorded by the bank, the larger the add–on to the outflow rate in the relevant maturity band. It is assumed that a larger decline in the capital ratio reflects larger losses or a higher overall level of risk, exposing the bank to larger liquidity outflows. The add–ons are set for each bank as follow: a decline of the capital ratio to -1% corresponds to an add–on of 0.25%, between -1% and -3% an add–on of 0.5% and above -3% an add–on of 1%.

Whereas the expected inflows are aggregately capped, net outflows are always positive. Therefore in the next step, the banks concerned are assumed to react to the shocks. The bank tries to close the gap between outflows and inflows by using some sort of asset from its liquidity asset buffer. The model assumes minimisation of transaction losses. The bank therefore uses firstly assets to which the lowest haircut is assigned according to the scenario.[25]

Two situations can arise when the bank reacts. In the first case, the liquidity buffer (LR) is sufficient to cover the net outflows. The size of bank's reaction (R) is thus smaller than or equal to its liquidity asset buffer reduced by a haircut (equation 4) and the liquidity indicator for the relevant maturity band is higher or equal than 1:

$$R_{Q\mathrm{ti}}^{b} \leq L\mathrm{R}_{Q\mathrm{ti}}^{b}, if\, L\mathrm{R}_{Q\mathrm{ti}}^{b} \geq N\mathrm{etOUT}_{Q\mathrm{t}}^{b}. \quad (4)$$

In the second case, where the bank is hit more seriously by a wave of shocks, its liquidity asset buffer is not sufficient to cover the net outflow in the given maturity band (equation 5) and the liquidity indicator for that maturity band is smaller than 1. In such a situation, the bank's reaction is equal to the liquidity asset buffer. The entire liquidity buffer is exhausted, i.e. the bank has a deficit liquidity position[26]:

$$R_{Q\mathrm{ti}}^{b} = L\mathrm{R}_{Q\mathrm{ti}}^{b}, if\, L\mathrm{R}_{Q\mathrm{ti}}^{b} < N\mathrm{etOUT}_{Q\mathrm{t}}^{b}. \quad (5)$$

The result of the bank's reaction is that a stock of unencumbered assets included in the liquid asset buffer will be reduced. On the one hand, the reaction may mitigate the impact of the shock on balance–sheet liquidity, but on the other it increases each reacting bank's reputational risk as well as raising systemic risk via the simultaneous reaction of banks on financial markets. Systemic risk rises if banks exert excessive unilateral pressure on the financial market (for example, if all banks try to sell the same type of bond), leading to a fall in market liquidity. Reputational risk consists in the signalling of problems with a bank's liquidity. The growth in these two risks then feeds back in the form of a second–round shock to banks' balance sheets. The third step therefore involves calculating and applying the feedback effect in the form of an additional market shock caused by banks' reactions. This endogenous systemic shock manifests itself as an additional haircut on the asset (q) held in the liquidity buffer. We differentiate between the impact of systemic risk on non–reacting banks (q^{bnon}) and that of systemic risk plus reputational risk on reacting banks (q^{breac}):

[25] In reality, the bank may first try to sell off or pledge lower quality assets even though they are subject to large market haircuts. The assumption of minimum transaction losses was chosen because the presented approach is aimed at testing the adequacy of a bank's liquidity buffer in relation to the maturity mismatch in its balance sheet.

[26] The liquidity position can be improved by accepting a short-term loan from another bank. Such "assistance" is not considered in the test given the assumption of a limit on the increase in funds. This does not apply to banks in a liquidity subgroup.

$$q_{Qti}^{bnom} = h_{Qti}^{*b} * \left(\sum_b B\right)^{\left(\frac{\left(1+\frac{\sum_b R_{Qti}^b}{\sum_i \sum_b R_{Qti}^b}\right)^s}{\sum_b B}\right)}, where\ t = 1,2,3,4 \quad (6)$$

where q∈ (h*,1) and h* reflects the market liquidity risk associated with the asset (see below), s is a market conditions indicator and B is a parameter equal to one if the bank is a reacting bank and zero if it is a non–reacting bank. A non–reacting bank is the bank that closes the gap between outflows and inflows by using cash or claim on the central bank. Those two liquid assets are not subject to haircuts and a usage of them does have no impact on markets. For parameter $h*$, the model uses one of three haircuts: the original haircut applied in the previous round of the test (h).[27] The size of the additional haircut depends on the number of reacting banks ($\sum_b B$) banks and the size and similarity of their reaction ($\sum_b R_{Qi}^b$). It is assumed that a larger number of similarly reacting banks causes greater market stress and hence a larger additional market shock. The market conditions indicator (s) in the model expresses risk aversion. This indicator is derived from the standardised distribution of risk aversion indicators using implied stock price volatility and bond spreads as proxies (Van den End, 2008). The indicator takes values in the range of (–1,1) in normal market conditions and up to 3 at times of high market stress. A higher market stress indicator magnifies the effect of the simultaneous reaction of banks. It is set by expert judgement based on knowledge of volatility and liquidity in the market concerned.

Reacting banks face reputational as well as systemic risk. In their case, the additional haircut is thus larger. This type of risk (like systemic risk) is expressed using a market conditions indicator, since the signalling effect of reacting banks has a large feedback effect in the event of market stress.

$$q_{Qti}^{breac} = q_{Qti}^{bnom}\sqrt{s}, where\ t = 1,2,3,4 \quad (7)$$

In a crisis, illiquid financial institutions – due to either prudential (liquidity–hoarding) or speculative (predatory)[28] motives – are driven out of private credit markets or are granted liquidity at punitive rates. It is assumed in the methodology that the impacts of the shocks applied to the first maturity band and the subsequent reactions of banks will pass through to connected bands in the individual steps of the test (Q = *2, 3, 4*). Here again, we consider an exogenous wave of shocks that affects the value of the assets held in the liquidity asset buffer and the size of the

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[27] If h is zero, the haircut on government bond, then we use the haircut applied to the asset type in the NSFR requirement, see BCBS, 2014, p. 11.

[28] This is a speculative motive based on the assumption that high demand for cash implies low asset prices. In a crisis, when some banks are in a difficult liquidity situation, liquid banks may use their market strength and curb the provision of liquidity to illiquid banks or raise the price of that liquidity for purely strategic, healthy competitive reasons. If loan rates are too high, an illiquid bank is forced to sell off its assets, often at very attractive prices (i.e. it falls prey to predators).

liquidity flows via h, r and p. Additionally, however, we take into account the market stress caused by reacting banks (q).[29] The liquidity indicator thus changes as follows:

$$LI_{Qt}^{b} = \frac{\sum_i LA_{Qit}^{b}(1 - h_{Qti}^{b} - q_{Qt-1i}^{b})}{NetOUT_{Qt}^{b}}, where\ t = 1,2,3,4 \qquad (8)$$

It is clear that the model has limitations that prevent it from fully capturing the liquidity risk that a tested banking sector may face. For instance, it fails to take in consideration that the provision and repayment of loans are closely bound up with the creation and termination of deposits. In the test, the liquidity position of banks is improved by loan repayments (inflow) but no longer shows up as deposit termination (outflow). The model also fails to take account of direct interbank contagion, an interaction with non-bank financial intermediaries and hence the potential domino effect. The scenario considers only a simplified general interest rate shock based on the evolution of government yield curves, and only in two currencies. Specific interest rate risk is captured only endogenously through banks' reaction functions. Exchange rate risk and real estate risk are not considered at all. The model does not distinguish the type of credit and liquid lines in relation to the counterparty, i.e. it does not work with intragroup liquidity lines. And the more relevant limitation is that the model takes into account only one type of banking reaction and does not work with a banking reaction through changes in interest rates for example. The liquidity stress test should be further refinement in these areas.

3.4 Application of the model to selected Czech banks

The methodology described above was applied to a representative sample of 19 banks domiciled in the Czech Republic, with various business models and bank sizes represented. The main objective was to monitor the sensitivity of the liquidity position of selected banks to a combination of shocks under the given methodology. The application was conducted on end–2016 data for the banks under review. The data was obtained from the CNB´s statistics. The CNB's November 2016 macro–stress scenario and macro–stress test results (CNB, 2016b) were used to simulate the bulk of the exogenous shocks. The parameters of the exogenous shocks are summarised in Table 3-1. The parameters of the shocks, including the endogenous ones, are summarised in Table 3-2 in the Appendix. We opted for a single market indicator (s) of 1.5, implying low market liquidity (van den End, 2008).

[29] The additional haircut is applied to available-for-sale assets in the portfolio. In the case of held-to-maturity bonds, the additional haircut is only applied to the part used as collateral.

Table 3–1 Liquidity stress test scenario (in %)

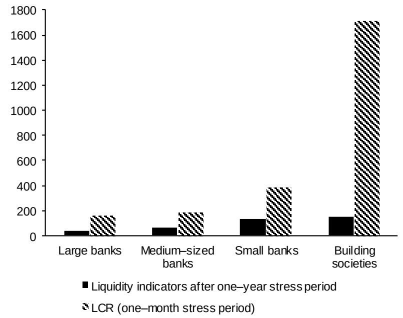
Balance-sheet item / Maturity bands	< 3M	3M– 6M	6M– 9M	9M– 12M
1. Liquidity buffer		**Interest rate and equity shock**		
1,1 Q-o-q change in yield curve in pp*				
1Y PRIBOR	0,3	0,0	0,0	0,0
5Y GB yield	1,0	0,6	0,5	0,4
1Y EURIBOR	0,2	0,0	0,0	0,0
5Y EUR GB yield	0,0	0,2	0,3	0,2
1,2 Haircuts from value of capital instrument	30,0	-	-	-
2. Inflows		**Size of deduction from expected inflow**		
2,1 Secured claims	0,9	0,9	0,9	0,9
2,2 Unsecured claims due**				
on NPs	2,1	2,2	2,4	2,6
on NFCs and retail SMEs	1,1	1,2	1,2	1,2
3. Outflows		**Expected outflow rate**		
3,1 Drawdown of credit lines	5,0	5,0	5,0	5,0
3,2 Issued debt securities	100,0	100,0	100,0	100,0
3,3 Retail deposits				
insured	3,2	3,5	3,2	3,1
others	6,3	7,0	6,4	6,3
3,4 Liabilities to NFC				
insured	12,6	14,1	12,9	12,5
others	25,3	28,2	25,8	25,0
3,5 Liabilities to Fis				
insured	12,6	14,1	12,9	12,5
others	31,6	35,2	32,2	31,3
3,6 Growth in new loans, of which***				
secured claims	0,0	1,4	1,3	1,0
due to NPs	0,0	1,0	0,6	0,4
due to NFCs and retail SMEs	2,4	0,0	0,7	0,0

Source: CNB, authors´ calculations

Note: The parameter values are the averages of those applied to individual banks. *The haircut is determined by multiplying the change in the yield curve by the duration of the bond portfolio. **Due claims on financial institutions were not subject to deductions in this scenario. ***The credit growth assumption is calculated using satellite models in macro stress tests of bank solvency. NFCs: non-financial corporations, FIs: financial institutions, NPs: natural persons. This table does not contain the endogenous (systemic and reputational) shocks generated in the second round of shocks.

The liquidity asset buffer (*LR*) was defined for the test as the weighted sum of cash, claims on the central bank (excluding minimum reserves), debt securities issued by domestic and foreign government, capital instruments and corporate debt securities excluding those held in credit portfolios.[30]

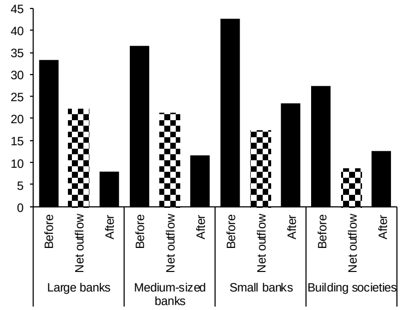
Figure 3–1 Post-stress liquidity indicators



Source: Authors' calculations based on CNB data
Note: end-2016 data.

Figure 3–2 Results of the one-year horizon liquidity stress test

(% of balance sheet total of bank type)



Source: Authors' calculations based on CNB data
Note: Note: end–2016 data. The column "Before" represents the pre–stress size of the liquidity buffer and the column "After" the post–stress size of the liquidity buffer. The column "Net outflow" represents the outflow of liquidity over the one-year horizon.

A few banks exhausted their entire liquidity asset buffers (*LR*) during our one–year test, although the earliest this occurred was in the last quarter (see Figure 3-3). However, some of those banks specialise intentionally in a particular product type. They rely mostly on funding sources within their financial groups and hold hardly any liquid assets. However, the methodology also indicated that some universal banks have less stable sources in relation to their liquidity asset buffers (*LR*). In the case of banks that did not exhaust their liquidity asset buffers (*LR*), the liquidity indicator (*LI*) gradually decreased as the maturity bands increased in length (see Figure 3-4). However, these banks are more than sufficiently compliant with the required indicator level (*LI*) despite the fact that they had to use their liquidity asset buffers (*LR*) to cover net outflows (*NetOut*) from the very first round of the test.

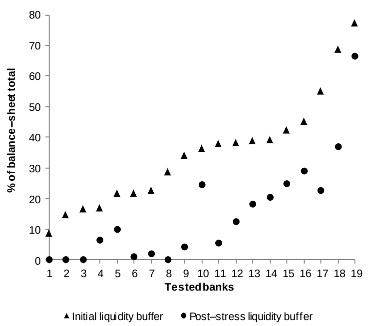
The source of resilience of most of the banks under review is their sufficient liquidity asset buffer (mostly 20% of bank´s assets, see Figure 3-3), which consists mostly of zero–haircut claims on the central bank and debt securities issued by

[30] Collateral accepted was not included in the buffer due to data unavailability.

domestic government. For the most part, government bonds are subject not to the interest rate shocks but only to the additional haircuts in the second round of shocks (see Appendix), since a large proportion of the banks under review hold them to maturity.[31] The liquidity asset buffer (*LR*) is fairly homogeneous across the tested banking sector, a property that may magnify the drop in its value if it is used by a large set of banks. Paradoxically, the overall endogenous shock in the form of the additional haircut (see Appendix) on domestic government bonds may thus be large by comparison with riskier assets with lower shares in the liquidity asset buffer (*LR*). On the one hand, a more diversified portfolio could mitigate this type of systemic risk. On the other hand, most market prices of assets are highly correlated during a crisis, so only cash or near–cash assets (such as claims on the central bank) can offer real hedging against such risk.

Figure 3–3 Liquidity buffers of tested banks

(% of bank´s balance sheet)

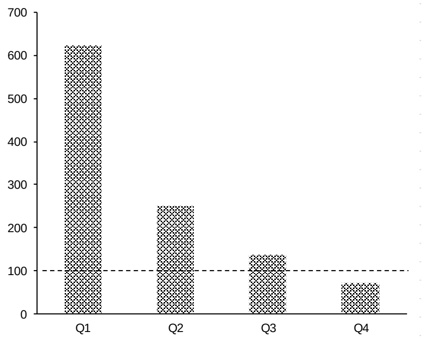


Source: Authors' calculations based on CNB data

Note: end-2016 data.

Figure 3–4 Liquidity indicator profiles over the tested period

(%)



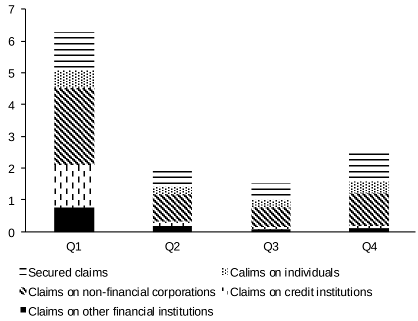
Source: Authors' calculations based on CNB data

Note: end-2016 data.

A more detailed breakdown reveals that claims on non–financial corporations, which banks usually provide with shorter maturities, make up the largest part of the inflows in all maturity bands. They therefore significantly exceed claims on individuals and credit institutions in maturities of one year or less (see Figure 3-5). Due to their very short maturities, inflows from claims on credit institutions are relevant only in the first maturity band of 0–3 months. By contrast, inflows from claims on households grow in importance with increasing maturity length. However, the one–year test period was too short for the simulated credit shocks to have a major impact via these claims.

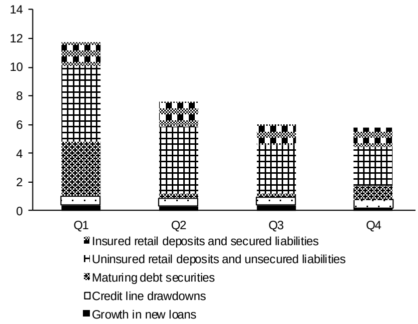
[31] In the case of held-to-maturity bonds, the additional haircut is only applied to the part used as collateral.

Figure 3–5 Liquidity inflow structure
(% of bank´s balance sheet; x-axis: maturity band)



Source: Authors' calculations based on CNB data
Note: end-2016 data, Q = maturity bands: of 0-3 months, 3-6 months, 6-9 months and 9-12 months.

Figure 3–6 Liquidity outflow structure
(% of bank´s balance sheet; x-axis: maturity band)



Source: Authors' calculations based on CNB data
Note: end-2016 data, Q = maturity bands: of 0-3 months, 3-6 months, 6-9 months and 9-12 months.

Uninsured retail deposits and unsecured liabilities to non–financial corporations and financial institutions dominate outflows at the aggregate level (see Figure 3-6). Outflows from relations with non–financial corporations far exceed those from other relations. There are two main reasons for this. The banks under review fund themselves primarily by accepting deposits from households and non–financial corporations rather than by obtaining loans from other banks in money markets. Compared to retail financing, however, corporate (wholesale) financing is considered a less stable funding source, so a relatively high outflow rate is applied to it. Banks whose sources consist mostly of corporate deposits therefore undergo severe stress in this test. Their liquidity buffers should thus be larger than those of banks with predominantly retail sources to survive the stress.

3.5 Conclusion

This chapter described a liquidity stress–testing framework based on some principles of the two Basel liquidity regulatory standards the LCR and the NSFR. The model took into account the impact of both bank–specific and market–wide scenarios and includes second–round effects of shocks due to banks´ feedback reactions with endogenous adverse feedback loop. We also showed how solvency and liquidity stress–testing frameworks can be interlinked, so that a complete stress–testing exercise can encompass mutually consistent shocks to liquidity, market, credit and other risks. The survival period was set on one year to monitor the liquidity position of banks over a longer period of market stress.

The output of the presented stress test is a liquidity indicator which, analogously to the LCR, expresses the coverage of the net expected liquidity outflow with liquid assets subject to haircuts. The liquidity indicator level is deemed adequate if it maintains a minimum value of one over a one–year period (analogously to the NSFR). The stress test methodology was applied to a representative sample of 19 banks domiciled in the Czech Republic, with various business models and bank sizes represented. The sole aim of the analysis – based on real data – was to present the methodology and monitor the sensitivity of the liquidity position of selected banks to the combination of shocks considered over a longer period.

The outcomes of the model showed that the most Czech banks seemed to be resilient against presumed liquidity, market and credit shocks. However, there were four of them who exhausted their liquidity buffers, partly also due to the second–round effects. Their liquidity indicators fell below 100% minimum although not before the last quarter. This proved that there is heterogeneity among tested banks and that sufficient liquidity in a banking sector as a whole can be specious. We also compared the liquidity indicators of banking groups with their LCR requirement. The results confirm that LCR requirement as a short–term stress test is inappropriate for testing some types of business models such as building societies. It results that in a stress test shorter and longer horizon should be explored to assess whether a bank´s outcomes are sensitive to this issue.

Appendix

Table 3–2 Summary of parameter settings with use of the scenario (in %)

Balance-sheet item	arameterisation sourc	Parameter value for maturity band				Shock type
		?3M	>3M–6M	>6M–9M	>9M–12M	
Inflows (*p*)						
Secured claims	macro-stress scenario	0.33	0.40	0.55	0.50	credit
Claims due*						
on individuals	macro-stress scenario	1.35	1.44	1.54	1.59	credit
on non-financial customers and retail SMEs	macro-stress scenario	0.56	0.70	0.69	0.69	credit
Liquidity buffer						
Interest rate shock to debt securities (*h*)						
Domestic government AFS in CZK	macro-stress scenario	4.31	2.96	4.43	1.06	market – interest rate
Foreign government AFS in CZK	macro-stress scenario	7.05	4.79	7.19	1.71	market – interest rate
Domestic CIs' AFS in CZK	macro-stress scenario	4.15	2.79	4.18	0.99	market – interest rate
Foreign CIs' AFS in CZK	macro-stress scenario	1.45	0.94	1.40	0.33	market – interest rate
Domestic corporates' AFS in CZK	macro-stress scenario	2.10	1.38	2.07	0.49	market – interest rate
Foreign corporates' AFS in CZK	macro-stress scenario	0.68	0.38	0.57	0.14	market – interest rate
Domestic government AFS in foreign currency	macro-stress scenario	0.84	0.76	1.19	0.63	market – interest rate
Foreign government AFS in foreign currency	macro-stress scenario	0.81	0.69	1.08	0.57	market – interest rate
Domestic CIs' AFS in foreign currency	macro-stress scenario	0.69	0.62	0.97	0.51	market – interest rate
Foreign CIs' AFS in foreign currency	macro-stress scenario	0.37	0.25	0.40	0.21	market – interest rate
Domestic corporates' AFS in foreign currency	macro-stress scenario	0.79	0.76	1.18	0.62	market – interest rate
Foreign corporates' AFS in foreign currency	macro-stress scenario	0.88	0.78	1.22	0.65	market – interest rate
Endogenous market liquidity shocks (r/n)						
Capital instruments (*h*)	liquidity stress test	61.24 / 50	78.3 / 63.93	77.94 / 63.64	61.24 / 50	market – systemic and reputational
Capital instruments (*q*)	liquidity stress test	11.24 / 0	28.3 / 13.93	41.87 / 29.83	- / 30.59	market – systemic and reputational
Debt securities of domestic government (*h*)	liquidity stress test	16.44 / 13.43	9.48 / 7.74	9.38 / 7.66	10.4 / 8.49	market – systemic and reputational
Debt securities of domestic government (*q*)	liquidity stress test	11.44 / 8.43	12.91 / 11.37	16.71 / 14.1	22.25 / 18.24	market – systemic and reputational
Debt securities of foreign government (*h*)	liquidity stress test	38692	7.9 / 6.45	8.14 / 6.65	8.37 / 6.84	market – systemic and reputational
Debt securities of foreign government (*q*)	liquidity stress test	01.12.2000	2.9 / 1.45	5.07 / 3.18	7.21 / 5.28	market – systemic and reputational
Debt securities of domestic CIs (*h*)	liquidity stress test	62.36 / 50.92	47.8 / 39.03	47.03 / 38.4	51.53 / 42.07	market – systemic and reputational
Debt securities of domestic CIs (*q*)	liquidity stress test	32.36 / 20.92	38.72 / 30.55	46.97 / 39.95	59.87 / 52.46	market – systemic and reputational
Debt securities of foreign CIs (*h*)	liquidity stress test	63.09 / 51.51	46.82 / 38.23	46.79 / 38.2	49.42 / 40.35	market – systemic and reputational
Debt securities of foreign CIs (*q*)	liquidity stress test	33.09 / 21.51	44.12 / 29.74	46.53 / 39.45	57.36 / 49.25	market – systemic and reputational
Debt securities of domestic corporates (*h*)	liquidity stress test	63.17 / 51.58	46.86 / 38.26	46.88 / 38.28	49.52 / 40.43	market – systemic and reputational
Debt securities of domestic corporates (*q*)	liquidity stress test	33.17 / 21.58	38.43 / 30.45	46.72 / 39.63	57.64 / 50.07	market – systemic and reputational
Debt securities of foreign corporates (*h*)	liquidity stress test	36.74 / 30	46.75 / 38.17	46.83 / 38.24	49.44 / 40.36	market – systemic and reputational
Debt securities of foreign corporates (*q*)	liquidity stress test	6.74 / 0	16.75 / 8.17	25 / 16.86	35.84 / 27.78	market – systemic and reputational
Outflows (*r*)						
Credit line draw dow ns**	expert judgement	5	5	5	5	liquidity
Debt securities issued	non-restoration of sourc	100	100	100	100	liquidity
Retail deposits						
insured	LCR floor, macro-stress	III.75	III.75	3.125	III.75	liquidity
other	LCR floor, macro-stress	07.V	07.V	VI.25	07.V	liquidity
Liabilities to NFCs						
secured	LCR floor, macro-stress	15	15	12.V	15	liquidity
other	LCR floor, macro-stress	30	30	25	30	liquidity
Liabilities to FIs						
secured	LCR floor, macro-stress	15	15	12.V	15	liquidity
other	LCR floor, macro-stress	37.5	37.5	31.25	37.5	liquidity
Grow th in new loans						
of w hich secured claims	macro-stress scenario	0.4	0	01.V	0.9	credit
of w hich due vis-à-vis individuals	macro-stress scenario	0	0	0	0	credit
of w hich due vis-à-vis non-financial customers	macro-stress scenario	01.II	0	0	0.6	credit

Source: CNB, authors´ calculations

Note: *r/n* stands for reacting/non-reacting bank, *h* for the haircut on a liquid asset, *p* for the size of the haircut on the expected inflow and *r* for the size of the outflow. The parameter values are the average parameter values applied to individual banks. * Due claims on financial institutions were not subject to haircuts in this scenario. ** The stock of credit lines as of the test date was multiplied by the value of this parameter.

Chapter 4

Monetary policy after the 2007-2009 global financial crisis in the context of systemic risk

By Liběna Černohorská and Petr Teplý

This chapter deals with the changes in implementing monetary policy that central banks were forced to employ in response to the effects of the 2007-2009 global financial crisis (GFC). These changes were in most cases needed because conventional monetary policy instruments were no longer effective at achieving their set goals. At the same time, it was also necessary for central banks to monitor not only price stability but also financial stability, which required deployment of macroprudential policy tools. The question remains as to whether the central banks increased or decreased systemic risk of financial markets with their measures.

In the first section, we explain the necessary changes that the selected central banks were forced to adopt. They began to simultaneously implement unconventional monetary policy in the form of quantitative easing, currency intervention, negative interest rates, and forward guidance. The next two sections present the basic principles of how monetary policy operated before the financial crisis, while also pointing out the areas of monetary policy that were reassessed in conjunction with the impact of the financial crisis on monetary policy. In the fourth section, we deal with the effectiveness of unconventional monetary policy in the selected countries, specifically as it relates to the Federal Reserve System (FED), the Bank of England (BOE), the Bank of Japan (BOJ), the Czech National Bank (CNB), the European Central Bank (ECB), and the Swiss National Bank (SNB). The fifth section deals with reevaluating analytic approaches to monetary policy regarding financial stability, and we also devote time to systemic risk in the context of contemporary monetary policy. The closing section summarizes the chapter and states final remarks.

4.1 Introduction

The international financial markets are increasingly interconnected; therefore, they have great impact on individual national economies. The GFC itself began on the American mortgage market in 2007; it subsequently affected the Western European banks and then circled back to the USA. It resulted in serious disruption of the global credit markets. Losses on the world's credit markets led to the worst global economic downturn since the Great Depression.

Financial crises nearly always result in steep increases in government debt. The fiscal situation in many countries was negatively influenced by massive emergency measures to stabilize financial institutions, fiscal stimulus packages, and sharp economic decline that resulted in lower tax revenues all around the world. Budget deficits became a basic component of advanced countries, and the ratio of government debt to gross domestic product (GDP) increased. Such increases in debt can even potentially result in government debt defaults.

It is still unclear how monetary policy can learn from the GFC. Certain authors (e.g., Krugman, 2009, and Cochrane, 2011) state that the financial crisis revealed major deficiencies in the monetary policy enacted over the past forty years and that fundamental change was therefore necessary. Consequently, certain central banks were forced to implement unconventional monetary policy. Central banks did so when conventional (classical) monetary policy failed and interest rates were near zero. Quantitative easing, currency intervention, negative interest rates, and forward guidance are examples of unconventional monetary policy instruments (Mishkin, 2017; Mejstřík et al., 2014).

Central banks implement quantitative easing by purchasing domestic financial assets – either from commercial banks or non-banking entities. For it to be considered a quantitative easing, there must also be the great increase in the central bank's balance sheet that quantitative easing entails. In practice, this primarily means the purchase of domestic government bonds. This unconventional monetary policy instrument is being or has been used by the BOE, the BOJ, the ECB, and the FED, for example. The result of quantitative easing is that governments and businesses – as the entities issuing the bonds purchased by the central bank – are able to further increase debt at low interest costs. The resulting situation influences the growth of inflation, the gross domestic product, and employment.

In currency intervention, the central bank sets a given level for the currency exchange rate. In order for the central bank to achieve this currency exchange rate, it must be willing to intervene on the currency market as necessary in order to achieve its set commitment. The scope of these interventions is not shared with the public in advance. This results in weakening the domestic currency by using domestic currency to purchase foreign currency. Because the central bank alone is able to issue currency, this procedure can be conducted without limit. Currency intervention is also easier for the public to understand. The result is increasing expectations for inflation. Prices for imported goods increase due to the weakened domestic currency, and this eventually results in increasing inflation in small open economies. This monetary policy instrument was used by the CNB and the SNB.

In the case of negative central bank interest rates, commercial banks pay the central bank for holding their excess financial resources. The reason for implementing negative interest rates is so that banks do not allow their surplus funds to remain in their accounts at the central bank, but rather have them released into the economy, e.g., in the form of loans for other economic entities. In conjunction with the GFC, central bank interest rates dropped to zero. In 2009 Riksbank, Sweden's central bank, was the first bank to use negative interest rates in practice. Shortly thereafter, the Danish and Swiss central banks followed the Swedish lead, and the ECB also joined the banks employing negative interest rates in 2014.

Forward guidance is used to signal future developments in monetary policy. With the help of forward guidance, central banks try to influence the expectations of economic entities concerning the future development of monetary policy. This instrument can be implemented in two possible ways – either the central bank can make public prognoses of monetary policy (future development) or it can define the explicit commitments it would like to achieve. For example, the ECB made it known in 2013 that its loose monetary policy would remain accommodating as long as necessary and that key rates would remain at current or lower levels over the long term.

Later in this study, we will also discuss monetary policy in the context of systemic, which can be defined in several ways. For instance, ECB (2009) defined it as the risk *"that financial instability becomes so widespread that it impairs the functioning of a financial system to the point where economic growth and welfare suffer materially."* Alternatively, Benoit et al. (2017) offered the following definition of systemic risk: *"the risk that many market participants are simultaneously affected by severe losses, which then spread through the system"*. For the purpose of our chapter, we will use the definition by Benoit et al. (2017).

4.2 The basic principles of monetary policy before the GFC

Until 2007, a positive general consensus prevailed among central banks when evaluating how monetary policy was being implemented. However, the question remains as to which changes in conducting financial policy were brought about by the financial crisis. Mishkin (2017) deals with the implementation of monetary policy previous to the financial crisis, when inflation was conceived as financial phenomenon. Friedman (1974) sees its causes in expansive monetary policy, i.e., in the excessive growth of money in the economy, which must be combated. Furthermore, central banks have the option of influencing inflation and should maintain it at a low, stable level, because price stability brings them great advantages. The necessary starting point for price stability is the Taylor principle, which is derived from the thesis that inflation will be stable only under the assumption that monetary policy increases the nominal interest rate by more than the growth of inflation, so that real interest rates increase along with inflation (Taylor, 1993). Numerous empirical studies (e.g., Sack, 2000; Clarida et al., 1999;

Levine et al., 2005; Smets and Wouters, 2003) described suitable monetary policy before the financial crisis using Taylor rules.

At the same time, monetary policy should not attempt to achieve lower levels of unemployment by aiming for higher inflation, because there is no long term relationship between unemployment and inflation. Central bank independence helps central banks free themselves from political pressure and allows them to conduct expansive monetary policy. Empirical studies show (e.g., Bleaney, 1996; Alesina and Summers, 1993; and Cecchettia and Krause, 2002) that central banks achieve higher performance from a given economy when they have greater independence.

Volatility on the financial markets plays an important role in the economic cycle. If a financial system is exposed to shocks that increase information asymmetry, the result is an increase in volatility on the financial markets, which leads to financial instability. Subsequently, the financial system is not able to provide financial resources for investment; therefore, the economy's performance declines. Before the global financial crisis, volatility on the financial markets was not a frequent subject of interest, and so it was not previously included in models analysing central bank policy.

Mishkin (2017) claims that these cited facts are elements of what can be called "the new neoclassical synthesis." Goodfriend and King (1997), for example, deal with this issue in more detail. Before the global financial crisis, nearly all central bankers agreed with these actualities. As conceived by the new neoclassical synthesis, monetary policy strategy is termed "flexible inflation targeting" (Svensson, 1997) in academic literature. It includes a strong and reliable commitment by the central bank to stabilize inflation over the long term, often at a precise numerical rate. However, it also makes it possible for the central bank to influence economic output around a potential product over the short term.

4.3 The impact of the GFC on monetary policy

Mishkin (2017) highlights that some new trends in monetary policy strategies and approaches after the GFC occurred, because of the evidence the development of the financial sector has a much greater impact on economic activity than had been previously thought. The GFC and the subsequent economic recession clearly showed the necessity of financial macroeconomic analysis, which should be included in macroeconomic models. These models should no longer be left out of central bank prognoses and analyses of monetary policy's effectiveness. Furthermore, Mishkin (2017) argues that zero interest rates constitute a serious problem, because conventional expansive monetary policy becomes ineffective when a negative shock affects the economy. Shocks from the destabilization that happens when financial systems are disrupted are much deeper than have been previously assumed. Therefore, low interest rates have become a more important monetary policy instrument for central banks than before the financial crisis. Previous to the global financial crisis, many economists believed that low interest rates were effective when combined with other unconventional monetary policy instruments, because they provided a sufficient impulse for renewing economic growth (Svensson, 2018).

Williams (2014) proved that unconventional monetary policy stimulates economic activity, and it is true that central banks around the world have tried to bring back full employment levels or achieve set inflation targets of 2% within individual economies. Accordingly, low or even negative interest rates are necessary for reviving economies. In this situation, central banks fall back on nontraditional (unconventional) measures for monetary policy, such as quantitative easing, which consists of purchasing assets, or currency intervention with the goal of reviving the economy, for example (as described in Černohorská, 2017; Mandel and Tomšík, 2018; Svensson, 2018; Wu and Xia, 2016; Williams, 2014; and Zamrazilová, 2014). According to Revenda (2016), quantitative easing was originally intended to support the banks' health but gradually it even managed to support banks' credit activities, which should reflect economic development and the aversion of deflation in a positive way.

Stable inflation and output do not guarantee financial stability, even though before the recent financial crisis, it was the common opinion of both academics and central banks that achieving stable prices and economic output supports financial stability. This was supported by research from the authors Bernanke et al. (1999) and Bernanke and Gertler (2001), who indicated that monetary policy in support of stable inflation and production most likely also stabilizes the price of assets. This would prevent the creation of asset bubbles on the market, which would thus become less and less likely to occur. Up until 2007, the economic environment did not do enough to protect the economy from financial instability – it actually managed to make the instability even greater. The overall costs for renewing financial market stability are very high. Besides the actual expenses resulting from the global recession, there are also the additional costs that arose from the global financial crisis, which fall into two categories: financial crises are usually accompanied by slow economic growth, simultaneously resulting in higher budget deficits for governments. The cumulative losses from financial crises are very high, and it is clear that there are no exceptions – even for a global financial crisis.

Mishkin (2017) has warned that monetary policy should not completely veer away from experience gained previous to the financial crisis. Currently, most of the steps for implementing monetary policy are the same as those before the financial crisis. Nonetheless, one clear lesson learned from the financial crisis is that developments on the financial markets can have a more significant effect on economic activity in individual countries than central banks previously realized. Mishkin (2017) lists the areas of monetary policy that it would be appropriate to reevaluate when implementing monetary policy itself. The steps listed are derived from the following principles of the new neoclassical synthesis:

1. *Flexible inflation targeting*
2. *Monetary policy's reaction to asset price bubbles*
3. *The dichotomy between monetary policy and financial stability*
4. *International coordination of monetary policy*
5. *Forward guidance*

Before the financial crisis, central banks did not have financial market volatility included in their economic models, even though this is one of the main causes of fluctuation in the economic cycle. This resulted in the dichotomy between monetary policy and financial stability policy, which has these two types of policy being conducted separately. As Mishkin (2011) states, the recent financial crisis supports systemic regulation, with central banks becoming a suitable choice for the role. The benefit of coordinating monetary policy and macroprudential policy is another reason why central banks should take on the role of system regulator. The global financial crisis led both economists as well as central bankers to approach the implementation of monetary policy differently. It is necessary to realize that some areas must be reevaluated, and there should be a focus on inflation and monetary policy's reaction to the possible appearance of asset price bubbles. It is further necessary to concentrate on the dichotomy between monetary policy and financial stability policy. Not least, there should also be greater international cooperation on monetary policy in order to be better able to cope with volatility on the financial markets.

4.4 The effectiveness of unconventional monetary policy in the selected countries

The effectiveness of monetary policy often tends to be evaluated according to how the development of monetary aggregates (including the monetary base) or central bank interest rates impact economic quantities. Monetarists start with the thesis that over the long term, monetary aggregates have been considered the deciding factor for conducting monetary policy. Friedman and Schwartz (2008) explain the economic cycle's development using changes in the money supply and inflation. As stated by Friedman (1968) as well as by Brunner and Melzer (1969), money has only short-term impact on the real economy. At the same time, they emphasize – the same as other monetarists – that monetary policy should not be used as an active tool for stabilizing the economic cycle.

If the central banks had already been using standard monetary policy instruments for meeting set targets (e.g., inflation targets) and the tools used did not result in their achievement, these central banks resorted to unconventional monetary policy tools. The selected central banks took unusual steps in monetary policy (so-called unconventional monetary policy) in order to minimize the effects of the financial crisis or avert the risk of inflation. Traditional instruments primarily began to fail in 2008 in conjunction with the financial crisis, when a number of central banks nearly reached zero while setting monetary policy interest rates, and it was not possible to lower rates further in order to ease monetary conditions. The central banks needed to resort to instruments with whose consequences they had no experience. Primarily, these tools consisted of negative nominal interest rates, currency intervention, quantitative easing, and forward guidance as has been previously mentioned.

The FED and the BOE purchased government bonds and other private assets (i.e., they implemented quantitative monetary easing). The FED implemented quantitative easing from 2008 until 2014 at an overall amount of roughly USD 3,940 billion. The ECB focused on purchasing covered bonds between 2015 and 2018. Roughly between August and October of 2008, the central banks cited increased their volume of repos (or similar instruments) in an attempt to lessen volatility on the interbank markets and facilitate access to sources of liquidity for financial institutions. Another FED reaction to the financial crisis was to establish a number of programs that were to provide liquidity directly to borrowers and investors. Examples of these are TALF (the Term Asset-Backed Securities Loan Facility), which provided liquidity to households and small businesses and the PDCF (the Primary Dealer Credit Facility), a so-called overnight loans primarily for businessmen – in addition to many others. The risk of quantitative easing lies in the enormous increase in the central banks' balance sheet.

This approach also makes it possible for governments to increase their debt and provides moral hazard for governments, which continue to increase debt because their bonds are always in demand. Furthermore, this huge growth in the amount of money increases the risk of having higher inflation, which becomes more difficult to decrease over the long term. Specifically, quantitative easing was used by the FED, the ECB, the BOJ, and the BOE. Each month, the ECB purchased bonds worth EUR 80 billion; near the end, they gradually lowered the amount to EUR 30 billion then 15 billion. It purchased a total of EUR 2.6 billion in bonds over nearly four years (from March 2015 to December 2018). Their balance sheet more than doubled to reach EUR 4.7 billion, which is nearly 35% of GDP. According to their calculations, quantitative easing was supposed to increase GDP and inflation by 0.4% annually. Within the Eurozone, each of the 19 central banks purchased bonds issued by their governments and thus also carried the risk of possible non-reimbursement, which is a real threat in some countries. Between December 2008 and October 2014, the American FED pumped USD 3.7 billion into the American economy in three phases by purchasing government and mortgage-backed securities. The FED's balance sheet increased to more than four billion dollars, which is more than eight times the pre-crisis level.

Meanwhile, as early as 2009, Sweden's central bank Riksbank was the first to implement negative interest rates. Denmark's central bank followed in 2012; next was the ECB in 2014 and then the SNB, the BOJ, and finally the Central Bank of Hungary. Their rates as of September 2019 are listed in Table 4-1.

Together with the SNB, the CNB began to intervene on the currency exchange market with the goal of preventing its currency's exchange rate from increasing or turning back potential deflation. Currency intervention was specific to the perspective of the individual country. The SNB conducted currency intervention since 2009, between September 2011 and January 2015 using a currency floor. The reasons why the SNB started to intervene were low inflation, the attempt to support the competitiveness of its exports, and strong pressures causing the currency to appreciate. The CNB intervened on the currency exchange markets between November 2013 and April 2017 due to threatening deflation. The CNB decided to use currency intervention only after neither verbal intervention on the part of the Bank Board members nor forward guidance worked. The verbal intervention consisted of a CNB announcement that if it became necessary to further ease monetary conditions, they would do so by weakening the Czech koruna. This tool affected the market for one year by weakening the koruna by a few tens of hellers.

Table 4–1 Negative interest rates of the selected central banks in September 2019

Central Bank	Basic Interest Rate	Deposit Interest Rate
Danmarks Nationalbank	0.00%	- 0.75%
ECB	0.00%	- 0.50%
Riksbank (Sweden)	- 0.25%	- 1.00%
Swiss National Bank	- 1.25% to -0.25%	- 0.75%
Bank of Japan	- 0.10%	- 0.10%
Central Bank of Hungary	0.90%	- 0.15%

Source: Authors based on websites of selected central banks

As of March 2013, the CNB indicated in advance via forward guidance how they would be proceeding with their monetary policy. In this way, they tried to influence the expectations of economic entities and thus hasten economic revival and the growth of inflation. After the effects of these unconventional nonfinancial instruments receded, the CNB decided to use currency intervention between November 2013 and April 2017, when it committed to pin the Czech koruna's exchange rate at CZK 27/EUR. Directly in the first phase, the CNB purchased euros amounting to EUR 7.5 billion, i.e., roughly CZK 202 billion, This convinced the markets, and the koruna was maintained at the given level without problem up until the summer of 2015, when the CNB gradually made another intervention that consisted of purchasing euros. The CNB intervened on the currency exchange market in the amount of USD 51.4 billion, whereas the SNB invested roughly USD 556.6 billion. The method for concluding the currency intervention differed for the two countries. In the Czech Republic, there was no significant strengthening of the koruna, whereas the Swiss franc increased by 15%.

There were differences not only in the intervention programs' commencement but also in their exit phases. Representatives of the SNB left the domestic currency rate to its "fate", which also subsequently meant that it showed great volatility (Table 4-2). The reason the SNB ended its currency floor was doubts concerning quantitative easing by the ECB, which was likely to result in further pressures pushing the franc higher. The second, relatively specific reason was apprehension by SNB stockholders (the Swiss cantons) that there would be high SNB losses due to abnormal exchange rate risk considering the large amount of assets being held in foreign currencies. Afterward, the SNB used negative interest rates for easing monetary conditions. Nevertheless, interventions have also been conducted in a discretionary manner.

Table 4–2 Comparison of currency intervention by the CNB and the SNB

CB Name	CNB	SNB
Reason for initiation	Ineffectiveness of conventional monetary policy instruments, risk of deflation	strong pressures appreciating the domestic currency as the result of an influx of capital from abroad, competitiveness of exports, the prediction of low inflation
Volume	approx. USD 90 bn	approx. USA 560 bn
Currency intervention goal	Achieving an inflation target of 2%	To weaken the domestic currency, to achieve an inflation target of 2%
Period	2013-2017	Since 2009
Form of intervention	A previously announced, one-sided exchange rate floor of 27 CZK/EUR	A one-sided exchange rate of 1.2 CHF/EUR in 2012-2105
Exit	Tied to meeting the inflation target	Discretionary
Communication about the exit	From the beginning of the commitment	An unexpected exit
Length of duration	An unspecified intervention time	An unspecified intervention time
Regime after exit	Managed floating exchange rate	Free floating exchange rate
Evolution of the nominal rate after exit	The assumed enormous strengthening of the koruna did not occur	Considerable appreciation of the franc by 15%

Source: Authors based on CNB´s and SNB´s websites

During the crisis, the CNB's Bank Board also discussed implementing negative interest rates. However, it did not consider them an appropriate instrument for the Czech Republic's monetary policy. This was a given primarily by the lack of experience with their operation on the financial markets and indirectly on the real markets. Also, there were additional concerns as to the extent to which they would need to lower the negative rate in order to eventually instigate the shift of interbank liquidity to bank loans for companies and consumers. However, there were also opinions that even though implementing negative rates would increase bank costs for maintaining their liquidity, this would not be a fundamental problem considering their profitability. In the end, the Bank Board decided not to begin experimenting with negative interest rates.

Quantitative easing did not make sense under the Czech circumstances, because historically there has been a so-called systemic surplus of liquidity on the Czech banking market. In other words, there is enough "interbank money" on the market and it does not make sense to create more here, when banks have not yet been able to appreciate all the available liquidity. The use of currency intervention in the form of weakening the exchange rate thus prevailed among Bank Board members as the most effective instrument for the Czech conditions. This was because the Czech economy is highly open. Czech exports represent more than 80% of GDP, with import goods having a value over 70% GDP. This means that the Czech economy is highly dependent on changes in the exchange rate – it is one of the most significant variables in our economy.

On the basis of these facts, we can state that none of the central banks examined here implemented unconventional monetary policy in the same way. The common goal of these unconventional policies was to avert the outbreak of deflation, ensure price stability, support economic growth, and contribute to the stability of financial systems.

4.5 Systemic risk in the context of current monetary policy

In previous sections we discussed the role of monetary policy during and after the GFC, now we will focus on systemic risk implications. Several researchers such as Acharya and Richardson (2009) or Diamond and Rajan (2009) highlighted that a loose monetary policy was one of the causes of the GFC as it resulted in risky behaviour of financial companies. Gambacorta (2009) concludes that monetary policy may influence banks' perceptions of risk in two ways: through a search for yield process and by means of the impact of interest rates on valuations, incomes and cash flows, which in turn can modify how banks measure risk.

When evaluating the success of the central banks, often the factor under consideration is whether or not they achieved their goals. This evaluation is usually connected with the achievement of monetary, price, or financial stability. As Borio (2014) warned, the process of achieving financial stability is far too extensive to be ensured by monetary policy alone. For this reason, central banks implement macroprudential policy, which has the goal of achieving financial stability. Recently, economists have also been contemplating the impact of unconventional monetary policy in various countries.

Borio and Disyatat (2010) have clarified the differences between various forms of unconventional monetary policy. At the same time, they provided systematic descriptions for a wide spectrum of central bank behaviour during the period of the global financial crisis, including unconventional monetary policy's effect on inflation. The recent financial crisis resulted in a fundamental reevaluation of analytic approaches to monetary policy as it relates to financial stability. The crisis demonstrated the necessity of focusing more on systemic risk and incorporating the financial sector into macroeconomic models. The shift in monetary policy towards macroprudential policy is visible in the area of regulation and oversight. There is the question of whether it is sufficient to use the achievement of price stability as the criteria for evaluating the effectiveness of monetary policy. As is clear, establishing price stability alone has let to financial instability in some countries (Borio, 2011).

Borio and Shim (2007) place great emphasis on central banks' macroprudential policy, which is key for financial and macroeconomic stability. In the future, central banks should aim to be more focused on macroprudential policy, which should limit the emergence of any financial instability. Macroprudential and monetary policies affect each other mutually, although both have different goals and instruments. At the same time, monetary policy should be treated entirely separately from macroprudential policy, i.e., financial stability (Svensson, 2018). Macroprudential policy instruments lower the financial system's vulnerability and increase its resilience by establishing capital and liquidity cushions, which prevent procyclicality in the financial system. Malovaná and Frait (2017) discuss how monetary and macroprudential policies may interact and potentially get into conflict. They conclude that accommodative monetary policy contributes to a build-up of financial vulnerabilities, what implies that it boosts the credit cycle. Laséen et al. (2017) conclude that a monetary policy tightening surprise does not necessarily reduce systemic risk, particularly when the state of the financial sector is fragile.

More recently, Colletaz et al. (2018) find that causality from monetary policy to systemic risk in the long run in the Eurozone. As a result, they claim that central banks must be aware that a too loose monetary policy stance may be conducive to a build-up of systemic risk. Moreover, Kurowski and Smaga (2019) demonstrates on data from the UK, the Eurozone and the US that the occurrence of potential procyclical behaviour of monetary policy underlines the need for proactive macroprudential policy.

Based on the previous literature survey we state that there is no unique view whether the conventional and non-conventional monetary policy measures reduce or increase systemic risk. However, one can measure systemic risk through various indicators such as Composite Indicator of Systemic Stress (CISS) developed by Holló et al. (2012) and regularly published by the ECB. The CISS indicates a low risk (but rising) of systemic stress in recent years (ECB, 2018).

4.6 Conclusion

Up until the outbreak of the GFC in 2007, central banks conducted conventional monetary policy using changes in interest rates. During the GFC all big central banks including the ECB, the FED, and the BOE were forced to begin to use unconventional monetary policy instruments, because conventional instruments failed in meeting set inflation targets.

When these central banks had interest rates very close to zero, the financial systems had not yet been stabilized, and the economic situation began to rapidly degenerate. The selected central banks took unusual steps in monetary policy by using unconventional monetary policy instruments in order to minimize the impact of the GFC or to turn back the risk of deflation. The FED, the ECB, and the BOE implemented unconventional monetary policy using quantitative easing. Whereas the ECB focused on purchasing covered bonds, the FED and the Bank of England purchased government bonds and other private assets.

In our study we use the definition of systemic risk provided by Benoit et al. (2017) stating that systemic risk is *"the risk that many market participants are* simultaneously *affected by severe losses, which then spread through the system."* Since there has been neither financial crisis nor financial turmoil on global scale in last years, we argue that central bank´s monetary policies have not increase systemic risk until September 2019. This fact is also supported through a decline of the CISS indicator, ECB´s measure of systemic risk, in the 2011-2018 period. However, the recent monetary policies might have contributed to distortions in particular markets (e.g. the Eurozone bond market or the Czech real estate market), what might result in systemic risk in the future.

Chapter 5

Foreign exchange market contagion in Central European countries

By Luboš Komárek and Narcisa Kadlčáková

This chapter examines contagion in the foreign exchange markets of three Central European countries and the Euro area. Contagion is viewed as the occurrence of extreme events taking place in different countries simultaneously and is assessed with a measure of asymptotic tail dependence among the studied distributions. Currency crisis contagion is one strand of this research. However, the main aim of the chapter is to examine the potential of "bubble" contagion. To this end the representative exchange rates are linked to their fundamentals using a cointegration approach. Next, the extreme values of the differences between actual daily exchange rates and their monthly equilibrium values determine the episodes associated with large departures from equilibrium. Using tools from Extreme Value Theory, we analyse the transmission of both standard crisis and "bubble" formation events in the examined currency markets. The results reveal a significant potential for contagion in the currency markets of Central Europe.

5.1 Introduction

Recent developments in financial markets have shown that crises can have quick and often devastating effects in areas far beyond their epicentres. The speed with which the recent US sub-prime crisis reached a global dimension took economists and policy makers alike by surprise. It proved that the global nature of the current market inter-linkages makes the transmission of disequilibria across markets and regions a very likely outcome.

In this chapter we look at the disequilibrium transmission within the foreign exchange markets of three Central European countries (Hungary, the Czech Republic and Poland) and the Euro area. Although no major currency crises have occurred in this region, we analyse the potential co-alignment of such crises in this region. However, the main aim of the chapter is to extend traditional currency crisis analysis by looking at contagion during episodes of significant departure from exchange rate equilibrium values. This offers an insight into how likely it is that disequilibria of a "bubble" type is transmitted in a coordinated manner across the exchange rate markets in this area.

Contagion during the disequilibrium formation process is examined using tools from cointegration and Extreme Value Theory (EVT). Contagion is viewed as the occurrence of extreme events taking place in different markets simultaneously, and is assessed with a measure of asymptotic tail dependence among the studied distributions. Currency crisis contagion is assessed in a standard way, by focusing on the extreme values of exchange rate return distributions. The potential of "bubble" contagion is examined by firstly linking the representative exchange rates to their fundamentals using a cointegration approach. This gives the equilibrium exchange rate values at a coarser (monthly) frequency. Next, the data is considered at a daily frequency and the extreme values of the differences between actual daily asset values and the monthly equilibrium values determine the episodes associated with large departures from equilibrium. Consequently, an EVT-based contagion approach is applied to these departures from equilibrium distributions and this forms the basis for the analysis of transmission of such "bubble" formation events among the analysed currency markets.

The results reveal a significant potential for contagion among the currency markets in Central Europe, both in terms of currency crises and disequilibrium formation. We look at episodes of both depreciation (right tail) and appreciation (left tail) of the examined exchange rates. In all cases our results reveal asymptotic dependence values close to one, which proves that the contagion potential in these markets is very high.

The chapter is organized as follows. Section two offers a brief description of the main approaches used and the related literature. Section three contains an overview of the main developments of the analysed exchange rates. Next section four sheds light on the methodologies employed. The main results of the empirical analysis are presented in fifth section. The final section contains main conclusions of this chapter.

5.2 Contagion and extreme value theory

The empirical analysis undertaken in this chapter draws intensively from cointegration and extreme value theories. Cointegration is a standard textbook methodology that does not require further explanation. The caveat that we bear in mind, however, is that cointegration employs variables covering long time horizons and this raises the question of the existence of structural breaks in the evolution of the employed variables. The presence of structural breaks affects the decision taken with regard to the order of integration of the variables. This is an argument originally put forward by Perron (1989) and carried on in a number of subsequent chapters. The reasoning is that unit root tests have reduced power in the presence of structural breaks, meaning that such tests might be biased towards the non-rejection of the unit root hypothesis even if the data were in reality stationary around a broken deterministic trend.

A stumbling block in testing for unit roots with structural breaks is the fact that these two aspects are closely interrelated. Testing for unit roots requires knowledge about the existence of a structural break and vice-versa. Unless prior knowledge about the existence of an (exogenous) break is already available, deciding where to start is not obvious. A way out of this vicious circle is offered by the methodology of Perron and Yabu (2005). These two authors propose a testing procedure for the existence of a break in the trend function without prior knowledge about the stationary nature of the variables (i.e. I(0) or I(1)). They also indicate a method of endogenously estimating the time of the break. This is done by minimizing the sum of squared residuals from regressions run at each time spot that, besides standard regressors used in the unit root setting, also include time dummies reflecting the modelled trend changes. The methodology of Perron and Yabu is applied in this chapter to test for the existence of one endogenously determined structural break. As the results show, the existence of such structural breaks cannot be rejected for the majority of the employed variables.

If the existence of a break is not rejected with the Perron and Yabu test, unit root tests allowing for a break in the trend function of the type proposed in Kim and Perron (2009) are further employed. These two authors developed a unit root testing methodology assuming the existence of one break whose time of occurrence is not a-priori known. Their break identifying method coincides with the one proposed in Perron and Yabu and thus the timing of the break is the same under both approaches. If the null hypothesis of a break is rejected, the decision about the stationary nature of the series is based on standard Augmented Dickey-Fuller (ADF) and Phillips-Perron tests.

This chapter draws from the EVT part of the vast amount of economic literature related to currency and, more generally, financial crises. In the EVT approach, financial crises are viewed as rare and extreme events whose occurrence is governed by different laws than those governing the entire domain of studied asset return distributions. The focus is on the tails of the distributions. This allows the avoidance of some typical 1 misassumptions, of which the most commonly made are that (a) the analysed empirical distributions follow normal distributions and (b) the Pearson correlation is a good measure of crisis dependency.

In fact, it is a common finding in the economic literature that asset returns significantly depart from the assumption of normality in the majority of markets and asset type studied. As a rule, empirical asset returns display fat tails, implying that the probability of extreme events is higher than studies based on the normal distribution usually assume. Additionally, asymptotic dependence or tail-based dependence measures are usually quite different from linear dependence measures proxied by the Pearson correlation. Embrechts and al. (2002) and de Vries (2005), for instance, proved that tail dependence may still be significant among variables with a zero Pearson correlation. It is also true that asymptotic dependence is zero in the case of bivariate normal distributions with a non-zero but less than one Pearson correlation.

This chapter draws inspiration from several chapters employing EVT in the crisis context. Cumperayot and Kouwenberg (2011) used EVT to search for asymptotic dependence between exchange rates and several macroeconomic variables, in an attempt to find early warning systems for currency crises. From a rather comprehensive list of macroeconomic variables, asymptotic dependence was found only between domestic real interest rates and exchange rates. Their methodology was based on the approach of Poon et al. (2004) who were the first to formalize two measures of asymptotic dependence/independence for two random variables - these will be used in this chapter too.

The first measure is rather intuitive. Asymptotic dependence is examined based on the conditional probability that one variable takes extreme values given that the second variable is taking such values. If the limit of such a conditional probability goes to zero when we move more deeply into the tails of the distributions, then the two variables are said to be asymptotically independent. Otherwise, if the limit is non-zero, they are considered to be asymptotically dependent.

A second measure is the measure of extreme association in the tails. It shows the speed with which conditional probability decays to zero. It has been proved (Ledford and Tawn, 1996) that this second measure equals one for all asymptotically dependent variables but is less than one for asymptotically independent ones. Consequently, the decision about asymptotic dependence is taken based on a test of equality to one of the second measure. If this hypothesis cannot be rejected, the two variables are said to be asymptotically dependent and the limiting conditional probability is computed. If the above hypothesis can be rejected, the two variables are said to be asymptotically independent and the conditional probability is zero at the limit. Poon et al.'s approach was discussed and applied in a comparative manner by Schmuki (2008) who also provided a Matlab code for its practical implementation. In this chapter, we employ Poon et al's approach and a slightly adjusted version of Schmuki's code to compute the two measures of asymptotic dependence.

Contagion in other markets, using tools from EVT, has been studied by Hartmann et al. (2004). Focusing on the co-movement of extreme returns in bond and stock markets in the G5 countries, these authors found that the potential of co-crashes in stock markets and bond markets was substantial. Moreover, contagion from stock to bond markets was as frequent as flight to quality from stocks to bonds in times of crises of the former. International crisis linkages were similar to those found in the national context, a result that underscored the downside risk of financial integration. Hartmann et al. (2010) focused on contagion in exchange rate markets in relation to the statistical properties of the exchange rate fundamentals. Although interesting insights are gained from these chapters, their methodological approach is different from the one used in this chapter and will not be further commented on here.

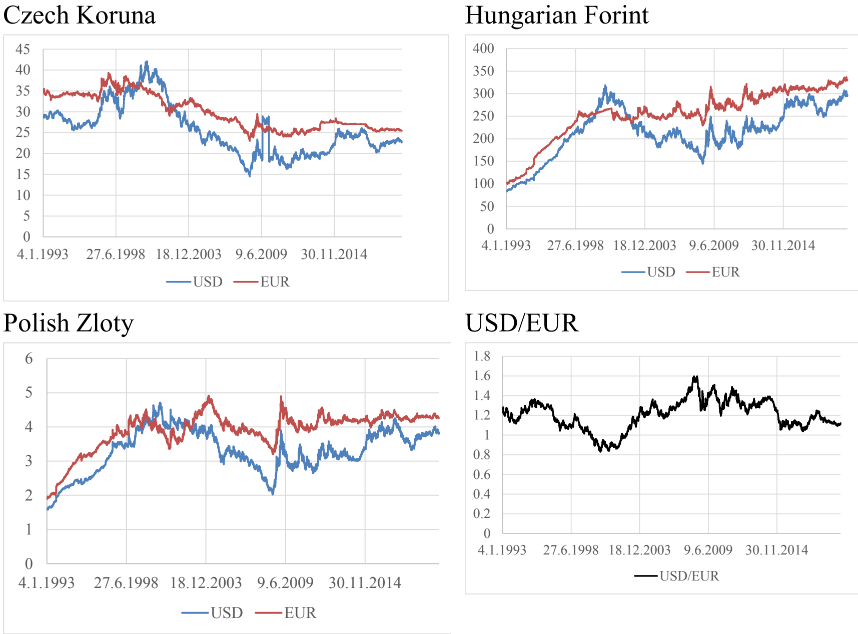
5.3 Exchange rate developments and crisis episodes in CEE

At the beginning of their transformation Central European economies (CEE) had limited capacity for absorbing large exchange rate fluctuations and that is why they initially preferred currency arrangements that limit the flexibility of the exchange rate (basket peg, adjustable peg, crawling peg). The main factors were poor development of markets, liberalization of prices and trade at the beginning of the transformation. Economic growth and the liberalization of the capital account attracted foreign direct investments. Subsequently, in the second half of the 90s, remarkable progress was made with respect to disinflation; economic development was accompanied by political and social pressure. Under such circumstances, many countries had to resist speculative attacks against their domestic currencies, which resulted to sharp movements of exchange rates (Chart 1). The most visible from among the Central European economies was the situation at the Czech Republic in May 1997. During this advanced transition phase, the Czech Republic, Poland and finally also Hungary switched to more flexible regimes (managed floating or free floating) with an inflation targeting framework (Table 5–1). This change in exchange rate strategy was consistent with both domestic factors (the progressive capital account liberalization in the CEEs) and external factors (the increasing risk of speculative attacks as a result mainly of Asian 1997 and Russian 1998 financial crisis). On the basis of the described changes of monetary and exchange rate regimes in CEE one can distinguish the main periods for subsequent empirical investigation.

In the Czech Republic we can distinguish three key periods. The first (1993:01-1996:02) was an exchange rate targeting period with conventional fixed parity of the Czech koruna. The second (1996:02-1997:12) period was related to transitional monetary strategy toward inflation targeting. An intermediate exchange rate regime in the form of a corridor was implemented, followed by the process of moving to a managed floating exchange rate regime- as a result of significant exchange rate turbulences in May 1997. The third (1997:12-now) period was an inflation targeting period combined with a managed floating exchange rate regime, which used FX intervention at the beginning of this period (until 2002:09) as a tool for macroeconomic stabilisation. The CNB Bank Board decided to use the exchange rate as a monetary policy instrument, and therefore to commence foreign exchange interventions, on 7 November 2013.[32] For the Czech Republic, as a small open economy with a long-term excess of liquidity in its banking sector, this is a more effective instrument for easing the monetary conditions than any other. The CNB Bank Board decided to end the CNB's exchange rate commitment on 6 April 2017.

[32] The decision to use the koruna exchange rate as a potential additional tool for monetary policy easing after the lower bound on interest rates was reached was made in autumn 2012

Figure 5–1 Development of Koruna, Forint and Zloty against USD and EUR



Source: CNB, MNB, NBP, and Thomson DataStream.

The Polish experience with exchange rate management leads us to distinguish also three main periods. In the first (1990:01-1995:05) Polish zloty plays the role of nominal anchor. The Exchange rate regime was arranged as conventional fixed parity and crawling peg with a decreasing rate of crawl. In the second (1995:05-2000:04), again as in the Czech Republic, a transitional monetary strategy toward inflation targeting was applied. The exchange rate regime was designed as a crawling corridor regime with widening fluctuation margins and a decreasing rate of crawl. The recent period (2000:04-2009:01) is characterized as a period of explicit inflation targeting and free exchange rate floating. FX intervention was not used as the tool of monetary policy.

The Hungarian strategy with exchange rate regimes was slightly different compared to the Czech or Polish one. It was oriented on a long term basis to different peg arrangements, which delivered the possibility of balancing between fixed and floating exchange rates. The Hungarian case could be divided into four main stages of development. Firstly (1990:01-1995:03) they applied an adjustable peg, which also played the role of nominal anchor. The spring of 1995 saw a stabilization program, because Hungary was regarded by international financial institutions as the next candidate for financial crisis after Mexico in 1994. The second stage was (1995:03-2001:04) oriented to the application of a crawling peg, which was afterwards changed to a horizontal peg (2001:05-2008:02). From the end of 2008 Hungary applied free floating regime.

Table 5–1 Exchange rate regimes: Czech Republic, Hungary and Poland

Czech Republic
03/03/1993 – 29/02/1996: Basket Peg (65% DEM, 35% USD), Band ±0.5%
01/03/1996 – 26/05/1997: Basket Peg (65% DEM, 35% USD), Band ±7.5%
27/05/1997 – present: Managed Float
(07/11/2013 – 06/04/2017: Exchange Rate Commitment)
Hungary
02/06/1993 – 15/05/1994: Adjustable Peg (50% DEM, 50% USD), Band ⟨±0.3; ±2.25%⟩
16/05/1994 – 15/03/1995: Adjustable Peg (70% ECU, 30% USD), Band ⟨±0.3; ±2.25%⟩
16/03/1995 – 31/12/1998: Crawling Peg (70% ECU, 30% USD), Band ±2.25%
01/01/1997 – 31/12/1998: Crawling Peg (70% DEM, 30% USD),, Band ±2.25%
01/01/1999 – 31/12/1999: Crawling Peg (70% DEM, 30% USD), Band ±2.25%
01/01/2000 – 30/04/2001: Crawling Peg, (100% EUR), Band ±2.25%
01/05/2001 – 25/02/2008: Horizontal Peg (100% EUR), Band ±15
26/02/2008 – present: Free float
Poland
14/10/1991 – 05/03/1995: Crawling Peg (45% USD, 35% DEM, 10% GBP, 5% FRF, 5% CHF), Band ±0.6%
06/03/1995 – 15/051995: Crawling Peg (45% USD, 35% DEM, 10% GBP, 5% FRF, 5% CHF), Band ±2%
16/051995 – 24/02/1998: Crawling Peg (45% USD, 35% DEM, 10% GBP, 5% FRF, 5% CHF), Band ±7%
25/02/1998 – 31/12/1998: Crawling Peg (45% USD, 35% DEM, 10% GBP, 5% FRF, 5% CHF), Band ±10%
01/01/1999 – 25/03/1999: Crawling Peg (45% USD, 55% EUR), Band ±10%
26/03/1999 – 11/04/2000: Crawling Peg (45% USD, 55% EUR), Band ±15%
12/04/2000 – present: Free float

Source: Czech National Bank, Magyar Nemzeti Bank, National Bank of Poland

A summary of in-sample extreme movements of the exchange rates is displayed in Table 5–2. Although longer span data were available for the Central European countries, their extreme statistics are shown here only over the period used to assess contagion.

Table 5–2 shows the lowest/highest daily changes of the exchange rates over the period January 1st, 1999 – February 29th, 2012, together with the specific dates when these values occurred. For example, the maximum daily appreciation and depreciation values of the Czech crown were 5.737% (29th of October 2008) and 4.999% (4th of April 2002), respectively. To get a better glimpse on how crisis events are identified in the chapter, the threshold values defining the tails are also shown. For example, in the Czech case, extreme depreciation changes are those exceeding the 1.308% daily value which is the 95% quintile of the empirical distribution of the Czech daily exchange rate changes.

Table 5–2: Extreme values and tail defining thresholds of the exchange rates

	Left tail - Appreciation			
	Min	**Date**	**Tail Threshold**	**Date**
CZ	-5.737%	29.10.2008	-1.256%	1.10.2010
EU	-4.617%	19.3.2009	-1.054%	8.10.2004
HU	-5.520%	29.10.2008	-1.452%	13.12.2004
PL	-21.487%	5.1.2009	-1.339%	30.12.2010
	Right tail - Depreciation			
	Max	**Date**	**Tail Threshold**	**Date**
CZ	4.999%	4.4.2002	1.308%	26.10.2010
EU	3.845%	19.12.2008	1.056%	11.2.2009
HU	6.967%	10.10.2008	1.580%	26.6.2003
PL	23.061%	2.1.2009	1.523%	14.12.2007

We are aware that this "crisis" identifying method might rely considerably on in-sample information. However, perfectly objective guidelines for identifying asset crises are rarely available in empirical work. We think that our method is still superior to crisis identifying criteria of the type "plus/minus two standard deviations", which, besides the fact that they exploit the same in-sample information, may be subject to additional and often neglected limitations[33]. The analysis undertaken here should be viewed as an attempt to analyse coordinated extreme exchange rate movements. This could offer to policy makers in the concerned countries a first indication about the potential of synchronized exchange rate crises.

5.4 Loss absorbency in resolution as a major potential threat

To test for one structural change in the trend function of a variable when information about the stationary nature of the variable is not available, we apply the methodology of Perron and Yabu (2007). Their model specification is similar to Perron (1989) and allows the implementation of three types of structural change:

[33] To mention only one, is the fact that some empirical distributions might have such fat tails that computing their second moment is not possible. In these cases, the "plus/minus two standard deviations" rule is completely flawed.

a change in intercept (model 1)

$$X_t = a + b \cdot t + \beta \cdot DU_t + \alpha \cdot X_{t-1} + \sum_{i=1}^{k} \lambda_i \cdot \Delta X_{t-i} + \varepsilon_t ,$$

a change in slope (model 2)

$$X_t = a + b \cdot t + \gamma \cdot DT_t + \alpha \cdot X_{t-1} + \sum_{i=1}^{k} \lambda_i \cdot \Delta X_{t-i} + \varepsilon_t$$

a mixed model allowing for a change in both intercept and slope (model 3)

$$X_t = a + b \cdot t + \beta \cdot DU_t + \gamma \cdot DT_t + \alpha \cdot X_{t-1} + \sum_{i=1}^{k} \lambda_i \cdot \Delta X_{t-i} + \varepsilon_t$$

Here DU and DT are dummy variables controlling changes in intercept and slope, respectively:

$$DU_t = \begin{cases} 1 & if\ t > TB \\ 0 & otherwise \end{cases} \quad and \quad DT_t = \begin{cases} t - TB & if\ t > TB \\ 0 & otherwise \end{cases}.$$

and TB is the supposed time breakpoint. The augmented form of the regression is used to correct for serial correlation in error terms.

The procedure is a sequential one. It requires computing Wald statistics (Wt) for testing the null hypothesis that the coefficients of the relevant dummy variables are zero at each considered break point candidate. The Exp-functional of Andrews and Ploberger (1994) is further constructed based on Wald statistics at all considered break points:

$$ExpW = \log\left[\frac{\sum_t \exp\left(\frac{1}{2} W_t\right)}{N}\right]$$

The ExpW functional has almost identical limit distributions under both assumptions of I(0) and I(1) residuals, thus providing a testing procedure with similar sizes in both cases. It also has good power properties in finite samples given the use of a bias-corrected value of the autoregressive parameter α. The critical values of the test are determined by simulations and are based on the asymptotic distributions of the ExpW test. The decision about the existence of a break is taken in a standard way, involving a comparison of the computed ExpW statistic with the critical values at the chosen significance level.

In terms of EVT, a relatively standard approach is followed in this chapter. At the univariate level we assess the degree of tail fatness of the distributions using the tail index. A distribution has heavy tails if it varies slowly at infinity, in other words if a positive parameter α exists such that:

$$\lim_{t \to \infty} \frac{1 - F(t \cdot x)}{1 - F(t)} = x^{-\alpha} , \quad x>0.$$

This means that in the case of a distribution with fat tail, tail probabilities decrease according to a power law, which is much slower compared with the exponential decay followed in the case of the normal distribution.

The parameter α is called the tail index and is customarily estimated with the Hill estimator:

$$\alpha = \left[\frac{1}{K} \sum_{I=1}^{K} \ln \frac{X_{N-I+1}}{X_{N-K}} \right]^{-1}.$$

Here K represents the number of observations in the tail and the values in the sum are the values above the chosen tail threshold.

The inverse of the parameter α (γ, or the shape parameter) describes the shape of the tail. Positive values of γ are characteristic for distributions with fat tails, while a γ value of zero is representative for the normal distribution. For a positive γ, the number of existent moments of the distribution is determined by the tail index α. Thus, the number of moments that can be reliably computed for a distribution with fat tails equals the greatest integer that is less or equal to α.

Turning to multivariate EVT, a measure of asymptotic dependence can be derived starting from conditional probabilities of the type:

$$P\left(X > F_X^{-1}(q) | Y > F_Y^{-1}(q) \right)$$

This gives the probability that the random variable X takes an extreme value given the occurrence of an extreme event in Y. Here extremeness is defined with the q quintile, which is in general bounded by the 10% value on both ranges of the distribution. In our case, the 5% and 95% left and right ranges have been used. Asymptotic dependence in the right tail is defined with the limit of the above conditional probability when q tends to one:

$$\chi = \lim_{q \to 1} P\left(X > F_X^{-1}(q) | Y > F_Y^{-1}(q) \right)$$

We follow the approach of Poon et al. (2004) who describe the asymptotic dependence structure in the bivariate case with the help of the already mentioned two measures $(\chi, \bar{\chi})$, the first of which is a limit of the type defined above and the second is a measure of the speed of convergence of the conditional probabilities to zero. If χ is non-zero, the variables are said to be asymptotic dependent and the limit χ measures the degree of such dependence. If χ is zero, the variables are asymptotic independent but the parameter $\bar{\chi}$ measures the amount of extreme association or the speed with which extreme events converge to zero for both tails.

In this chapter the approach of Poon et al. is closely followed. We first apply unit Frechet transformations to the original data in order to eliminate the impact of the marginal distributions on the bivariate distribution function but to preserve the original dependence structure. The parameters χ and $\bar{\chi}$ are computed for the transformed series and the decision regarding asymptotic dependence/independence involves the following steps: (1) test the null hypothesis $\bar{\chi} = 1$ ($\bar{\chi}$ follows a normal distribution), (2) if this hypothesis is rejected the series are asymptotic independent (χ=0), (3) if $\bar{\chi} = 1$ cannot be rejected the variables are asymptotic dependent and compute χ, the final asymptotic dependence measure.

5.5 Empirical findings

The representative assets are the exchange rates of three Central European countries (Czech Republic, Hungary and Poland) and the Euro vis-à-vis the US dollar. The quest for fundamentals is based on a money-income model (see, for example Engel and West, 2003) that is summarized by the following equation:

$$s_t = \alpha_0 + \alpha_1 \cdot (m_t - m_t *) + \alpha_2 \cdot (y_t - y_t *) + \alpha_1 \cdot (p_t - p_t *) + \alpha_1 \cdot (i_t - i_t *) + \varepsilon_t$$

Here s_t is the logarithm of the nominal exchange rate versus the dollar, m_t is a measure of money supply (M1), y_t is a proxy for output (industrial production, IP), p_t is the Consumer Price Index (CPI) and it is the money market interest rate (IR). Excepting the interest rates, which enter the regression as differences from the US interest rate values, all other variables are expressed in logarithmic form and are measured relative to the corresponding US variables.

Dividing the variables by the corresponding US values offers a convenient way to isolate common external shocks affecting the variables. Equation 1 can be viewed as a combination of different simple exchange rate determination models, i.e. purchasing power parity, interest parity conditions or the asset view of the exchange rates, viewing exchange rates as determined by the ratio of two monetary stocks.[34]

5.5.1 Unit root tests

Cointegration tests can be conducted only among variables with the same order of integration. Preliminary standard Dickey-Fuller and Phillips-Perron tests including a linear deterministic trend and an intercept, suggested that all nominal exchange rates (in logarithmic form) and the majority of the macro variables considered were I (1) processes. However, we further tested for the presence of structural breaks in the deterministic functions of the variables. As already mentioned, this was done to account for the reduced power of unit root tests in the presence of structural breaks. The reduction in power of the unit root tests would imply a non-rejection of the unit root hypothesis even if the data were in reality stationary around a broken deterministic trend.

The Perron and Yabu methodology was applied in considering two types of structural change: (a) a change in the growth model described by a change in the

[34] The data were collected primarily from the International Financial Statistics (IFS) database of the IMF. However, a few variables were not available there and in those cases alternative data sources were used (Datastream and the Arad database of the Czech National Bank).

slope of the deterministic trend (model 2) and (b) a mixed model that considers a change in both slope and intercept (model 3). Beyond accommodating one-time changes of the mentioned type, mixed models additionally offer a good approximation for trend changes, which are not one-time events but take place gradually in time.

With the exception of the Euro/USD exchange rate variable, the hypothesis of a break cannot be rejected in any other exchange rate case. Thus, for the Euro/USD exchange rate, standard ADF and Phillips-Perron unit root tests were applied concerning its stationary nature. These tests suggested that this variable contained a unit root.

It is worth mentioning that in many cases the existence of a break could be rejected according to model 2 but not according to model 3. This result does not necessarily deny the existence of a break in slope. It brings evidence that the change was rather a gradual adjustment and not a one-time change. The final decision about the existence of a structural break will in the end be taken based on the results obtained with model 3.

In all the cases where the presence of a break was confirmed by the Perron and Yabu tests, Kim and Perron unit root tests were unable to reject the unit root hypothesis. Overall, it appears that, after controlling for the presence of a structural break, all variables are characterized by the presence of a stochastic trend. Searching for higher orders of integration, the unit root hypothesis was rejected for differenced variables in all cases excepting Polish CPI. Thus, almost all series appear to be I(1). In the Polish CPI case, the unit root hypothesis applied to the differenced series was rejected with the Phillips-Perron test but not with ADF. It is thus arguable whether this variable is I(2) or not.

5.5.2 Cointegration

Given that the majority of variables are I(1), we tested for the existence of a cointegration relationship of the type described in (1) using a standard Johansen methodology. In the Hungarian case both trace and rank tests supported the existence of one cointegration relationship. In the Czech, Polish and the EU cases the presence of two cointegration relationships was supported by these tests. In the Polish case, by excluding the CPI variable one cointegration relationship was supported among the remaining variables. It might be the explosive nature of the CPI that did not allow it to be cointegrated with the remaining variables. In the Czech and the EU case one cointegration relation could be found by excluding the M1 variable. In all these three cases, the variables that contained a stochastic trend not integrated with the others were eliminated from the analysis.

The cointegration relationships were estimated with a Canonical Cointegration Regression (CCR) method and are displayed in Kadlčáková and Komárek (2017). They express the equilibrium relations between exchange rates and their macroeconomic fundamentals. As a final step, the equilibrium exchange rates were computed as a linear combination of the macro variables entering the cointegration relationship.

A graphical representation of the actual daily exchange rates and their monthly equilibrium levels is contained in Kadlčáková and Komárek (2017). The final time span differs among countries, given different time availability for different variables at the country level. When implementing the EVT approach, the time span is restricted to the longest common denominator for all variables, which is 1st of January 1999-29th of February 2012.

Implementing the EVT approach requires variables that are identically and independently distributed. However, correlograms of the deviation from equilibrium series obtained so far[35] (at daily frequency) showed strong evidence of first-order autocorrelation, with the potential of second-order autocorrelation in the Polish case. Additionally, the variance of these series was not constant over time, implying that the assumption of homoscedasticity was also violated. For these reasons, we filtered out the autocorrelation and heteroscedacity from the deviation series by estimating GARCH regressions in which the mean equation contained lagged terms of the specified orders and the volatility was modelled through GARCH specifications of adequate orders. In order to account for error term distributions with heavy tails, the assumed error distribution in these regressions was a Student t distribution. In the case of the exchange rate return series only the homoscedasticity assumption was not met. Thus, in this case the GARCH modelling considered only a constant in the mean equation.

Table 5–3 Tail indices of the distributions

	Deviations from equilibrium		**Exchange rate returns**	
	Right (depreciation)	Left (appreciation)	Right (depreciation)	Left (appreciation)
CZ	2.13	2.04	3.39	3.47
EU	2.17	2.04	4.28	4.00
HU	2.51	2.35	3.71	4.10
PL	2.17	2.03	3.45	3.87

It is clear that extreme values are present, a fact also reflected by the heavy tails of the empirical distributions. In fact, in all cases the kurtosis largely exceeds the value 3 characteristic for normal distribution (it takes values between 22 and 38) and the skewness also suggests deviations from the normal distribution[36]. Although the normality assumption is rejected in all these cases, the third and

[35] These residuals should not be confounded with the residuals from the cointegration tests, which should satisfy the i.i.d. condition given the inclusion of lagged terms in these tests' specifications.

[36] In fact, the tail indices of these distributions are less than 3, suggesting that the third and fourth-order moments do not even exist in these cases.

fourth order moments show values closer to those representative for the normal distribution (somehow less so in the Polish case).

5.5.3 Extreme value theory

The mentioned EVT tools are applied to assess the degree of asymptotic dependence among different distributions. The analysis takes into account both the left and the right tails, thus separately examining depreciation and appreciation episodes, both in terms of exchange rate returns and deviations from equilibrium. The tail indices (α parameter) at the country level are given in Table 5–3 5–3.

Table 5–4 Measures of bilateral asymptotic dependence

a) Deviations from equilibrium series

	Depreciation (right tail)			**Appreciation (left tail)**		
	$\bar{\chi}$	Hypothesis $\bar{\chi}=1$	χ	$\bar{\chi}$	Hypothesis $\bar{\chi}=1$	χ
CZ_EU	0.960	Not rejected	0.924	0.924	Not rejected	0.946
CZ_HU	0.944	Not rejected	0.944	0.906	Not rejected	0.945
CZ_PL	1.026	Not rejected	0.944	0.875	Not rejected	0.936
HU_EU	0.933	Not rejected	0.924	0.968	Not rejected	0.945
PL_EU	1.026	Not rejected	0.924	0.922	Not rejected	0.936
HU_PL	0.925	Not rejected	0.947	0.946	Not rejected	0.936

b) Exchange rate return series

	Depreciation (right tail)			**Appreciation (left tail)**		
	$\bar{\chi}$	Hypothesis $\bar{\chi}=1$	χ	$\bar{\chi}$	Hypothesis $\bar{\chi}=1$	χ
CZ_EU	0.969	Not rejected	0.929	0.962	Not rejected	0.940
CZ_HU	0.966	Not rejected	0.947	0.950	Not rejected	0.940
CZ_PL	0.947	Not rejected	0.872	0.950	Not rejected	0.940
HU_EU	0.962	Not rejected	0.929	0.986	Not rejected	0.950
PL_EU	0.906	Not rejected	0.872	0.978	Not rejected	0.947
HU_PL	0.941	Not rejected	0.872	0.969	Not rejected	0.947

As can be seen from Table 5–3 both distributions display fat tails (γ>0). For the exchange rate return series, the existence of third-order and in some cases fourth-order moments is assured since α is greater than 3. However, for the deviation from equilibrium series the maximum number of moments is two, meaning that only the mean and the variance can be reliably computed from their empirical distribution. Here extremeness is defined with the q quintile, which we chose to represent the below 5% and above 95% ranges of the distributions. The estimated parameters χ and $\bar{\chi}$ according to the Poon at al.'s approach are shown in Table 5–4 .

Four cases are again distinguished, involving the two distributions and their left (appreciation) and right (depreciation) tails. The results suggest that significant tail dependence is present among all the pairs of exchange rate variables considered in this chapter.

5.6 Conclusion

The objective of this chapter was to empirically analyse the potential for contagion in three exchange rate markets in Central Europe and the EU. Tools pertaining to Extreme Value Theory offered a suitable methodological approach and were used in conjunction with unit root tests allowing for the presence of structural breaks and cointegration.

The main finding of the chapter is that the potential for contagion in the exchange rate markets of this region is particularly high. Conceived both in terms of currency crises and deviations from equilibrium, we found that all pairs of examined exchange rates exhibited high values of asymptotic dependence both on the depreciation and appreciation side.

A further insight into the behaviour of exchange rates in this region was offered by the tests of structural changes implemented in conjunction with the unit root hypothesis. It is interesting to note that with only one exception, all the variables used in this chapter showed evidence for a structural break. The presence of such breaks is usually neglected in the empirical studies dealing with these markets and this might render the conclusions reached there less reliable.

Another interesting result of the chapter was that support for cointegration was found among all exchange rates and the small set of macro variables that we proposed as fundamentals. This result shows that these markets function in accordance with basic theoretical models, if not on a standalone basis at least as the interplay of more factors. Based on cointegration we were also able to distinguish episodes of divergence from equilibrium. It is worth noting that these were mostly predominant during the early transition period and accentuated to some extent during the recent global financial crisis. The chapter also offered interesting insights into exchange rate developments in these countries from a long-term perspective.

Chapter 6

Risks associated with the transition to fixed exchange rate regimes

By Mojmír Helísek

6.1 Introduction

One of the source of financial instability are currency (foreign exchange, speculative) crises associated in particular with fixed exchange rate regimes. Member states of the EU replacing their national currency with the euro will (sooner or later) also have to transition to such a regime. This is one of the Maastricht convergence criteria (the criterion of exchange rate stability), which in particular means to peg the given currency to the euro in *Exchange rate mechanism* ERM II for a period of at least two years. A condition is to maintain the so-called "normal fluctuation margin" without "severe tension", in a manner that prevents devaluation of central parity.

The objective of this chapter is to specify the circumstances under which a national currency becomes part of ERM II (including historical experiences) and find potential risks of currency crisis during the transition to a fixed exchange rate regime. After a review of the literature, there follows an explanation as to why these regimes are more susceptible to currency crises. The next section of the chapter focuses on empirical facts – what exchange rate regimes were (or have been) used in ERM II and whether they have been associated with currency crises. This empirical section is followed by a theoretical section which first characterizes three generations of currency crisis models and seeks a suitable model for ERM II conditions. The continuation of this theoretical section contains an articulation of the risks that lead to a hypothetical currency crisis in ERM II as well as the circumstances that weaken these risks. The last section is devoted to the Czech koruna become part of ERM II in terms of selecting a suitable exchange rate regime.

With regard to methodology, we use two approaches for assessing currency crisis risks when a national currency becomes part of ERM II. First we evaluate (through analysis and comparison) the existing empirical knowledge associated with national currencies becoming part of ERM II. We define the criteria for "currency crisis", which we then compare with indicators of its actual development:

- exchange rate development,
- indicators of pressure on exchange rate (i.e. "severe tension").

Has a currency crisis ever occurred in ERM II? For this we use statistical data from Convergence Reports of the European Central Bank and from national statistical databases.

Second we use various theoretical models of a currency crisis (application modelling). Which of these models can be applied to the conditions of a peg in ERM II? We evaluate the selected model as follows:

- in its original (general) variant for any "peg" exchange rate,
- in our (specific) variant for a peg in ERM II.

The result is our modified model containing specific risks and specific causes of their weakening in ERM II.

The subject of our research is therefore the connection between the fixed exchange rate and the hypothetical currency crisis. We do not deal with many other consequences of fixing the exchange rate, i.e. the loss of an independent monetary policy and of the exchange rate policy, especially the danger of the so-called internal devaluation.[37]

6.2 Literature review

Empirical studies prove that currency crises more frequently occur for currencies maintaining a fixed exchange rate regime when compared to currencies maintaining a flexible exchange rate regime. Older studies (such as Bubula and Otker-Robe, 2003) and newer studies alike (such as Zhao et al., 2014, or Melvin and Norrbin, 2017) have reached this conclusion.

A range of authors[38] report the risk of a currency crisis using *fixed exchange rates in ERM II*. We differentiate this literature into two timeframes, prior to and following accession of new EU Member States to the euro area (beginning with Slovenia in 2007).

Most frequently the risk of a fixed exchange rate in ERM II is associated with concurrent free movement of capital. According to Begg et al. (2002, p. 70):

[37] "Today, studies seem to recognise that without an autonomous monetary policy and a flexible exchange rate, their economies might be forced to undergo painful "internal devaluations" in cases of severe asymmetric shocks." (Gabrisch, Kampfe, 2013, p. 181).

[38] For the position of Czech authors (in relation to the Czech koruna) see section 7.

“However, crises, particularly of the contagion type, cannot be ruled out in any scenario that combines full capital mobility with the ERM-II.” “However, crises, particularly of the contagion type, cannot be ruled out in any scenario that combines full capital mobility with the ERM-II.”

Similar statements are made by Égert – Kierzenkowski (2003, p. 22): “In the context of fully mobile capital flows, the defensible nature of the asymmetric band,[39] especially on the weaker side seems to raise some doubts in times of financial turmoil.” whereas not even the 15% limit of deviations around central parity are sufficient to reverse a strong attack.”

Krawczyk (2004, pp. 7-9) compares the ERM mechanism (part of the European Monetary System, EMS) with ERM II. He sees risks of becoming part of ERM II in the following relevant directions: 1) In the original ERM system the parity of two currencies was always established and both countries of the exchange rate pair were involved in retaining this parity (via foreign exchange market interventions). In the ERM II system this consists of maintaining parity against the euro and the ECB (according to Krawczyk) has no obligation to maintain this parity. For this reason, even under a relatively broad fluctuation band the ERM II is just as susceptible to crises as the original ERM exchange rate mechanism. 2) Membership of new countries in the EU was conditioned on free mobility of capital. There are a range of circumstances such as loss of faith in economic policy or increased inflation expectations that lead to rapid outflow of capital, which is not compatible with maintaining a peg in ERM II. Krawczyk reaches the following conclusion: “It seems possible to argue that insisting on the ERM II participation […] means a disregard to the experience of the 1990s currency crises and makes the waiting period inside the ERM II likely to become a self-defeating experiment.” (p. 9)

For similar findings see Backé et. al. (2004, p. 6): “Acceding countries regard ERM II as an intermediate exchange rate regime, subject to risks of speculative attacks.” Dyson (ed., 2006) warns against “speculative attacks” while joining ERM II: “Critics loath the ERM II as a »soft peg« prone to speculative attacks” (p. 163[40]). The cause of these attacks is the destabilization of investor expectations, prompted on the one hand by monetary policy, on the other hand by exchange rate fluctuations. It is explained here also why not only the Czech Republic but also Poland seeks to spend as little time as possible in ERM II. “The concern in both cases is that financial markets will use participation in the ERM II as an excuse to speculate against their national currencies.” (p. 99, chapter author E. Jones) Likewise, Baldwin and Wyplosz (2006, p. 397) consider entry to

[39] The asymmetry of the fluctuation band lies in its interpretation by the European Commission: the original band of 2.25% in the direction of depreciation, and the band of 15% in the direction of appreciation, should be respected.

[40] The author of this chapter (F. Bonker) continues: “Participation in ERM II thus requires a far-reaching shift in monetary and exchange-rate policy, which can further increase the risk of a currency crisis by destabilizing the expectations of investors.”

ERM II as "a delicate step where full capital mobility and an exchange peg may trigger speculative attacks."

Concerns of currency crisis at the time of becoming part of ERM II also appear after the experiences of new member states. Michalczyk characterizes risk of speculative attacks as follows (2011, p. 128): "[…] it must be remembered that formal accession to the ERM II, although assumed to result in a higher degree of the exchange rate stability, may cause tensions in the foreign exchange market, being a consequence of speculation and the desire to "test" the authorities by market entities (vide European currency crisis in first half of the nineties)." Palankai presumes that the Hungarian forint may be considered an example of the threat to currency in ERM II. It was pegged to the euro with oscillation of ± 15% in the years 2001-2008. Free floating was then introduced "just due to the speculative threats of the financial crisis" (Palankai, 2015, p. 54).

De Grauwe (2016, p. 155) considers ERM II a merely temporary regime that enables rapid acceptance of the euro. In the opposite case (when entry to the euro area is put off), participation in ERM II is undesirable. "It may then face similar problems to those the EMS experienced in 1992-1993 with speculative crises and a collapse of the arrangement." Concerns of "Spekulationsbewegungen" during participation in ERM II are also expressed by Brasche (2017, p. 227).

6.3 Fixed exchange rate and currency crisis

According to the standard definition, a currency crisis is a significant depreciation of the nominal exchange rate of a given currency. This devaluation is caused by loss of investor confidence in this currency. This leads to an *expectation of devaluation* of this currency.[41] Investors therefore transfer their assets in this currency into assets in other currencies. These represent two groups of investors. In the case of investors engaged in speculation, these trades are designated as "attacks by greedy speculators" who wish to maximize their profits. In the case of investors who diversify the assets in their portfolios, this is considered the "flight of careful investors" who want to minimize their losses. Central banks typically oppose a fixed exchange rate after a certain time, which leads to a decrease in their foreign exchange reserves and to interest rate increases. They can also implement administrative control of capital movements. However, investors ultimately force the central bank to devalue or (more often) to abandon the fixed exchange rate of the currency and its subsequent depreciation.

When defining a currency crisis empirically, a distinction is typically drawn between the narrower and broader concept of a crisis (Glick and Hutchison (2011, pp. 7-8). According to the *narrow concept*, a currency crisis results if the exchange rate of the given currency vis-à-vis reference currency (typically USD) exceeds the average annual level of devaluation of 25% and simultaneously the increasing

[41] The most common causes of devaluation of expectations (and simultaneously indicators of a currency crisis) are worsening government balance, falling central bank reserves, increasing money market rate (Babecký et al. 2012, p. 24).

of the rate of depreciation (year-on-year basis) is at least 10 p.p. (this criterion, which is still in use, was introduced by Frankel, Rose, 1996, pp. 352-353; other authors modify it in various ways). According to the *broader concept* a currency crisis is identified using an index of pressure on the exchange rate containing not only the above exchange rate but also a change to foreign exchange reserves and interest rates, always against a specific reference value (the standard concept of this index was implemented by Eichengreen et al., 1996, pp. 474-475; elaborated further by Kaminsky et al. 1998). Apart from these two concepts of a currency crisis, a currency crisis may be defined solely using "qualitative criteria" such as a forced change of parity, abandoning the fixed exchange rate, or international aid (Bordo et al., 2001).

Currency crises were relatively frequent in the 1980s and 1990s, when they affected 5-10 currencies on average each year. At the beginning of the 21st century their frequency dropped significantly; it once again rose in connection with the financial crisis from the year 2007. According to Glick and Hutchison (2011, p. 19) in the years 2008-2009 a devaluation of 25% or more occurred with 23 currencies. Bush et al. (2011, p. 7) cite the frequency of currency crises as an average of 5.4 per year from 1973-1989; 2.4 per year from 1990-2009.

Currency crises most often affect currencies maintaining a fixed exchange rate regime. In the case of currencies with flexible exchange rates, the defence of the exchange rate occurs to a far lesser extent (if at all) through interventions by the central banks on foreign exchange markets. Therefore, foreign exchange reserves are not exhausted, unlike from fixed exchange rates, where temporary defence of the exchange rate leads to loss of part of these reserves. A sufficient amount of foreign exchange reserves (in the case of a flexible exchange rate) then reduce investor concerns that they will be unable to convert their receivables from the given currency into a different currency. Investors therefore do not succumb to panic. "The combination of depleted reserves plus the broken promises [to maintain a fixed exchange rate – note by M. H.] leaves the country very vulnerable to panic. With a floating rate system, countries can maintain their foreign reserves and thereby maintain a defence against financial panic." (Ghosh, 2001, pp. 306-307).[42] A currency crisis is therefore less probable in the case of a flexible exchange rate regime.

In all significant cases of currency crises such as the Mexican crisis 1994-1995, Asian crisis 1997-1998, Russian crisis 1998-2000, Brazilian crisis 1999, and the Argentinian crisis 2002, the affected economies maintained one of the variants of a fixed exchange rate (see Helísek, 2004). The same goes for other currency crises - examples are the Turkish crisis 2000-2001, the Icelandic crisis 2008, or the Russian crisis 2014-2015.

According to an MMF study[43] focusing on all MMF Member States in the years 1990-2001, out of a total 196 identified cases of currency crisis 73% resulted

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[42] The authors of the chapter (Lesson from the Asian financial crisis, pp. 295-315) are Radelet, S., Sachs, J.

[43] Bubula, Otker-Robe (2003), p. 13. For more details see Helísek et al., 2007, pp. 57-59.

in crisis with currencies maintaining a fixed exchange rate, and only 27% with currencies maintaining a floating exchange rate. As part of the "fixed exchange rate" regime, the regime of a peg was most susceptible, accounting for 40% of cases of currency crisis. The following case specifies the fixed exchange rate regimes most susceptible to crisis (share of the given regime to total number of currency crises in %):

- peg ………………………………………..39.8%
- horizontal band …………………..……….11.2%
- crawling peg ……………………….…….10.2%
- crawling band ……………………………..4.6%
- currency board ……………..…………..…… 1.5%

Another study (Zhao et al., 2014) examined the currencies of 88 countries in 1981-2010. 167 currency crises were assessed in three groups of exchange rate regimes (simplified):

- peg, currency board, horizontal band) narrower than ± 2% ……….…. 19%
- crawling peg, horizontal band) wider than ± 2%, managed floating …. 71%
- freely floating …………………………………………………...... 11%

Newer studies also reach this same conclusion (Melvin and Norrbin, 2017, p. 213): "Fixed exchange rates encouraged international capital flows into the countries … Once pressures for devaluation began, countries defended the pegged exchange rate by central bank intervention … and the fixed exchange rate is abandoned."

Table 6–1 Exchange rate regimes in ERM II

Country (currency code)	Regime before ERM II	Regime in ERM II	Central parity to EUR	In euro area from
Denmark (DKK)	since March 1979 v ERM	peg ± 2.25%	7.46038 DKK	---
Greece (GRD)	since March 1998 in ERM	peg ± 15%	353.109 GRD **	2001
Slovenia (SIT)	since October 1991 crawling peg	peg ±15%	239.640 SIT	2007
Cyprus (CYP)	since January 2001 peg to euro ± 15%	peg ± 15%	0.585274 CYP	2008
Malta (MTL)	since August 2002 peg to a basket of currencies *	peg ± 0%	0.4293 MTL	2008
Slovakia (SKK)	since October 1998 managed floating	peg ±15%	38.4550 SKK ***	2009
Estonia (EEK)	since June 1992	currency board	15.646 EKK	2011

	currency board to euro			
Latvia (LVL)	since February 1994 peg to SDR ± 1%	peg ± 1%	0.702804 LVL	2014
Lithuania (LTL)	since february 2002 currency board to euru	currency board	3.4528 LTL	2015

Notes: * Shares: EUR 70%, GBP 20%, USD 10%.
** Revaluation 17. 1. 2000 by 3.5% (1 EUR = 340.750 GRD).
*** Two revaluations: 19. 3. 2007 by 8.5% (1 EUR = 35.4424 SKK) and 29. 5. 2008 by 17.6% (1 EUR = 30,1260 SKK).

Sources: European Central Bank, Convergence Report incl. Technical Annex (various years); Oesterreichische Nationalbank (2007), pp. 22-23; Amerini, 2003, pp. 1-8; Antal, Holub 2007, pp. 314-315; Backé et al. 2004, pp. 14-15.

6.4 Currency crisis in ERM II – empirical experience

The ERM II mechanism exists since 1999 along with the creation of the euro. Joining ERM II is compatible only with certain exchange rate regimes. ECB refers to a "a number of the exchange rate strategies" that can be used as part of ERM II. However, it only explicitly references strategies that are not compatible with ERM II, specifically:[44]

- free floating,
- managed floating without a mutually agreed central rate,
- crawling peg,
- pegs against anchors other than the euro.

Fahrholz (2003, p. 15) adds that unilateral euroization is also not permissible for participation in ERM II. Of course, unilateral euroization is not compatible with membership in the EU either (Komárek et al., 2005, p. 25).

The following limited options implicitly expressed therefore come under consideration (*according to previous experiences*, contained in Table 6–1):

- peg against the euro without a fluctuation band,
- peg within ERM II with standard fluctuation band ± 15%,
- or with narrowed band that must be defined in advance,
- euro-based currency board.

Table 6–1 gives a list of currencies incorporated into ERM II.

All exchange rate regimes listed in Table No. 1 are included among the first two regimes that according to the MMF study are most susceptible to currency

[44] European Central Bank, 2003 (p. 3); this position of the ECB is de facto assumed by the ECOFIN Report of the Council of the European Union (2000), pp. 2-3).

crises (Bubula, Otker-Robe, see above). The sole exception is the currency board applied twice.

From subsequent evaluation we can eliminate the countries that became part of ERM II only for a short period of time:

- Greece – the Greek drachma transitioned from ERM to ERM II, where it remained for 24 months,
- Slovenia – the Slovenian tolar for a mere 30 months (at the time of evaluation it had been in ERM II for a mere 22 months, like Lithuania),
- Cyprus and Malta – the Cypriot pound and the Maltese lira were in ERM II for 32 months,
- Slovakia – the Slovak koruna was in ERM II for 37 months.

On average the currencies of these countries were in ERM II for 29 months.

We will also monitor only four countries that remained in ERM II for longer periods. On the one hand, we will evaluate the trend of nominal exchange rate, on the other hand the indicator of "severe tension". In total this represents the following indicators (Table 6–2):

- maximum exchange rate deviation around central parity to the euro (plus sign indicates depreciation in the exchange rate of the given currency, minus sign indicates appreciation of the exchange rate of the given currency);
- the official international reserves (a comparison of their status at the end of the monitored period with the beginning of the monitored period);
- the interest differential measured as the difference between the three-month interbank interest rate (CIBOR, VILIBOR, RIGIBOR, TALIBOR) and the EURIBOR, always by the end of the year).

From Table 6–2 the following rating is derived:

- the exchange rates of the monitored changes for the entire period of remaining in ERM II were either almost stable (DKK, LVL), or entirely stable (LTL, EKK);
- the official international reserves reflected growth trends in all countries. Significant decreases occurred in the year 2008 (in association with the global financial crisis and the debt crisis in the euro area which led to lack of faith in the European currencies). In the annual indicator, however, this decrease was not reflected;
- interest rate differentials demonstrated (for the same reason) higher values solely in 2008.

Table 6–2 Criteria of exchange rate stability in ERM II

Country (currency)	ERM II involvement period	Duration of stay in ERM II (months)	Exchange rate deviations (%)	Change of international reserves (%)	Interest rate differential (p. b.)
Denmark (DKK)	I 1999 – XII 2018	218 *	+0.1 / -0.5	296.2	-0.65 – 2.02
Lithuania (LTL)	VII 2004 – XII 2014	126	0	172.0	0.05 – 7.00
Latvia (LVL)	V 2005 – XII 2013	104	+1 / -1	189.1	-0.16 – 10.65
Estonia (EKK)	VII 2004 – XII 2010	78	0	43.6	0.11 – 4.98

Notes: * From January 1999 to the end of 2018; involvement continues.
Sources: EURIBOR: https://www.emmi-benchmarks.eu/euribor-org/euribor-rates.html
Denmark: Exchange rate: http://nationalbanken.statistikbank.dk/909; Reserves: http://nationalbanken.statbank.dk/nbf/125955
CIBOR: http://www.finansraadet.dk/Tal--Fakta/Pages/satser/regler-for-fastlaeggelse-af-cibor/historiske-satser.aspx
Lithuania: Exchange rate: https://www.lb.lt/exchange/history.asp?Lang=E&Cid=EUR&Y=2014&M=12&D=31&id=4046&ord=1&dir=ASC; Reserves: https://www.lb.lt/en/official-reserve-assets; VILIBOR: https://www.lb.lt/en/historical-data-and-external-links
Latvia: Exchange rate: https://valutaskurss-eiro.lv/kursi/LVL-lats-latvija/; Reserves: For 2005-2006 (net reserves) https://www.bank.lv/en/statistics/stat-data/net-international-reserves; next years: https://statdb.bank.lv/lb/Data.aspx?id=121
RIGIBOR: https://www.bank.lv/statistika/dati-statistika/naudas-tirgus-index/rigibid-rigibor-vesturiskie-dati
Estonia: Exchange rate: http://statistika.eestipank.ee/#/en/p/VALUUTA; Reserves: http://statistika.eestipank.ee/#/en/p/1134/r/1122/970; TALIBOR: http://statistika.eestipank.ee/#/en/p/1010/r/1730

These empirical findings do not confirm concerns of the currency crisis that could result during the inclusion of the currency in ERM II. Maintaining exchange rate stability can be explained by *confidence of participants in the foreign exchange market in the obligation of the central bank to retain the fixed exchange rate.* According to the Danish central bank: "Officially, the krone may fluctuate by up to 2.25 per cent on either side of its central rate, but in reality the fluctuations are far smaller. This reflects the high credibility of the fixed exchange rate policy […] The credibility of the regime means that market participants take positions which in themselves stabilise the exchange rate of the krone." (Spange, Wagner Toftdahl, 2014, p. 49)[45] The intention of the central bank to keep the exchange rate

[45] The Danish central bank illustrates the behavior of participants in the foreign exchange market in the case of pressures on devaluation: "Participants in the financial markets are confident that the exchange rate of the krone will continue to fluctuate within a narrow

in ERM II is reinforced by an effort to retain prestige. When failing to uphold the criterion of exchange rate stability the central bank would lose trustworthiness.

An exception was in the years 2007-2009, when pressure ensued on the devaluation of the central parities of these currencies in relation to the euro. An expression of “severe tension” was a decrease in international reserves (with the exception of Estonia, where reserves stagnated) and the increased interest rate differential between 2-11 p.p. Thanks to interventions on the foreign exchange markets and temporary high interest rates, fixed exchange rates could be retained in ERM II in this crisis period. The Danish central bank evaluates this period as follows: “Moreover, the instruments (i.e. the intervention on the foreign exchange markets and the interest rate adjustments performed by the central bank – M. H.) have proved to be sufficiently robust to handle extraordinary situations such as, most recently, the implications of the 2008 financial crisis and the subsequent sovereign debt crisis in several euro area member states on the exchange rate of the krone” (Spange, Wagner Toftdahl, 2014, p. 50).

However, it is not certain how the European Commission and ECB would rate the fulfilment of the exchange rate convergence criteria in terms of the condition of “without severe tension”. If it were taken into consideration that this was a period of global financial crisis (not internal economic problems of these countries), the criterion could be fulfilled.

6.5 Theoretical models of currency crisis and their relevance in relation to ERM II

Currency crises are most often associated with abandonment of a fixed exchange rate regime. Central banks are forced into this by devaluation expectations prompted by various causes (see section 3). Currency crisis models address various combinations of these causes and the judgment of authorities on performing devaluation. These models are typically divided into three generations (e.g. Krugman, 2014; Zenker, 2014).

The first generation of currency crisis models are models with *fundamental causes of the crisis*. If the worsening of these fundamentals occurs (often under the influence of inappropriate macroeconomic policies), it leads to an outflow of capital and a decrease in foreign exchange reserves, which forces authorities of the given country to abandon the fixed exchange rate. Crises are then considered as deserved and foreseeable.

In the second generation of currency crisis models, central authorities consider whether to allow the devaluation of the exchange rate, whether to abandon their

band around the central rate. […] In a weak krone scenario, positions are typically taken in expectation of a strengthening, which has contributed to stabilising the exchange rate of the krone close to the central rate. The stabilising positions taken by market participants have reduced the need for intervention by Danmarks Nationalbank.” (Ibid, p. 53).

obligation to maintain a peg. For this reason these models are called *"escape-clause models"*. Central authorities compare the benefits and costs of devaluation (see below.) Currency crises in these models are unforeseeable, the worsening of fundamental quantities need not be significant; here an important role is played by self-fulfilling expectations.

The third generation of models focuses on the entrepreneurial sphere (*models with business balance sheets*). These models work with a range of financial indicators for businesses such as financial vulnerability, moral hazard and reinvestment, and influence of foreign debt of companies growing as a result of devaluation. The models also explain the causes of "twin crisis", i.e. concurrent currency and banking crises.

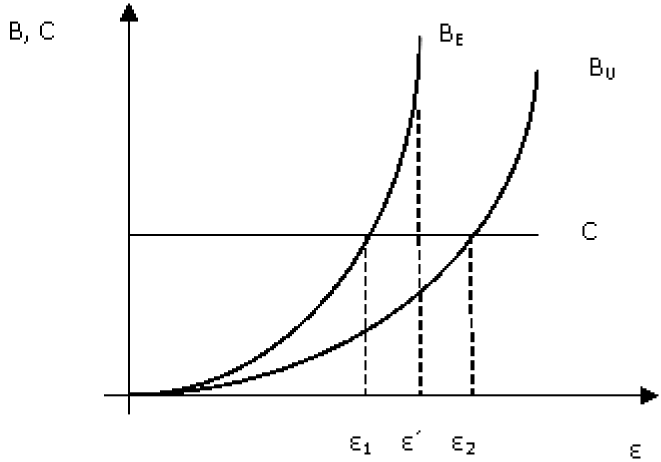
We presume that the most accurate models for interpreting currency crisis risk during involvement in ERM II are the second generation models, which explain the currency crisis without significant worsening of economic fundamentals. The reason for this model selection is the necessary performance of the following:

- Maastricht convergence criteria (low inflation, low interest rates, "healthy" public finance)
- supplemental criterion, i.e. low deficit of balance of payments' current account.

In these currency crisis models the authorities maintain a fixed rate regime, and yet not an irrevocable fixed rate. Under certain circumstances the fixed exchange rate can be revoked using an "escape clause", i.e. the obligation to uphold a fixed exchange rate can be cancelled. What are these "certain circumstances"? The given economy can be affected by a certain exogenic shock that leads, for example, to an increase in price level. The effort of the authorities for its stability (their restrictive policies) then leads to an increase in unemployment. A worsening of fundamental economic indicators (e.g. the aforementioned unemployment) leads investors to lose confidence in this economy and its currency. For this reason they will begin to consider devaluation from which the authorities promise that it should boost competitiveness and reduce unemployment. The pressure from investors to devalue (they are getting rid of the given currency) thereby increases until the authorities finally comply. And yet the fundamental economic quantities are not decisive in this case; rather it is the devaluation expectations that are decisive. The devaluation occurs because it is expected.

Out of the various variants of the second generation models, we use for interpretation of our hypothetical currency crisis under the conditions of ERM II the approach of De Grauwe (2016, pp. 102-105). The fundamental quantity monitored by investors and according to which the trustworthiness of the given currency is assessed is that of the original DeGrauwe example, a deficit of the balance of payments' current account. A different fundamental quantity could also be applied, e.g. a deficit of public finances, decreasing foreign exchange reserves, or a growing interest rate. In Figure 6–1 this quantity is measured on a horizontal axis, denoted by the symbol ε.

Figure 6–1 Currency crisis without fundamental causes



Source: De Grauwe (2016), p. 105

Authorities are aware of the unfavourable consequences of growth of this quantity on investor decision-making, and for this reason seek to decrease this quantity using restrictive policies. And yet this leads to the increased unemployment. If the authorities perform devaluation (or abandon the fixed exchange rate), the need not enact these restrictive policies and can thereby reduce unemployment. Devaluation is therefore a benefit. This benefit is measured on the vertical axis; it is designated B (benefit). The combination of ε and B is expressed by the growing curve B: the less favourable the economic trends, the higher the benefit of devaluation. The shape of curve B is explained by the principle of indifferential analysis. Curve B has two variants. The lower curve B_U does not contain devaluation expectations. The higher curve B_E contains devaluation expectations, i.e. it results in a "speculative attack" (under these expectations the authorities must select a stronger restrictive policy; devaluation would offer them greater benefit). And yet devaluation is also associated with costs (designated in the figure as C, costs). We presume these costs to be fixed. In Figure 6–1 there is a horizontal line C. These costs explain DeGrauwe as a loss of the reputation of the authorities.

Let us now explain the associations between ε, B, and C:

- if the fundamental quantity under observation is strongly favourable ($\varepsilon < \varepsilon_1$), devaluation will not occur because C > B,
- if, on the other hand, it is markedly unfavourable ($\varepsilon > \varepsilon_2$), devaluation will occur, because B > C,
- if ε is on a "moderate level" around ε´, it will then depend on investors ("markets"). expectations.

In the interval "$\varepsilon_1 - \varepsilon_2$":

- devaluation will not occur if investors do not expect this devaluation,
- devaluation will occur if investors expect this devaluation.

In other words, the depreciation of the exchange rate (i.e. currency crisis) is caused by expectations of this crisis. This is a *self-fulfilling expectation*. This model of a currency crisis therefore explains that the change in fundamental economic quantities is not important when they are at a "moderate level". The devaluation (or abandonment of a fixed exchange rate) is decided by investor expectations.

6.6 Risk of currency crisis in ERM II

In our application of the model of the second generation in ERM II the currency crisis is not dependent on significant worsening of fundamental quantities. In our opinion, however, investors uncertainty and their devaluation expectations may be prompted by factors other than development of economic fundamentals. These are specific causes of loss of confidence associated with participation in the ERM II mechanism. We presume that this consists of five specific risks.

1) Potential conflict between the fulfilment of two criteria, namely the criterion of low inflation at the same time as the criterion of a stable exchange rate, where the free international movement of capital takes place concurrently. This is the trilemma of currency policy in an open economy: of three goals only two are achievable. If a strong inflow of capital occurs (see below), the retention of low inflation will not be possible without appreciation of the exchange rate. This endangers the fulfilment of the criteria of a stable exchange rate. These concerns can be weakened by the following arguments:

- the inflation criterion allows for exceeding the "Maastricht inflation" by 1.5 p.p.,
- the fluctuation band in ERM II is relatively wide[46], enabling up to 15% appreciation under central parity,
- revaluation of central parity is not in conflict with the fulfilment of the exchange rate convergence criterion.

2) Establishing central parity during entry to ERM II differently in relation to the current exchange rate. Experience with becoming part of the ERM mechanisms indicates that both undervalued parity (the case of the Greek drachma) and overvalued parity (the case of the British pound and the Italian lira) lead to subsequent exchange rate fluctuations that endanger the fulfilment of the condition of exchange rate stability. It is for this reason as well that countries that became part of ERM II selected central parity to the euro that was either exactly the same or very close to the current exchange rate. Following this tried and tested strategy

[46] That is why ERM II is sometimes referred to as the "semi-fixed exchange rate" – see for example Minenna, 2016, pp. 66, 79.

allows the risk of lack of investor confidence toward maintaining a fixed exchange rate to be reduced.

3) Risk of appreciation overshooting of the exchange rate. While remaining in ERM II it is possible to expect a strong inflow of capital caused by increased reliability of the economy, meeting the Maastricht criteria (low inflation, favourable fiscal indicators). Confidence can also be enhanced by the expectation of accelerating economic growth arising from the effect of the growth of trade or the effect of the decrease in risk premiums upon adopting the euro. All of these circumstances can lead to appreciation pressures, which can result in overshooting the exchange rate, i.e. significant appreciation. This leads to the opposite expectations, expectations of correction of the exchange rate for central parity, i.e. its depreciation.

4) Expected shift of euro adoption date. This may occur as a result of worsening (actual or expected) of compliance with Maastricht criteria. Investors then begin to predict cancellation of central parity and subsequent depreciation of the exchange rate.

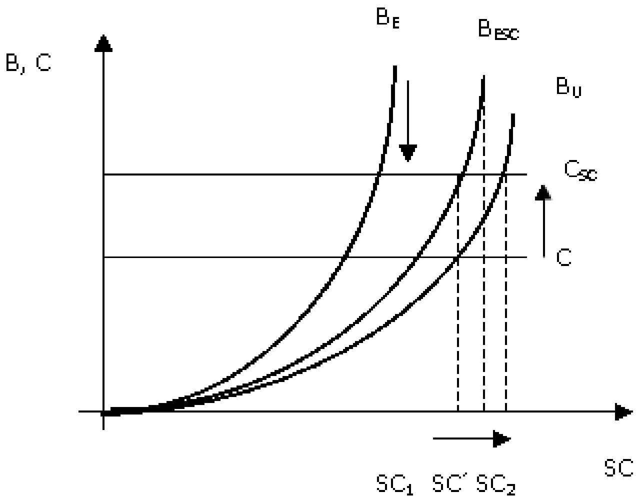
5) Refusal of entry to the euro area. This case occurred as part of ERM II only once, with the rejection of the request by Lithuania to enter the euro area (decision of the European Union in 2006 due to failure to meet inflation criterion). As we see from the development of the LTL/EUR exchange rate, even this event did not lead to devaluation of expectations and investor "attacks" on the Lithuanian currency. LTL remained in ERM II and for the entire subsequent period met the criterion of exchange rate stability.

We allow that a "speculative attack" on a currency remaining in ERM II could hypothetically ensue under the influence of the above risks. It is then possible, by our opinion, to expect measures by the central banks for keeping the exchange rate in ERM II, in particular strong intervention in foreign exchange markets. We can explain this with three arguments.

First: The decision to remain in ERM II, which is dependent on strict approval procedures, will be a prestigious affair for national central authorities (governments, central banks). It is a matter of retaining their trustworthiness, both in the eyes of the domestic public (citizens, firms) and those of EU authorities.

Second: If a speculative attack were successful and resulted in a change of central parity in a devaluing direction (or even to the abandonment of the fixed exchange rate), it would mean the end of meeting the exchange rate criteria. Upon subsequent entry to ERM II an additional two-year minimum requirement to remain in ERM II would begin. This would prolong the high-risk period of remaining in ERM II.

Figure 6–2 Modification of the 2nd generation model according to ERM II conditions



Source: own elaboration

Third: In the event that the exchange rate should reach the boundary of the fluctuation band, the national central bank as a matter of principle has unrestricted access to "very short-term" financing on the part of the ECB. This principle has the limitation that interventions will not be supported if they could conflict with the primary goal of the ECB, i.e. price stability. The relatively small scope of the national (e.g. Czech) financial market compared to the financial market of the euro area will nonetheless not endanger this inflation risk.

Now we apply to the general 2nd-generation's model of currency crisis:

- the above explanation of specific risks influencing investor decision-making,
- the circumstances that weaken these risks within the ERM II regime.

In this way we modify this model to the conditions of ERM II (Figure 6–2):

1) We replace the fundamental quantity on the horizontal axis (ε) with "specific causes of devaluation expectations" (SC).
2) The weakening of devaluation expectations shifts curve B_E downward (from B_E to B_{ESC}).
3) When the currency does not meet the criterion of becoming part of ERM II for at least two years, the authority of the given country loses trustworthiness. Moreover, the two-year period must be repeated, which extends the term of persisting in ERM II. This increases the costs of abandoning the fixed exchange rate and shifts line C upward (from C to C_{SC}).

From Figure 6–2 it is clear that the conditions of ERM II result in a "moderate level" shift of specific causes of devaluation expectations (SC′) to the right. In other words, this means that the causes of loss of investor confidence such as an inflow of foreign capital, unsuitable setting of central parity, etc., must be very strong in order to invoke this loss of confidence. This also reduces currency risk in ERM II.

6.7 Involving the Czech koruna into ERM II

The Czech Republic is one of the Member States of the European Union with a temporary derogation on to the euro's introduction. None of these countries has their currency in ERM II (Table 6–3).

Concerns about possible speculative attack (i.e. currency crisis) when joining the currency to ERM II are expressed for the Czech koruna as well.

E.g. Janáčková (2002, p. 777) claims that financial markets "could use a firmly set fluctuation interval for speculation against the Czech currency."[47] Membership in ERM II should therefore be as short as possible. Jílek similarly states (2004, 661): "The CNB in this case [when the narrow band of 2.25% attracts speculative attacks – M. H.] would have to intervene on a massive level in order for the rate to hold. The probability that it would succeed, however, is not that great." Šaroch et al. (2003, pp. 48-49) repeat the concern about the possibilities for speculative attacks and recalls the proposals of certain central banks to reduce the two-year period for remaining in ERM II. Lacina, Rozmahel, et al. also warn against currency crises (2010, p. 21): "Remaining in ERM II regime for a period of two years moreover poses a risk of speculative attacks on the currency of the candidate country".[48] Likewise, Sychra (2009) warns of "potential instability" for the period in which the currency remains in ERM II; Marková (2011) does as well. A similar warning is also stated by Helísek and Mentlík (2018). Fassmann, Ungerman (2018) warn of the risk of unsustainable appreciation of the exchange rate.

Table 6–3 Planned date of entry to the euro area

Country	Original date	New date	State of preparations
Bulgaria	"as soon as possible upon meeting the Maastricht criteria", later 2010, 2020	2022	Action plan for involving into ERM II (2018). Request for entry to ERM II 29 June 2018.
Czech Republic	1 January 2010; cancelled 25 October 2006	not set	National Euro Changeover Plan for the Czech Republic (2003, updated 2007)

[47] The author draws attention to "the risk of speculative attacks on ERM II entry" in her next work (2014, p. 67).
[48] Likewise Lacina et al. (2008).

Croatia	2023-2025	---	Strategy for the Adoption of the Euro in the Republic of Croatia (2018)
Hungary	1 January 2010; canceled 1 December 2006	not set	National Euro Changeover Plan (updated 2009)
Poland	1 January 2012; cancelled at the end of 2009	not set; “as soon as conditions for accession are met"	National Euro Changeover Plan (2011)
Romania	2015, 2019, 2022	2024	National Plan for Adoption the Euro (2019)
Sweden	not set	---	preparations were suspended by the rejection of the Euro by referendum on 14 September 2003

Source: European Commission, 2014, and previous reports (no newer reports were issued). Websites of NCBs banks. Haratyk (2019)

Opposing votes are less frequent: “The danger of a speculative attack during the ERM II is small and negligible upon accepting the euro.” (Kohout, 2004, p. 14).

Concerns of a currency crisis during participation in ERM II are also expressed by the Czech central authorities creating economic policy. *The Czech Republic’s Euro Area Accession Strategy* (2003, p. 3, emphasis M. H.) demands the shortest possible time in ERM II. The reason is as follows. “Given that participation in the ERM II … does not in itself eliminate the risk of currency turbulence, it is regarded merely as the gateway into the euro area …staying in the ERM II for longer than the minimum required period of two years does not seem desirable”.

This position is developed in greater detail in the study by the Czech National Bank *ERM II and the Exchange-rate Convergence Criterion* (2003, pp. 4, 6, emphasis M. H.): “The ERM II …is a fixed exchange rate regime. …In a world of massive capital flows [participation in ERM II] may be associated with potential costs as the financial markets “test” the willingness of the authorities to maintain the exchange rate within the fluctuation band”. “The ERM II … is a fixed exchange rate regime. … In a world of massive capital flows [participation in ERM II] may be associated with potential costs as the financial markets “test” the willingness of the authorities to maintain the exchange rate within the fluctuation band”.

Another (new) reason for remaining in ERM II for as short a time as possible is the requirement of the European Central Bank to enter the banking union[49] along with entry to ERM II (in the case of non-member euro area countries this consists of formally establishing "close cooperation". This requirement was first articulated by the ECB in the case of the interest of Bulgaria in accession to ERM II in April 2018.[50] Originally this entry to the banking union was required no sooner than at the time of entry to the euro area. The requirement was accepted by Bulgaria. The ECB expects also from other countries to meet this requirement. However, the legal binding of this requirement is questionable.

The opposite opinion (compared to "the shortest possible time in ERM II") is offered by the analysis *The Czech Republic and the euro area* (2017). It reports that circumstances may occur that lead to an interest in rapid accession to the euro area, namely:

- domestic circumstances in the form of reinforcing pressure of businesses to adopt the euro,
- international circumstances in the form of separating the euro area from the rest of the EU.

The rapid implementation of the euro would therefore help *the Czech koruna become part of ERM II without specifying the deadline for acceptance of the euro*. The above mentioned analysis marks this entry to ERM II as "technical entry". At present only Denmark is keeping its currency in ERM II. This membership in ERM II is therefore called the "Danish scenario".

Making the Czech koruna part of ERM II would have other favourable impacts apart from facilitating entry to the euro area, such as:

- the obligation to adopt a single European currency would be confirmed, by which the Czech Republic could enhance its trustworthiness,
- its position in cooperation with the euro area would be enhanced, e.g. participation in certain euro area summits or access to certain information.

6.8 Conclusion

The fixed exchange rate regime is more susceptible to currency crisis than a floating regime. All regimes allowable for ERM II are fixed exchange rate

[49] Specifically this consisted (for the time being) of the first part, the *Single Supervisory Mechanism* – SSM, which became operational from 4 November 2014, and the second pillar of the banking union, the *Single Resolution Mechanism* – SRM, operational from 1 January 2016).

[50] Euractiv 27 April 2018: Bulgaria's Borissov unveils secret criteria for joining the eurozone https://www.euractiv.com/section/banking-union/news/bulgarias-borissov-unveils-secret-criteria-for-joining-the-eurozone/

regimes. Worries about currency crisis as part of ERM II are confirmed by any of the following:

- empirical experience (nine countries in ERM II),
- theoretical models (we applied the second generation model).

We paid special attention to long-term involvement in ERM II (we reviewed four countries – Denmark, Estonia, Latvia, Lithuania). These study results may be a jumping-off point for assessing alternatives for the shortest possible period of the Czech koruna being part of ERM II. This alternative is the “Danish scenario”, i.e. joining ERM II without specifying a date for adopting the euro.

Chapter 7

Measuring credit risk based on CDS and bond spreads

By Petr Budinský and Michal Bezvoda

Credit rating is a traditional measurement of credit risk in financial markets. This paper introduces an innovative approach based on implied ratings defined by CDS spreads. Using this approach, the credit risk can be better managed because CDS are provided on daily basis. The implied rating is compared with credit ratings provided by Moody´s, S&P, and Fitch agencies. The model of implied rating deals only with sovereign ratings. 52 countries were chosen for comparison of both types of above-mentioned ratings. The model uses cumulative default probabilities (CPD) derived from CDS spreads and the main results are CPD intervals which define implied credit ratings. For those countries where the credit rating and implied credit rating are different, the chapter shows how implied rating can serve as a signal for potential upgrade or downgrade of the credit rating provided by rating agencies. The presented model is also used to verify ratings provided by Moody´s, S&P, and Fitch in cases where these agencies provide different ratings for a specific country. This is especially important when some ratings are investment-grade and others are speculative-grade.

7.1 Introduction

Credit rating agencies provide credit ratings for issuers of debt instruments. Issuers are governments, companies, or municipalities. The credit rating is based on the issuer's ability to repay debt and reflects its creditworthiness. The higher the credit rating, the lower the probability of default. The most respected credit rating agencies are Standard and Poor´s (S&P), Moody´s, and Fitch. They classify issuers into several credit rating categories. The following categories are investment-grade ratings (Table 7–1):

Table 7–1 Long-term credit ratings – investment grade

Moody's	S&P	Fitch
Aaa	AAA	AAA
Aa1	AA+	AA+
Aa2	AA	AA
Aa3	AA-	AA-
A1	A+	A+
A2	A	A
A3	A-	A-
Baa1	BBB+	BBB+
Baa2	BBB	BBB
Baa3	BBB-	BBB-

Source: Moody's, S&P, Fitch

The highest rating is AAA and the probability of default in this case is very low. In this paper, four rating categories are used: AAA, AA, A and BBB. Moody's ratings A1, A2 and A3 are considered as being category A, and S&P/Fitch ratings BBB+, BBB and BBB- are considered as BBB. The categories in Table 7–2 express speculative-grade ratings.

Table 7–2 Long-term credit ratings – speculative grade

Moody's	S&P	Fitch
Ba1	BB+	BB+
Ba2	BB	BB
Ba3	BB-	BB-
B1	B+	B+
B2	B	B
B3	B-	B-
Caa1	CCC+	CCC+
Caa2	CCC	CCC
Caa3	CCC-	CCC-
Ca	CC	CC

Source: Moody's, S&P, Fitch

Here the probability of default is substantially higher than for investment-grade issuers. We will use the "S" category to represent all the speculative-grade ratings in Table 2. This paper deals only with sovereign ratings to 31 January, 2017, where 52 countries were selected and categorized within the categories introduced above: AAA (8 countries), AA (10 countries), A (11 countries), BBB (13 countries), and S (9 countries), all based upon their median rating among the three above-mentioned rating agencies. A feature of credit ratings is that they do not change frequently. In one respect this brings stability, but it does not allow them to be adjusted due to actual events as rapidly as necessary. The main objective of this paper is to introduce a different type of rating based on market instruments that will allow investors to analyze the status of issuers on a daily basis. The selected market instrument is the credit default swap (CDS) which will aid in defining the implied rating. A CDS is a contract where a bond is the underlying asset and the CDS functions as insurance in case the bond defaults. The riskier the underlying bond, the higher the CDS price (also called “CDS spread”) will be, and so therefore the higher the probability of default. Defaulting means that some or all payments associated with the bond will not be recovered by the investor. The CDS seller is obliged to deliver missing payments to the CDS buyer. Based on the CDS spread, the cumulative probability of default (CPD) can be calculated. The CPD is the probability that the bond will default before expiration of the relevant CDS (normally 5 years). We have defined the implied rating for 52 selected countries based on their CPD.

7.2 Development of CDS

CDSs offer the market an additional tool to determine the degree of credit risk. Unlike agency ratings, which are discrete and are only adjusted after time, usually in response to an important event related to underlying assets, CDS prices change in real time. The market reacts to events much faster than the time it takes for agencies to change their ratings. Georgievska et al. (2008) estimated default probabilities of emerging countries and compared them with the default rates implied by sovereign credit ratings. They detected that CRAs generally underestimated the risk of sovereign debt, and that sovereign credit ratings from rating agencies were much too optimistic. Callen et al. (2009) observed that credit ratings may have a close relationship with CDS spreads with respect to obligors sharing a common credit rating. They found that earnings of referenced firms are negatively correlated with the level of CDS prices, consistent with earnings conveying information about default risk. In accordance with Iyengar (2010, 2012), we found differences among the sovereign ratings granted by Moody’s, Standard & Poor’s, and Fitch. He carried out a comparison of sovereign ratings and examined their differences. Results showed that these differences are statistically significant and that they increase over time. This may lead to increased doubts about the consistency of such ratings.

Budinský, Heissler, Wawrosz (2011) dealt with the theory of equality between CDS spreads and bond spreads and they brought the evidence that this theory was valid for selected European countries before Lehman Brothers but after October 2008 it was valid for these countries only in some time periods. The above mentioned equality is presented by following equilibrium model. De Haan (2011) provided a basic background on the functioning of rating agencies. He focused on two main tasks for which rating agencies have come under criticism, namely the rating of structured instruments, and the issuing of sovereign ratings. Based on these tasks, they investigated how and whether there should be regulation. Budinský et al. (2013) focused on the theory of equality between CDS spreads and bond spreads. This theory was valid for selected European countries before Lehman Brothers, but after October 2008, it was valid for these countries only in some time periods. Cizel (2013) argued that CDS spreads are a market-based measurement of credit risk relative to credit risk ratings. If CDS spreads represent an element of pure credit risk, and credit ratings are a relative default risk metric, then there should be a connection between the market price of credit risk and the credit rating assigned to an obligor. Castellano and D'Ecclesia (2013) investigated the ability of fluctuations in CDS indexes in anticipating the occurrence of market crises. They found that CDS volatility tends to increase almost eight months before the market changes, confirming the impressive informational value of CDS changes that may reflect future expectations. Budinský (2014) researched that implied rating based on CPD could be used to check sovereign ratings obtained by rating agencies through implied rating categories.

Kiesel (2015) analysed the impact and effectiveness of regulation on the European sovereign CDS market. He focused on regulation that prohibits buying uncovered sovereign CDS contracts in the European Union. His results indicated significant change in CDS spreads prior to regulations and stable CDS spreads following the introduction of regulation. Berg (2016) was focused on monitoring 57 countries and he found that the CDS market relative to a country's debt is substantially larger for small countries, countries just above investment-grade, and countries with weaker creditor rights. Further, he came to view that the CDS market usually reacts only to negative events, and that changes in the size of CDS markets are determined by agency ratings. Budinský et al. (2016) suggested two methods to measure credit risk. He investigated bond and CDS spreads in the equilibrium model and found that changes in economic situations may lead to the change of both bond and CDS spreads. Drago and Gallo(2016) analysed the impact of sovereign ratings announcements on the CDS market. The study concluded that agency warnings had zero to little impact on the CDS market. Based on his study, the market seems to react only to negative announcements.

7.3 Model of implied ratings

Before we introduce the model for implied rating, we must place each selected country into category AAA, AA, A, BBB, or S. The median rating is introduced here based on omitting the best and worst of three different ratings (Moody´s, S&P and Fitch). If at least two ratings are the same, the median rating is defined by those ratings. The median rating categories are in Table 7–3.

Table 7–3 Ratings by Moody's, S&P, Fitch and Median Rating

No	Country	Moody's	S&P	Fitch	Median Rating
1	Australia	Aaa	AAA	AAA	AAA
2	Norway	Aaa	AAA	AAA	AAA
3	Denmark	Aaa	AAA	AAA	AAA
4	Germany	Aaa	AAA	AAA	AAA
5	Sweden	Aaa	AAA	AAA	AAA
6	Netherlands	Aaa	AA+	AAA	AAA
7	Canada	Aaa	AAA	AAA	AAA
8	Singapore	Aaa	AAA	AAA	AAA
9	Finland	Aa1	AA+	AA+	AA
10	United Kingdom	Aa1	AA	AA	AA
11	Austria	Aa1	AA+	AA+	AA

12	Belgium	Aa3	AA	AA	AA
13	France	Aa2	AA	AA	AA
14	South Korea	Aa2	AA	AA-	AA
15	Abu Dhabi	Aa2	AA	AA-	AA
16	Qatar	Aa2	AA	AA-	AA
17	Chile	Aa3	AA-	A+	AA
18	China	Aa3	AA-	A+	AA
19	Japan	A1	A+	A	A
20	Czech Republic	A1	AA-	A+	A
21	Slovakia	A2	A	A+	A
22	Estonia	A1	AA-	A+	A
23	Latvia	A3	A-	A-	A
24	Ireland	A3	A+	A	A
25	Poland	A2	BBB+	A-	A
26	Israel	A1	A+	A	A
27	Peru	A3	A+	A	A
28	Malaysia	A3	A	A	A
29	Slovenia	Baa3	A	A-	A
30	Spain	Baa2	BBB+	BBB+	BBB
31	Thailand	Baa1	BBB+	BBB+	BBB
32	Philippines	Baa2	BBB	BBB+	BBB
33	Romania	Baa3	BBB-	BBB-	BBB
34	Panama	Baa2	BBB+	BBB	BBB
35	Mexico	A3	BBB+	BBB+	BBB
36	Italy	Baa2	BBB-	BBB+	BBB
37	Kazakhstan	Baa3	BBB+	BBB	BBB
38	Colombia	Baa2	BBB-	BBB+	BBB
39	South Africa	Baa2	BBB-	BBB-	BBB
40	Hungary	Baa3	BB+	BBB-	BBB
41	Bulgaria	Baa2	BB+	BBB-	BBB
42	Indonesia	Baa3	BB+	BBB-	BBB
43	Russia	Ba1	BB+	BBB-	S
44	Turkey	Ba1	BB+	BBB-	S
45	Vietnam	B1	BB-	BB	S
46	Croatia	Ba2	BB	BB	S
47	Brazil	Ba2	BB	BB	S
48	Portugal	Ba1	BB+	BB+	S
49	Argentina	B3	B-	B	S
50	Egypt	B3	B-	B	S
51	Venezuela	Caa3	CCC	CCC	S

Source: Moody’s, S&P, Fitch

Table 7–3 shows that all three rating agencies placed 38 countries into the same rating category and that only 13 countries (the Netherlands, Chile, China, the Czech Republic, Estonia, Poland, Slovenia, Mexico, Hungary, Bulgaria, Indonesia, Russia, Turkey) have differing rating categories from two separate rating agencies. None of the countries have three different rating categories, so the ratings are very similar. The model of using CDS spreads and CPD (cumulative probabilities of default) is based on the following idea: the better the credit rating, the lower the CDS spread, and the lower the CPD.

Hull, Predescu and White 2004 and Arce, Mayordomo, Peña 2011 assumed that CDS spreads should be equal to bond yield spreads. Based on this assumption, the research was conducted Budinský (2011) where the prerequisite was set for the following statement:

$$s = y - r,$$

where s is defined as n-year CDS spread, y as yield on an n-year par bond issued by a reference entity and r as yield on an n-year par riskless bond.

In the model may occur following states:

Table 7–4 Possible states in equilibrium model

State	Result
$s > y-r$	The arbitrageur should decide to buy a riskless bond, to short the corporate bond and to sell CDS. The reason is that the CDS market is overvalued and the bond market underestimates the probability of a bond failure.
$s < y-r$	The arbitrageur should decide to buy a corporate bond, to buy CDS and to short the riskless bond. In this situation the CDS market is underestimated and the bond market overestimates the probability of a bond failure.
$s = y-r$	The CDS market has an equivalent predictive value to the risk of failure as a corporate bond.

Source: Budinský, Heissler, Wawrosz 2011, edited by the authors

The model described in Table 7–4 was primarily designed for corporate bonds, however it can be applied also for sovereign bonds assuming that one of the sovereign bonds is defined as riskless. As a riskless sovereign bond is frequently used the German bond. The credit risk of this bond is very low whatever criterion mentioned above is used: first, rating of Germany is AAA - the highest. Second, the bond yields and CDS spreads are very low as well.

Table 7–5 CDS and CPD for selected countries

No.	Country	5 Year CPD (%)	5 Year CDS Spread (bps)	Median Rating
1	Germany	1,39%	25	AAA
2	Australia	1,49%	21	AAA
3	Sweden	1,54%	25	AAA
4	Finland	1,89%	25	AA
5	Norway	1,93%	23	AAA
6	Austria	1,98%	34	AA
7	Denmark	2,03%	24	AAA
8	United Kingdom	2,03%	33	AA
9	Canada	2,08%	33	AAA
10	Netherlands	2,33%	28	AAA
11	Japan	2,33%	33	A
12	Belgium	2,48%	36	AA
13	France	3,06%	39	AA
14	Slovakia	3,16%	47	A
15	Czech Republic	3,69%	43	A
16	South Korea	4,08%	46	AA
17	Estonia	4,52%	57	A
18	Abu Dhabi	4,71%	62	AA
19	Singapore	4,85%	60	AAA
20	Latvia	5,00%	63	A
21	Ireland	5,04%	64	A
22	Spain	5,95%	78	BBB
23	Israel	6,10%	77	A
24	Qatar	6,24%	80	AA
25	Thailand	6,33%	81	BBB
26	Poland	6,43%	76	A
27	Chile	7,14%	83	AA
28	Philippines	7,37%	99	BBB
29	Slovenia	8,22%	103	A
30	Romania	8,40%	108	BBB
31	Peru	8,45%	108	A
32	China	8,64%	117	AA
33	Hungary	8,87%	123	BBB
34	Bulgaria	9,15%	143	BBB
35	Malaysia	10,11%	134	A
36	Panama	10,30%	129	BBB
37	Indonesia	11,39%	154	BBB
38	Italy	11,80%	157	BBB
39	Colombia	11,94%	161	BBB
40	Kazakhstan	11,98%	157	BBB
41	Mexico	12,25%	154	BBB
42	Russia	12,97%	176	S

43	Vietnam	14,17%	189	S
44	South Africa	15,23%	211	BBB
45	Croatia	15,62%	210	S
46	Brazil	17,61%	273	S
47	Turkey	18,59%	269	S
48	Portugal	18,84%	274	S
49	Egypt	27,04%	435	S
50	Argentina	29,98%	432	S
51	Venezuela	65,67%	3193	S

Source: Compiled by the authors based on Deutsche Bank Research

The cumulative probability of default within five years is lower than 2% for seven countries (Germany, Australia, Sweden, Finland, Norway and Austria), so their implied rating category of AAA is expected. On the other hand, three countries with CPD higher than 25% would clearly be in the S category. We now derive the exact model, which allows us to put each country into its respective implied rating category. This is done based on Table 7–4, which combines the ratings from Table 7–3 with CPD from Table 7–5. The countries in Table 7–5 are in sequence by their CPD – from the lowest to the highest. We can see that Finland, Austria and the United Kingdom (in the AA category) are distributed among the AAA category countries. Peru, China, and Malaysia, which are in the A and AA categories, are distributed among the BBB category countries. We must determine CPD ranges to maximize the number of countries with matching rating categories and implied ratings (see Table 7–6).

Table 7–6 Implied rating categories

5 Year CPD (%)	Implied Rating
0 – 2,09	AAA
2,10 – 4,19	AA
4,20 – 6,29	A
6,30 – 12,59	BBB
> 12,60	S

Source: Compiled by the authors

The choice of ranges defining the intervals for CPD is not unique. Instead of 2,10, we could use 2,20 or 2,30 with the same result, or instead of 4,20, we could use 4,30 or 4,40. The solution represented in Table 7-6 is important because the ranges of intervals for the implied ratings AAA, AA, and A are 2,10, and the range of the fourth interval (BBB) is 6,30, which 3 x 2,10.

7.4 Comparison of selected countries

The above introduced model will now be applied to the selected 52 countries. Using Table 7–3 for rating categories AAA, AA, A, BBB and S, we created the following tables: Table 7–7 for the AAA category, Table 7–8 for the AA category, Table 7–9 for the A category, Table 7–10 for the BBB category, and Table 7–11 for the S category. These tables list implied rating categories based on the CPD intervals from Table 7–6.

Table 7–7 Countries with AAA median rating

Country	Moody's	S&P	Fitch	Median Rating	Implied Rating
Australia	Aaa	AAA	AAA	AAA	AAA
Norway	Aaa	AAA	AAA	AAA	AAA
Denmark	Aaa	AAA	AAA	AAA	AAA
Germany	Aaa	AAA	AAA	AAA	AAA
Sweden	Aaa	AAA	AAA	AAA	AAA
Netherlands	Aaa	AA+	AAA	AAA	AA
Canada	Aaa	AAA	AAA	AAA	AAA
Singapore	Aaa	AAA	AAA	AAA	AA

Source: Compiled by the authors

In Table 7–7 there are only two countries in the AAA median rating category (the Netherlands and Singapore) where the median rating (AAA) differs from the implied rating (AA). Implied rating is in both cases lower than the median rating. For the other seven countries, both ratings are the same (AAA).

Table 7–8 Countries with AA median rating

Country	Moody's	S&P	Fitch	Median Rating	Implied Rating
Finland	Aa1	AA+	AA+	AA	AAA
United Kingdom	Aa1	AA	AA	AA	AAA
Austria	Aa1	AA+	AA+	AA	AAA
Belgium	Aa3	AA	AA	AA	AA
France	Aa2	AA	AA	AA	AA
South Korea	Aa2	AA	AA-	AA	AA
Abu Dhabi	Aa2	AA	AA-	AA	A
Qatar	Aa2	AA	AA-	AA	A
Chile	Aa3	AA-	A+	AA	BBB
China	Aa3	AA-	A+	AA	BBB

Source: Compiled by the authors

There are three countries (Belgium, France and South Korea) in the AA median rating category (Table 7–8) where the median rating (AA) coincides with the implied rating (AA). For the other seven countries, both ratings are different, whereas the biggest differences are found for Chile and China, with their implied ratings of BBB being significantly lower than AA.

Table 7–9 Countries with A median rating

Country	Moody's	S&P	Fitch	Median Rating	Implied Rating
Japan	A1	A+	A	A	AA
Czech Republic	A1	AA-	A+	A	AA
Slovakia	A2	A	A+	A	AA
Estonia	A1	AA-	A+	A	A
Latvia	A3	A-	A-	A	A
Ireland	A3	A+	A	A	A
Poland	A2	BBB+	A-	A	BBB
Israel	A1	A+	A	A	A
Peru	A3	A+	A	A	BBB
Malaysia	A3	A	A	A	BBB
Slovenia	Baa3	A	A-	A	BBB

Source: Compiled by the authors

In median rating category A (Table 7–9), there are four countries (Estonia, Latvia, Ireland, and Israel) where the median rating (A) coincides with the implied rating (A). For the other seven countries, both ratings are different.

Table 7–10 Countries with BBB median rating

Country	Mo-ody's	S&P	Fitch	Median Rating	Implied Rating
Spain	Baa2	BBB+	BBB+	BBB	A
Thailand	Baa1	BBB+	BBB+	BBB	BBB
Philippines	Baa2	BBB	BBB+	BBB	BBB
Romania	Baa3	BBB-	BBB-	BBB	BBB
Hungary	Baa3	BB+	BBB-	BBB	BBB
Panama	Baa2	BBB+	BBB	BBB	BBB
Bulgaria	Baa2	BB+	BBB-	BBB	BBB
Mexico	A3	BBB+	BBB+	BBB	BBB
Indonesia	Baa3	BB+	BBB-	BBB	BBB
Italy	Baa2	BBB-	BBB+	BBB	BBB
Kazakhstan	Baa3	BBB+	BBB	BBB	BBB
Colombia	Baa2	BBB-	BBB+	BBB	BBB
South Africa	Baa2	BBB-	BBB-	BBB	S

Source: Compiled by the authors

In median rating category BBB (Table 7–10), there are only two countries (Spain and South Africa) where the median rating (BBB) is different than the implied rating (A for Spain and S for South Africa). For the other 11 countries, both ratings are the same (BBB), but the S&P credit ratings for Hungary, Bulgaria and Indonesia are BB+ (S category).

Table 7–11 Countries with S median rating

Country	Mo-ody's	S&P	Fitch	Median Rating	Implied Rating
Russia	Ba1	BB+	BBB-	S	S
Vietnam	B1	BB-	BB	S	S
Croatia	Ba2	BB	BB	S	S
Turkey	Ba1	BB+	BBB-	S	S
Brazil	Ba2	BB	BB	S	S
Portugal	Ba1	BB+	BB+	S	S
Argentina	B3	B-	B	S	S
Russia	Ba1	BB+	BBB-	S	S
Venezuela	Caa3	CCC	CCC	S	S

Source: Compiled by the authors

Nine countries are in median rating category S (Table 7–11). The median rating (S) coincides with the implied rating (S) for all of these countries, but the Fitch credit ratings for Russia and Turkey are BBB- (BBB category).

Summarizing the content of the previous section, we can conclude that the median rating and implied rating are the same for 34 countries, and different for 18 countries. We can divide these 18 countries into 3 groups:

- Median rating lower than implied rating – seven countries (Table 7–12).
- Median rating slightly higher than implied rating – seven countries (Table 7–13).
- Median rating significantly higher than implied rating – four countries (Table 7–14).

Table 7–12 Countries with lower median rating than implied rating

Country	Median Rating	Implied Rating
Finland	AA	AAA
United Kingdom	AA	AAA
Austria	AA	AAA
Czech Republic	A	AA
Slovakia	A	AA
Japan	A	AA
Spain	BBB	A

Source: Compiled by the authors

All countries in Table 7–12 are investment-grade and CDSs suggest an upgrade of their credit ratings.

Table 7–13 Countries with slightly higher median rating than implied rating

Country	Median Rating	Implied Rating
Netherlands	AAA	AA
Abu Dhabi	AA	A
Qatar	AA	A
Poland	A	BBB
Peru	A	BBB
Malaysia	A	BBB
Slovenia	A	BBB

Source: Compiled by the authors

Table 7–14 Countries with substantially higher median rating than implied rating

Country	Median Rating	Implied Rating
Singapore	AAA	A
Chile	AA	BBB
China	AA	BBB
South Africa	BBB	S

Source: Compiled by the authors

All countries in Table 7–13 and Table 7–14 are investment-grade and CDSs suggest a downgrade of their credit rating. Substantial potential downgrades for countries in Table 7–14 mean that Singapore, Chile, and China would drop by two categories and South Africa would even obtain a speculative-grade rating,

We can now investigate the accuracy of ratings delivered by rating agencies in case they differ, or if at least one of the ratings (Moody´s, S&P, or Fitch) coincides with its respective implied rating.

First, we notice that out of 18 countries with different median and implied ratings, there are only four countries (Table 7–15) where at least one of the ratings provided by rating agencies coincides with the implied rating. Such coincidence is marked with a plus symbol. Differences are marked with a minus symbol. S&P is the most precise rating agency in this respect, although this example of only four countries is quite small.

Table 7–15 Countries with different median rating and implied rating

Country	Median Rating	Implied Rating	Moody's	S&P	Fitch
Netherlands	AAA	AA	-	+	-
Czech Republic	A	AA	-	+	-
Poland	A	BBB	-	+	-
Slovenia	A	BBB	+	-	-

Source: Compiled by the authors

The same procedure will now be applied to the other 34 countries with the same median and implied ratings.

Table 7–16 Countries with equal median rating and implied rating

Country	Median Rating	Implied Rating	Moody's	S&P	Fitch
Estonia	A	A	+	-	+
Mexico	BBB	BBB	-	+	+
Hungary	BBB	BBB	+	-	+
Bulgaria	BBB	BBB	+	-	+
Russia	S	S	+	+	-
Turkey	S	S	+	+	-
Indonesia	BBB	BBB	+	-	+

Source: Compiled by the authors

Moody´s, S&P, and Fitch deliver different ratings for only eight of these 34 countries. Moody´s is the most precise rating agency for this group. Note that each of the last five countries in Table 7–16 (Hungary, Bulgaria, Russia, Indonesia, and Turkey) have at least one investment-grade rating and at least one speculative-grade rating. For these five countries, the match with the credit rating provided by Moody´s and the implied rating is 100%.

7.5 Conclusion

Implied rating based on CPD that is derived from CDS spreads is a powerful tool used to verify the sovereign ratings granted by rating agencies. Implied ratings are defined by CPD intervals (Table 7–6). First, implied rating could provide a signal for future upgrades or downgrades of ratings in cases where the median rating and implied rating differ. Special attention should be paid to cases where all three ratings are investment-grade, but the implied rating category is S (South Africa), or, if some ratings are investment-grade and others are speculative-grade (Hungary, Bulgaria, Russia, Indonesia, and Turkey).

Second, we can find which rating agency is the most precise by using implied ratings. In cases where implied rating and median rating are the same, but the ratings from Moody´s, S&P, and Fitch are different, we can use implied rating to verify the relevant rating agency when its credit rating and implied rating are the same. In case implied rating and median rating are different, one rating agency can still provide a rating that is equal to the implied rating. The deterioration of the economic situation may lead to the increase of both bond spreads and CDS spreads but they may increase differently because both markets are different – there is different counterparty risk, different liquidity and different funding costs. But in case that bonds spreads and CDS spreads are substantially different then we can use that information in the following way: 1) $s > y-r$ indication of higher probability of default, 2) $s < y-r$ increasing funding costs and possible depreciation of local currency.

Chapter 8

Insurance linked securities and their future research

By Bohumil Stádník

New risks for insurance industry arise from global environment changes, under-valuation of lifetime (longevity risks) due to the significant scientific progress in medicine or, vice versa, overvaluation due to higher risk of global war conflicts with enormous impact on mortality, caused by new weapons technologies, as well as a global increase in losses due to higher volatility in climate changes.

Insurance-linked securities (ILS) such as mortality-linked securities and its derivatives, longevity (survivor) bonds, mortality catastrophe bonds or natural catastrophe (CAT) bonds are defined as investment instruments which are linked to cover the insurance claims resulting mainly from life insurance events, such as longevity/mortality events, or natural catastrophes (CAT bonds) as earthquake, floods or hurricane damages; and whose values are closely connected to the probability of certain insured event. ILS have many interesting aspects of interest for investors and risk managers. They have shown low correlations with other types of investment risks, such as interest rate or currency risk or they may provide attractive yields. Its pricing is an interesting challenge for researches.

8.1 Introduction

The reason of securitization of typical insurance products is the under/overestimation of the value of death/health or natural catastrophes-related claims. In the last years, the mortality improvements have become serious issue for pension funds and annuity providers to manage. The reason is that longevity has been systematically underestimated, making balance sheets riskier to unexpected increases in liabilities. On the other hand, we also newly observe issues of mortality bonds. The first mortality bond, known as Vita I, was issued by Swiss Re Group in December 2003 and was designed to reduce Swiss Re's own exposure to catastrophic mortality events, such as major terrorist attacks, avian flu pandemics, or other natural catastrophes.

Financial crises nearly always result in steep increases in government debt. The fiscal situation in many countries was negatively influenced by massive emergency measures to stabilize financial institutions, fiscal stimulus packages, and sharp economic decline that resulted in lower tax revenues all around the world. Budget deficits became a basic component of advanced countries, and the ratio of government debt to gross domestic product (GDP) increased. Such increases in debt can even potentially result in government debt defaults.

The traditional way of transferring insurance company risk through reinsurance seems to be problematic because of the lack of the capacity and liquidity to support an estimated global exposure in excess of $20tr (Loeys et al., 2007). The solution is, as in the case of natural catastrophes, to turn to capital markets which could play a very important role, offering additional capacity and liquidity to the life insurance market. In other words: the insurance industry, using ILS, transfers life insurance companies' risk to capital markets which also allow more transparent and competitive pricing of these products.

In 1992, Hurricane Andrew caused $17 billion in insured losses in Florida, and a loss figure doubles the modelling estimates at the time for the financial costs emanating from a severe hurricane. Several insurers went into bankruptcy, and reinsurance capacity was not able to satisfy the remainder. Eleven insurance companies went bankrupt, caused by more than 600 000 insurance claims filed. A new source of capacity outside traditional reinsurance was needed to fill the void. In 1996, according to Aon Securities Inc., the first catastrophe bond drawing risk-bearing capital from the capital markets to satisfy this need was developed by St. Paul Re UK. It was basically the beginning of a new story in the insurance industry which is characterized by transferring the risk from insurance companies to capital markets participants. Also the Northridge earthquake, 1994, in the San Fernando Valley region of the County of Los Angeles supported this process.

Catastrophe bonds (also known as CAT bonds) are risk-linked securities that transfer from a sponsor to investors a specified set of risks as: Hurricane and tropical storm, earthquake, flood, hailstorms. CAT bond, which is also included among insurance-linked securities (ILS) with face value F is a financial instrument which is expected to provide a stream of cash payments c at the end of every period $t = 1, 2, \dots, T$, where T denotes the bond's maturity, so long as a particular catastrophe does not occur. At the CAT bond's maturity, an investor receives both coupon payment and principal repayment. Provided a catastrophe occurs during the life of a CAT bond, an investor only receives a fraction of both coupon payment and principal repayment $\omega(F + c)$, where $\omega \in [0,1]$ denotes the fraction received. After this payment, the bond is wound up. Edesess (2014) claims that the periodicity t of the coupon payments c is usually quarterly and the maturity ranges between 1 and 5 years with an average of 3 years.

Edesess (2014) mentions 2 primary attractions of the CAT bonds. First, the risk of CAT bonds is virtually uncorrelated with other types of financial risks such as market risk, credit risk or interest rate risk. Second, the interest rates paid to the investors are rather high, consisting of the base interest on the money market funds in which the principal is deposited and the premium paid for the insurance coverage. The referred paper defines four main trigger types of principal losses: Indemnity trigger, Industry loss trigger, Parametric trigger, Modelled trigger.

Indemnity trigger - loss of principal triggers when there is an excess of total losses over the attachment point. Also, the exhaustion point is specified over which the principal is exhausted. This trigger favours the issuer and is not very attractive for investors. It may even cause a moral hazard, e.g., construction in flood areas. Industry loss trigger - the trigger is specified as total industry losses in excess of the pre-specified amount. Independent third party then estimates total industry losses on the insured event. The danger of moral hazard is partly mitigated. Parametric trigger – the trigger is based on the occurrence of a specific natural event, e.g., the speed of wind in excess of 100 km/h. The danger of moral hazard is completely mitigated, and thus parametric trigger favours the investors. Modelled trigger - very similar to indemnity trigger but is based on claims estimated by independent third party. The danger of moral hazard is partly mitigated.

According to Edesess (2014) most CAT bonds have an indemnity or an industry loss trigger. There are several CAT bond market participants:

1. Issuers are typically insurers and reinsurers, government entities or pension funds.
2. Structuring agents assist the issuer in selecting the trigger type, and they also place the bond with investors, e.g., investment banks creating SPV (Special Purpose Vehicle).
3. Modelling agents estimate the risk of the CAT bonds.
4. Rating agencies rate the CAT bonds typically as below investment grade.
5. Secondary market in CAT bonds.
6. Investors are typically institutional investor (pension funds, endowments funds or hedge funds).

CAT bonds are only privately placed. No CAT bonds can be publicly offered or traded in the USA. Only qualified institutional investors may engage in the secondary market in CAT bonds. Regarding the CAT bonds mechanics, Cizek et al. (2005) provide a thorough explanation. Sponsor creates an SPV as an issuer of bonds and as a source of reinsurance protection. The CAT bonds are then sold to investors. Raised money is immediately invested in collateral. The sponsor then makes premium payments to the SPV which together with the investment of bond proceeds make up an interest paid to investors. If there is a trigger event, the fund is immediately withdrawn from collateral and paid to the sponsor. At maturity, the remaining principal (up to 100 %) is paid back to investors. Although the CAT bond default rates have been historically very low, the spreads over US T-rates are considerably higher than those of comparably-rated junk corporate bonds.

Liu et al. (2014) argue that the securitization of catastrophe risks with small probability and high loss events can bring a solution to spread the catastrophe risk. They argue that to develop effective CAT bond market, it is crucial to create accurate pricing of CAT bonds. That is the reason they unlike the vast majority of other studies on the topic employ credit risk in CAT bond valuation. Liu et al.

(2014) basically employ Jarrow and Turnbull method to model the credit risk and using extreme value theory thus construct a general pricing formula. Liu et al. (2014) apply their theoretical model to Property Claim Services data to finally value the CAT bonds using the Monte Carlo method. Cox & Pedersen (2010) assume that there is no correlation between the default of CAT bonds and underlying financial market variables. They further assume that the financial markets are incomplete and that the catastrophic event occurs independently of the underlying financial market variables.

Cox & Pedersen (2010) propose two-step model. The first step is the estimation of the interest rate dynamics in the states of the world without the occurrence of the catastrophe. The second step contains the estimation of the probability of the catastrophe occurring. Cox & Pedersen (2010) compare the bond contract to lending money subject to credit risk, except the risk of default is, in fact, the risk of a catastrophe event happening. This comparison is of course made from the bond owner's perspective. Cox & Pedersen (2010) are then able to utilize proposed pricing methodology to assess the relative default spread on CAT bonds compared with traditional defaultable securities.

Jarrow (2010) proposes a simple closed-form valuation formula for CAT bonds consistent with Libor term structure of interest rates model. The pricing in Jarrow (2010) is predominantly based on the already existing methodology for pricing credit derivatives using a reduced form model. The pricing formula established by Jarrow (2010) requires two crucial inputs – likelihood of the catastrophe occurring and percentage realized loss rate. These two inputs are easy to obtain using historical event occurrence and realized loss data. Since counterparty risk is minimized, Jarrow (2010) assumes that the issuer is default free and that he makes all bond payments in time.

Cizek et al. (2005) argue that there is evidence of power-law distribution associated with catastrophe events losses which overturn the traditional assumption of lognormality of derivative pricing models. Cizek et al. (2005) model the catastrophe process as a compound doubly stochastic Poisson process. To calibrate the pricing model, Cizek et al. (2005) fit the distribution function of the incurred losses and the stochastic process governing the flow of natural events. Cizek et al. (2005) utilize 10-year catastrophe loss data provided by Property Claim Services data and argue that the claim size distributions describing property losses are often heavy-tailed. Thus, the authors employ Burr distribution for the calibration. Using the Monte Carlo simulation Cizek et al. (2005) simulate the dynamics of the CAT bond prices. Lai et al. (2014) propose a new arbitrage model which takes into account also currency exchange risk. Therefore, the authors value the CAT bonds using jump-diffusion CAT process, a stochastic process for the exchange rate and a stochastic process for both foreign and domestic interest rates. Lai et al. (2014) finally derive at semi-closed form formula for CAT bonds valuation. The authors also detected three other factors affecting the CAT bond's value - exchange rate volatility and correlations with both foreign and domestic interest rates.

Braun (2014) detects main determinants of the cat bond spread at issuance to be mainly expected loss, covered territory, sponsor, reinsurance cycle and the spreads on a comparably rated corporate bond. He then proposes an econometric pricing model that is applicable across territories, perils, and trigger types.

Instead of CAT group we meet insurance-linked securities such as mortality-linked securities and its derivatives, longevity (survivor) bonds are defined as investment instruments which are linked to cover the insurance claims resulting mainly from life insurance events, such as longevity/mortality events; and whose values are closely connected to the probability of certain event connected to demography development process and its parameters. There is quite a literature on this topic – see for example Kabbaj and Coughlan (2007), Krutov (2006), Leppisaari (2008), Levantesi and Torri (2008), Lin and Cox (2005), Reuters (2010), Richards and Jones (2004), and Thomsen and Andersen (2007). The reason for the securitization of typical insurance products is the under/overestimation of the value of death/health-related claims. In the last years, the mortality improvements have become a serious issue for pension funds and annuity providers to manage. The reason is that longevity has been systematically underestimated, making balance sheets riskier to unexpected increases in liabilities. In the journal Nature, medical researchers at Mayo Clinic College of Medicine - led by cell biologists Darren Baker and Jan van Deursen - have made this decade's biggest breakthrough in understanding the complex world of physical aging. The researchers found that systematically removing a category of living, stagnant cells (ones which can no longer reproduce) extends the lives of otherwise normal mice by 25 percent (Baker, Bennett, Childs, Durik, Wijers, Sieben, Zhong, Saltness, Jeganathan, Verzosa, Pezeshki, Khashayarsha, Miller & Deursen 2016). See also (Gil & Withers 2016 or Childs, Durik, Baker & Deursen 2015).

On the other hand, we also newly observe issues of mortality bonds (mortality catastrophe bonds (MCB) or extreme mortality bond (EMB)) connected with higher mortality events. We observe many studies regarding number of victims in case of modern war conflict (Wydra 2015, Brighi 2015) The first mortality bond, known as Vita I, was issued by Swiss Re Group in December 2003 and was designed to reduce Swiss Re's own exposure to catastrophic mortality events, such as major terrorist attacks, pandemics, or other natural catastrophes. The volatility of mortality rates is fairly low compared with the uncertainty surrounding changes in mortality trends. Forecasting mortality trends is a challenging exercise that concerns investors willing to take on exposures to longevity risk. Biffis and Blake (2008) explicitly distinguish the role played by trends and volatility in mortality rates in determining equilibrium risk premia in longevity risk transfers. Investors currently still seem to be uncomfortable enough with longevity risk to make this a plausible situation, even for securities written on publicly available demographic indices. At the other end of the spectrum, there are holders of longevity exposures (in terms of better experience data or forecasting technologies developed by monitoring the exposures). This situation is realistic for life insurers, reinsurers and other intermediaries (e.g., pension buyout firms and investment banks) that have developed considerable expertise in managing mortality-linked cashflows.

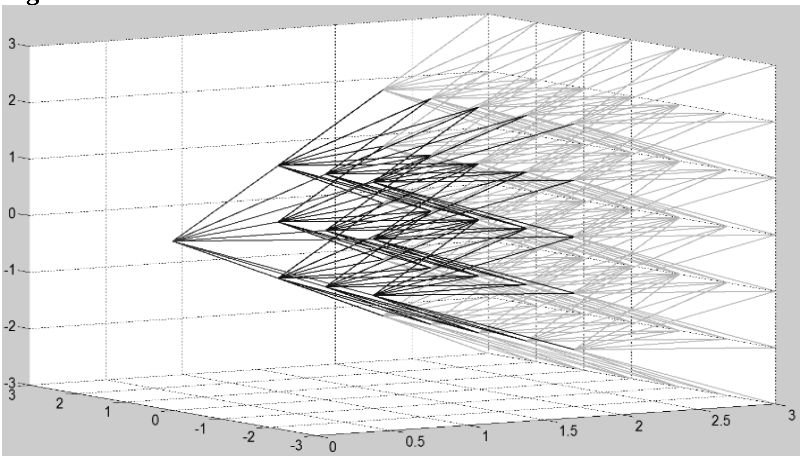
ILS have many interesting aspects of interest for investors and risk managers. They have shown low correlations with other types of investment risks, such as interest rate or currency risk or they may provide attractive yields.

Its pricing is an interesting challenge for researches. ILS Valuation using risk neutrality in general follows:

$$P = \sum_{t=1}^{T} d(0,t) \mathrm{E}_Q(S(t) \| \Omega_0) \qquad (1)$$

$\mathrm{E}_Q(S(t) \| \Omega_0)$ is the expected value of $S(t)$ under the risk-neutral measure Q conditional on the information $|\Omega_0$ available at time 0. Another valuation approach is, for example, distortion valuation approach.

Figure 8–1 3D tree



8.2 Valuation of ILS

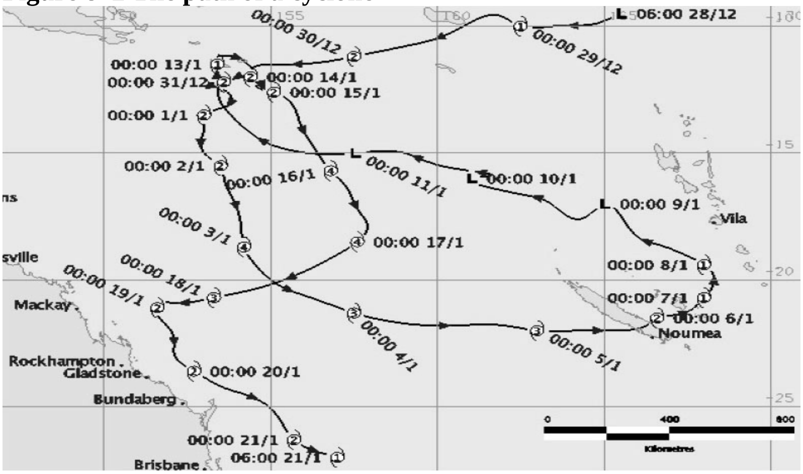
As it is written above the pricing of ILS is interesting challenge for researches. In the following text we provide certain examples in the field of valuation of ILS instruments, namely catastrophe bonds based on previous studies of Fučík & Stádník (2017). For the valuation in the context of risk neutrality (equation (1)) one way is to use more dimensional trees.

If we consider three-dimensional process, we suggest to deal with the three-dimensional trinomial tree of prices which has 9 possible ways from each node. The visualization of such tree is provided in Figure 8-1. We need to consider three-dimensional process with the following dimensions: time, interest rates development and catastrophe process development.

Interest rate development. We consider the development of interest rates to be a certain random process with three possible steps from each node or the process could be improved by utilizing a more sophisticated model such as Hull-White model.

Catastrophe process development. We expect catastrophe process to be independent on the interest rate development. Let us suppose for example the path of the cyclone approaching the area to which is linked (Figure 10-2). This process could be also certain random process closely connected to a random walk.

Figure 8–2 The path of a cyclone



Source: Australian Government Bureau of Meteorology (2004)

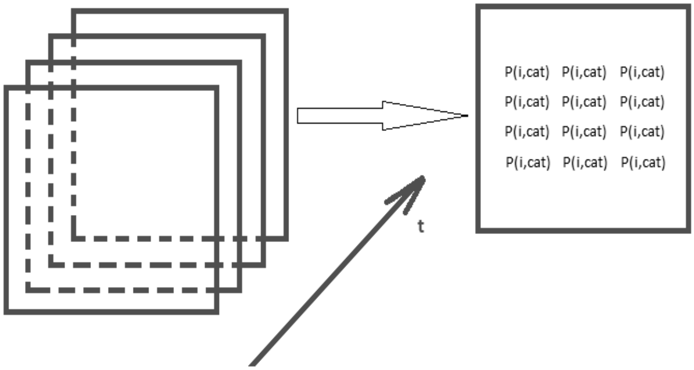
8.2.1 Calculations on 3D tree

Price at each node we calculate according formula (1):

$$P_{t,i,cat} = \sum_{s=1}^{n} q_s \frac{P_{s,t+1}}{(1+i_t)} \qquad (2)$$

where n is the number of paths from each node (from left to right), $P_{t,i,cat}$ is the total price of a bond at time t with interest rate i_t (unique for each node) and a state of catastrophe process cat; q denotes the probability of the transition from node at time t to time $t+1$. The principle is displayed in Figure 8-3. The calculation allows analytically calculate the price at each node and use 9^n scenarios where n is the number of coupon periods.

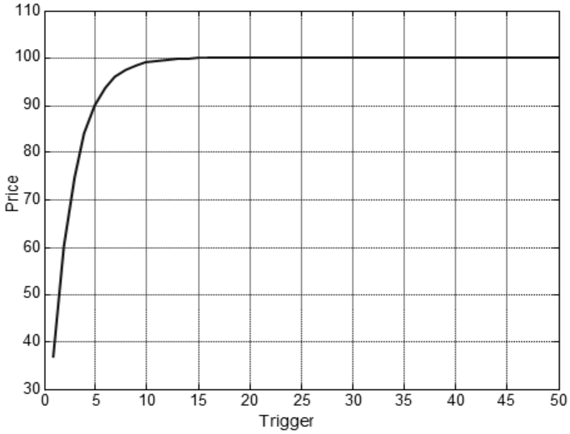
Figure 8–3 Principle of calculation using 3D tree



8.2.1.1 Results on 3D tree

Now let us have a CAT bond with, by the way of example, 100-years maturity, c equals to initial interest rate and we use Hull-White model for the interest rate forecasting. For the simulation of a catastrophe process we use independent random walk steps (close to Figure 8-2 – cyclone style), the range of its values $\in [-100,100]$. Initial value is 0, values < 0 are inactive as triggers, with higher value of trigger the probability of triggering is lower. Example of valuation (present value) for different parameters of trigger (implemented in Matlab) follows. The results are presented in Figure 8-4.

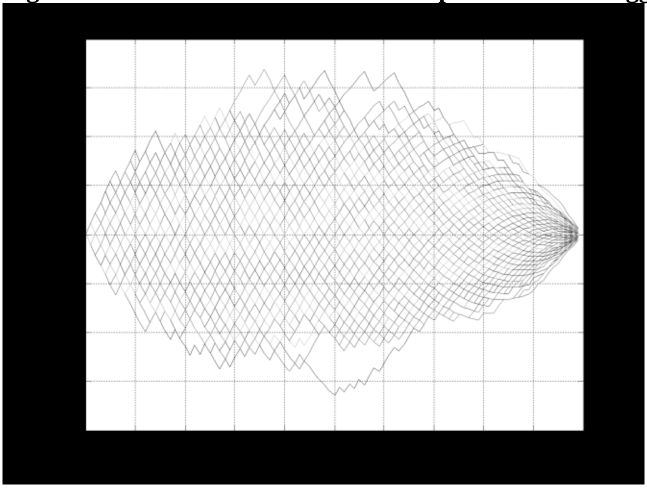
Figure 8–4 Price of a CAT bond with respect to trigger level



8.2.2 Simulation on 3D Tree

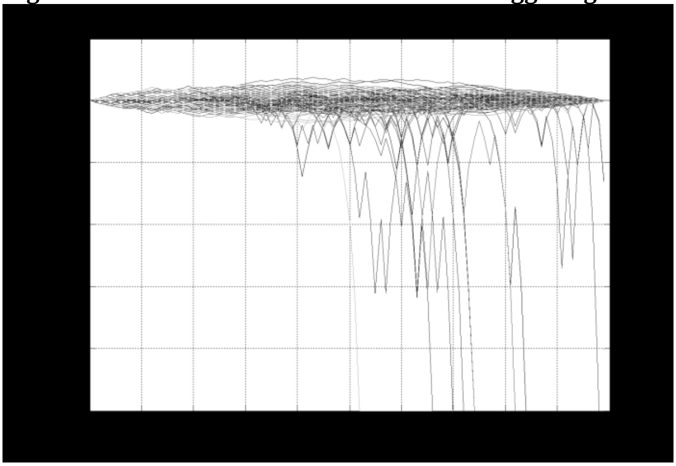
Performing simulation on 3D tree while reaching the trigger is almost impossible (trigger value is 100) we obtain typical price development with pull to par effect (Figure 8-5).

Figure 8–5 Simulation of a CAT bond price without triggering



In case of simulation on 3D tree while reaching the trigger is probable (its value is 20) we obtain a possible price development according to Figure 8-6. We observe higher volatility of price while catastrophe occurs and fall to zero in case of reaching the trigger level.

Figure 8–6 Simulation of CAT bond with triggering



Occurrence of volatility clustering in case of approaching of catastrophe process is in the Figure 8-7b.

Figure 8–7 CAT bond volatility without clustering (a), with volatility clusters (b)

(a) (b)

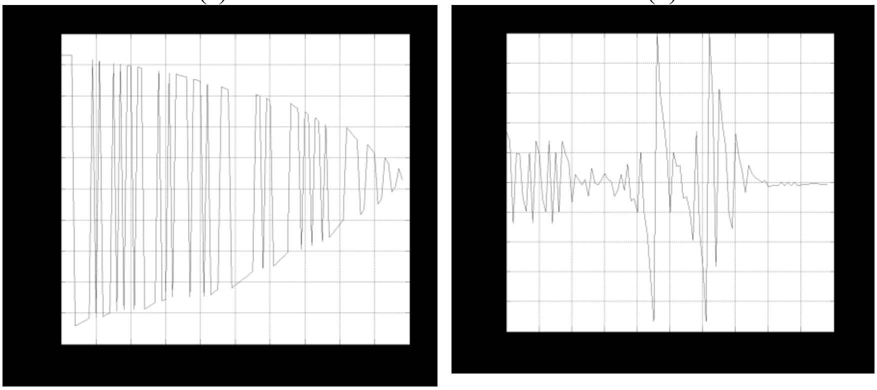
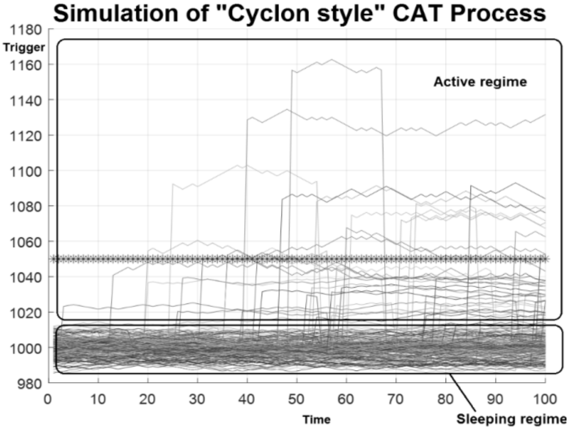


Figure 8–8 Cyclone style catastrophe development simulation

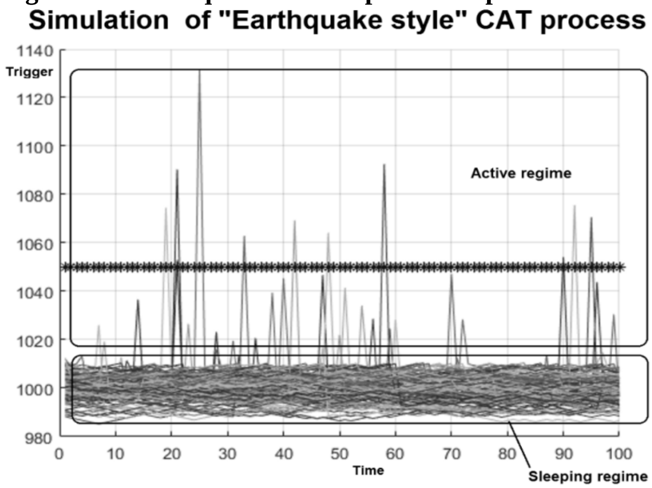


8.3 Valuation using 2 scenarious model

8.3.1 "Cyclone" Style Catastrophic Process

The catastrophe process occurs usually in two regimes (Fučík, Stádník, 2017). The first regime we named the "sleeping" regime and the second we named the "active" regime. Based on empirical observations the probability of switching from sleeping regime to active regime is rather small whereas the probability of switching from active regime to sleeping regime is 100% after certain period of time. We may generalize all catastrophic processes in this manner. For example the probability of cyclone appearance is quite small (“black swan”). If it suddenly appears (switches from the sleeping regime to the active regime) it may follow for example the paths presented in Figure 8-8. It describes cyclone style development as a cyclone usually appears and it takes some time to disappear. In some cases it may even reach the trigger level (thick line at 1050 level by the way of example).

Figure 8–9 Earthquake catastrophe development simulation



8.3.2 “Earthquake” Style Catastrophic Process

Figure 8-9 describes earthquake style with a very quick run. We expect sharp peaks in comparison to cyclone style. For the valuation of both the cyclone and the earthquake style we may use the following equation (3):

$$P_1 = \frac{(F+c)(1-q)+\omega(F+c)q}{1+i} \qquad (2)$$

where P_1 is a current price of a CAT bond, i is risk free rate, q is the probability of a catastrophe appearance during the period of 1year.

There is a comparison of valuation of a CAT bond covering cyclone and earthquake catastrophes in the Figures 8-10 and 8-11 (cyclone style-higher price in average, earthquake - lower price in average).

Figure 8–10 Cyclone and earthquake style probability of triggering

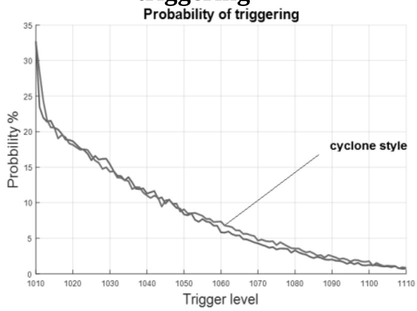
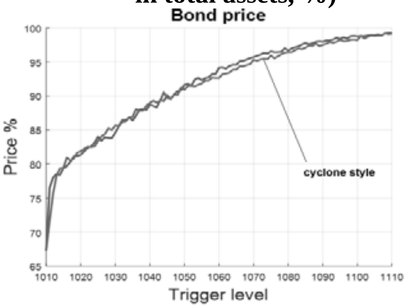


Figure 8–11 Evolution of the liquidity buffer in the severe scenario (share in total assets, %)



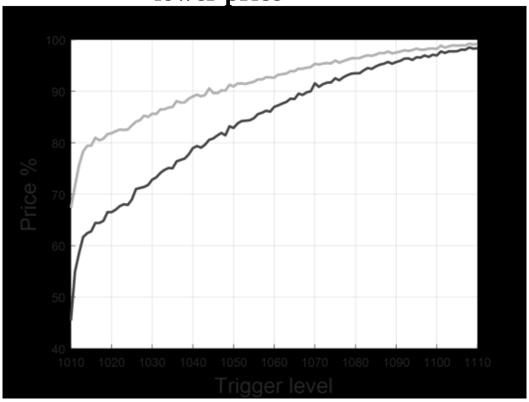
8.3.3 Earthquake + cyclone style components

For the valuation of the CAT bond which is composed from both the cyclone and the earthquake components we may use the following equation (4):

$$P_1 = \frac{(F+c)(1-q_1)(1-q_2)+\omega(F+c)q_1q_2}{1+i} \qquad (4)$$

Where q_1 and q_2 are probabilities of the catastrophe processes occurring. There is a comparison of valuation of a CAT bond covering one and two catastrophes in the Figure 12.

Figure 8–12 Cyclone style-higher price, cyclone + earthquake components - lower price



8.4 Possibilities of the future research

Future research should focus on the fundamental description of the basic scientific problem: global transformations lead to the appearance of new types of risks (the growth of a number and severity of natural catastrophes, the change of longevity). These risks, being natural ones, influence social processes in general and an economy in particular (first of all, by distortions of financial flows and by dysfunction of traditional social institutions). The usual insurance tools are not sufficient for managing of such risks, which generate negative social consequences. Hence, the development of new approaches, including some modifications of social institutes, in this area is important.

In other words, the fundamental scientific problem, which is planned to be solved by the offered research, and, hence, its main objective is to investigate some basic channels of the influence of social processes (including financial ones) by new natural risks, their quantitative measurement and the development of new tools that withstand the pressure of growing negative consequences of such risks.

Fundamental and systemic nature of the future research should be based on the following: Risks are generated by the natural processes, then their social consequences are quantitatively estimated and, as a result, some financial tools are developed to minimize those consequences. The main objective can be divided into the following research issues:

1. To develop a new approach to non-life catastrophe processes including a revised classification, renewed assumptions for their modelling based on the nature of such processes (floods, Hurricane and tropical storm, earthquake, hailstorms) and their physical and distributional characteristics.
2. To develop a new approach to life processes with longevity shocks in the trend and its consequences to volatility as well as mortality catastrophe processes with stress on the future lifetime distributions.
3. To contrast and compare consequences of life and non-life catastrophe processes from the point of view distributional features and financial damage (mostly insurance loss) of natural catastrophe events as well as in the framework of model risk.
4. To study specific features of insurance industry risk transfer to capital markets including the estimation of the potential capacity of capital markets to cover new risks analysing on previous stages.
5. To construct the design for ILS derivatives products to support transparency and liquidity.
6. To evaluate capital market tools (first of all, ILS) using new models described in the points 1-3 above.
7. To study ILS and its dependence structure with other assets in the context of portfolio implementation, including answering the question about existence or non-existence of systematic risk in the case ILS and of correlation or non-correlation with other financial assets (according to CAPM) as well as the question of specific features of return distribution and of fitting its tails using advanced mathematical methods.

8. To assess cyber risk transfers - the big opportunity for insurance investors. The risk of cyber-attacks is one of the few risks where the demand for insurance exceeds the supply. Despite the apparent opportunity, many traditional and alternative reinsurers have been reluctant to embrace this line of business, new class of transparent cyber transactions.

8.5 Conclusion

In this financial engineering article we make conclusion on possibilities on future financial research in the field of ILS products. We also describe the framework for the quantification of the catastrophe processes, mainly of the cyclone and the earthquake style, and consequently valuate the appropriate catastrophe (CAT) bond. We recognize and describe the difference between the both styles; while the earthquake style performs quickly and the calculation is basically only about the probability that the catastrophe may happen during a certain period of time, the cyclone style is also about the development of the process after a cyclone appears. During this time period we may observe interesting effects like increasing volatility and volatility clustering. We show the way of calculation using 3 D tree and also using more simple method by utilizing valuation using 2 scenarios model for the short time period. We apply this method to the both single and double catastrophe linked CAT bonds.

Chapter 9

Insurance and systemic risk[51]

By Jarmila Radová, Jaroslav Daňhel and Eva Ducháčková

9.1 Introduction

Banking and the insurance business are the backbone of the whole economy. Their financial health and good condition contribute, to a significant extent, to the overall health, stability and effectiveness of the national economy. However, due to the different nature of their financial business, these two branches behave very differently when the economic cycle reaches a period of negative growth, and they have, therefore, completely different characteristics with regard to the triggering of events in the current complex, global world marked by highly feared systemic risk, which can affect the whole economy.

9.2 Reasons for the varying resistance of banks and insurance companies to cyclical fluctuations

9.2.1 Methodological differences

Banks and insurance companies are the most important elements of the financial sector. Both businesses are significant institutional investors in the economy. The foundation of the activity of both the banking sector and the insurance sector is one of the most important economic goods – the trust of their clients. They have an irreplaceable role on the financial markets, because they, above all, are the financial subjects which amass temporarily available funds from retail clients and offer collected funds, via the financial markets, to issuers on the primary market to use to promote economic growth and also to increase the value of the funds. That is why it is important to know how these macroeconomically important sectors behave during the extremes of economic cycles, and, specifically, how they behaved during the last crisis, which presented several new features, and, above

[51] The chapter is processed as an output of a research project *Trends in the banking and insurance sectors in a changing financial markets* registered by the University of Economics under the registration number IGA F1/21/2016.

all, whether it is possible to ascertain a fundamentally different level of resistance of the two sectors to the trough of the economic cycle (Harrington, 2009).

From the point of view of methodology, both banking and the insurance business are characterized by a negative relationship to the category of volatility, which is regarded as one of the states of the current, complex, globally interconnected world. Seen from this viewpoint, there is an upper limit to the possible profits of both banks and insurance companies, while there is no limit to the size of their potential losses. The causes of a hypothetical, potential default in each sector are, of course, diametrically different.

In the case of the banking business the most common trigger has, historically, been a strong, destructive fluctuation during the trough of the economic cycle, while in the case of the insurance business, because of the different, and stronger, motivation to acquire insurance, such a trigger is extremely rare. Insurance companies may, though, be easily bankrupted by the occurrence of a threatened fatal, catastrophic event.

The character of the revenue of banks and insurance companies with limits on the right-hand side of the balance sheet, and practically no limits on the left-hand side, is of key important for both sectors. In a fatal, cyclical default or a catastrophic event, both banks and insurance companies can lose assets saved up over several generations.

It follows from this, that during a period of crisis events, these sectors have a completely different position. They differ significantly in their business model in several respects. Firstly, the principles of their internal economies are totally different. Banking houses are, in an economically unstable environment, particularly sensitive to a run caused by their clients. During the last crisis, a destructive run was actually organized by the bankers themselves, to their own mutual detriment. The sector's negative exposure to volatility was manifested during the last fatal financial crisis, when the banking sector was clearly incapable of dealing with the severe imbalances on the financial markets, which, to a considerable extent, it had itself helped to create.

The position of the insurance business is, in this regard, completely different. Because of their role in the economy (which is the provision of protection against risks, in advance and on a long-term basis), insurance companies are financed by a relatively stable income in the form of insurance premiums, and are, therefore, compared to banks, much less exposed to the risk of an acute shortage of liquidity and are much less prone to, and more resistant to sudden collapse. This has an important macroeconomic consequence; systemic risk, which is currently so highly feared, is, in this respect, almost exclusively a phenomenon of the banking sector. The last financial crisis was, indeed, triggered by the occurrence of a systemic risk event in that sector. By contrast, no significant crisis in history is known to have been caused by the default of an insurance company or reinsurance company.

It is, therefore, an important fact that the insurance business model, provided an insurance company sticks to its core business, does not create any significant systemic risk at the macro-level which could be transferred to the general economy. However, an insurance company will find itself in a complicated situation if it extends its business interests by including non-conservative products which are analogous to those offered by the banking sector, and which are not strictly based on the technical calculation models of the insurance sector. This was, indeed, demonstrated in the wake of the crisis of 2008; the troubles of the AIG insurance company and the defaults of the so-called monoline insurance companies during the first phase of the financial crisis arose from the earlier insuring of innovative derivative instruments for prices which had not been set on the basis of the conservative technical methods and models which are usual for the insurance business.

The balance sheet structure of banks differs considerably from that of insurance companies. In the balance sheet of an insurance company, the assets and liabilities are more interconnected, while banks have to cope more often with greater or smaller structural imbalances. The investment strategy of banks is generally more short-term and is focused more on profitability. Insurance companies, especially those which deal in life insurance, give priority, when investing temporarily available funds, to the criterion of security. They are more conservative and more carefully diversify their exposure, even though, in the current state of low effectiveness on the financial markets, their task, in this respect, is very complicated.

In any case, insurance companies, despite their high level of engagement as institutional investors in the economy, did not suffer any severe losses during the last financial crisis, either in the first phase of the mortgage crisis or its further development. The losses which they did suffer, especially due to the fall in value of the assets in their portfolios, were not fatal, and the insurance companies wrote them all off within a short space of time.

9.2.2 Differences in the character of business risks, consequences for the reduction of systemic risk by the insurance sector

The importance of the various business risks of banks and insurance companies is fundamentally different. In the case of banks, credit risk plays a key role, while market risk, operational risk and liquidity risk are also significant. Despite the general surplus liquidity in different economies, state regulators have paid greater attention to the business risks of banks. In the case of insurance companies, the most significant risk is technical risk arising from the specific characteristics of the insurance business. Credit risk is also significant, especially because of the possible failure of the most important counterparty of an insurance company – a reinsurance company. Market risk and operational risk are also significant, while liquidity risk is less important for the insurance business because of the stabilising function of life insurance products.

The regulatory bodies' current concept of the magic triangle, whose vertices are the stability of the sector, the security of the clients, and the effectiveness of the sector, clearly emphasises the first two vertices, even at the cost of the reduced effectiveness of insurance as an instrument for eliminating the consequences of randomness. According to the first pillar of the Solvency II regulatory project, an insurance company has a duty to refuse to provide cover if, according to the calculations of the solvency model, exposure to a hypothetical event is not covered by the resources of the company.

Table 9–1 Risk of bank and Insurance companies

Risks of	
Banks	Insurance companies

- credit risk
- market risk
  o interest rate risk
  o equity risk
- liquidity risk
- operational risk
	- underwriting risk
	  o life insurance: risk of longevity, mortality risk, risk of disability
	  o non-life insurance: premium risk, risk of technical provisions, risk of catastrophes
	- credit risk
	- market risk
	- liquidity risk
	- operational risk

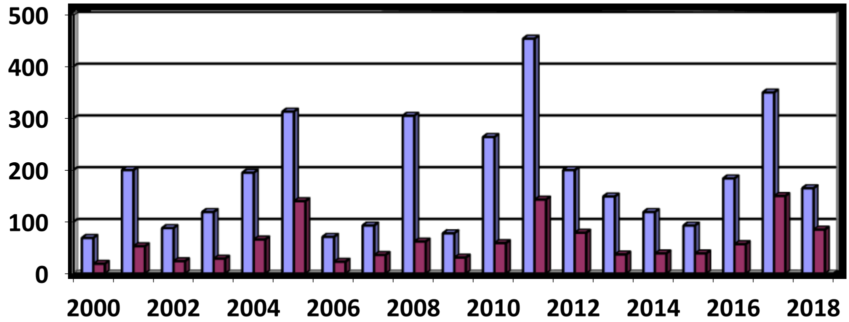
Source: Dvořák et al. (2014), Daňhel et al. (2012)

This concept is based, however, on the dubious presumption that such a risk can be mathematically quantified in advance, which is in total contradiction to the propositions of the empirical economist Nassim Taleb (2013) and his category of unforeseeable "black swans".[52] Any regulation which orders the exclusion of catastrophic events from insurance cover sounds, therefore, a bit like throwing the baby out with the bathwater. On the other hand, we cannot completely ignore the constant growth in the financial consequences of catastrophic events, which is connected with the growth in value of property on our finite planet Earth, and the

[52] The problematic nature of drawing conclusions on the basic of historical time series when faced with the unpredictability of Taleb's "black swans" and their mathematical elusiveness can be seen graphically in the Fukushima catastrophe (Taleb, 2013). The Fukushima nuclear power station, built in one of the world's most technologically developed countries, was designed to withstand the effects of the greatest catastrophe of that kind. Its reactor was built to withstand earthquakes equal in scale to the worst ever recorded in history, and its constructors did not expect there to be any significantly greater. The tsunami which destroyed the power station represented, however, a further "upgrade" of a "black swan", the like of which had not been recorded in historical data (Taleb, 2014).

increasing technological vulnerability of modern society. This dilemma clearly demonstrates the ambivalence and oversensitivity arising from the current position of commercial insurance in the economy and in modern society generally, including the sensitive problem of the limits of insurability for commercial insurance companies.

Figure 9–1 Catastrophes worldwide: total vs. insured losses (in USD bn)



Source: Catastrophes (2019). Swiss Re Institute. Available at: https://www.sigma-explorer.com/

One of the pillars of the Solvency II project has a shaky foundation. Currently it recognises an insurance company's legitimate right to refuse an applicant's request for insurance cover for potential catastrophic events with possibly fatal consequences for the insurance company. The dilemma is, in this case, very clear: on the one hand there is a reduction in the effectiveness of insurance for the clients (and the scientific discipline of risk management strongly recommends that the financial consequences of catastrophic events be unconditionally transferred). On the other hand, the insurance company, using the limits on insurance cover and exclusions from insurance, must strive to maintain the principle of equivalence between income and expenditure, and therefore also strive to maintain a balance in its own economy and attain a certain level of predictability in the economics of insurance products in the calculation model.

On the other hand, there is the fact that the almost geometrically increasing extent of the financial consequences of catastrophes in our developed, but consequently more vulnerable civilisation, makes it difficult for such events to be covered by commercial insurance. In this situation, insurers apparently have no other option than to reduce the effectiveness of insurance as an instrument for ensuring financial continuity following random, catastrophic events, and to adjust the limits of insurability – that is, to declare exclusions from insurance and to set an upper limit for insurance pay-outs. But don't clients rather regard exclusions and upper limits as unfriendly? Moreover, insurance products are, in general, not exactly the easiest to understand for clients. Indeed, the insurance market is presented in specialist literature as an example of an important market segment which functions problematically in this regard.[53]

On the other hand, the concept of regulated limits of insurability significantly strengthens the insurance sector against systemic risk. Even the regulators themselves believe that in the insurance sector, unlike the banking sector, it is not possible, in the current set-up, to identify an imminent, direct trigger of systemic risk which can affect the financial sector and, subsequently, the real economy. Nevertheless, they do see certain indirect, potential sources of systemic risk within the insurance sector. Dvořák et al. (2016) propose that the primary risk is the danger of herd behaviour on the part of the insurance companies arising from the similarity of the structure of their balance sheets and the business models they use, as well as the fact that they have the same regulatory principles.

When evaluating the risk factor caused by all insurance companies on the market having the same regulations, we see a certain paradox: one of the areas where regulation has, historically, appeared to be essential, is the investment policy of insurance companies, that is, handling the temporarily available funds of life insurance clients during the period between the start of insurance and the insurance pay-out, which may even be dozens of years. Historically, a traditional, and, we might say, tried and tested regulatory instrument was the so-called setting of quotas for the assets of an insurance company, which ensured the conservative handling of the funds in the life insurance reserves. Within the implementation of the Solvency II regulatory project, that traditional instrument was abolished and replaced by regulation within the framework of a multipurpose model. One of the possible threats is thought to be the inflation of price bubbles caused by the insurance companies' striving for risky yields, when safe assets are unable to ensure yields for the clients guaranteed by their insurance company.

9.2.3 Differences in information asymmetry

The banking and insurances markets also display important differences in the area of information asymmetry. Both markets display information imperfection in their relationships with their clients (Daňhel, 2010). The level of operational risk of banks and insurance companies is affected above all by the consequences of moral hazard and negative selection. However, even in this regard we find a significant difference. The aim of insurance is the financial elimination of the consequences of randomness. If, however, an insurance event is not random, in other words if it is caused intentionally with an intent to defraud, then, because of the very nature of the insurance business, it cannot be covered by insurance. This type of adverse selection, which cannot be identified in advance, lies, therefore, completely outside the scope of any insurance relationship and cannot be regarded as an information advantage on the client's side.

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[53] In the spirit of the text of this paragraph, the behavioural economist Dan Ariely (2011) criticises insurance products for their insufficient transparency in his book "The Upside of Irrationality".

In the banking sector, however, loan default cannot be viewed so strictly. A bank is more able to identify the level of a client's credit risk using standardised methods. Depending on whether the information asymmetry is immanent in a given economic activity (which in banking means that it is connected with imperfect information about the future development of the economic situation of a loan granted to a problem-free, creditworthy client, and in the insurance business means, above all, information imperfection connected with the stochastic foundation of insurance activity), or whether it is exogenous asymmetry introduced inorganically into a commercial relationship by negative selection and moral hazard, it is possible to distinguish what is the acceptable use of information asymmetry in the market sense of the word, and what is its abuse, or possibly even failure of the market, with its consequences, requiring market-appropriate regulation of both the banking and insurance sectors.

We observe that in the insurance sector, unlike the banking sector, there is no significant endogenous information asymmetry on the demand side. An insurance client is not equipped with the ability to predict his own claims history. A strong, behavioural motive for taking out insurance is the aversion most people have to risk, which makes them opt for a small, certain loss – the insurance premium – rather than a possible, large loss. On the supply side, there is, because of the stochastic nature of insurance activity and because of qualitative changes in the nature of insured risks, the possibility of endogenous asymmetry. It is, however, important that exogenous asymmetry may also be introduced, by a problematic or even dishonest insurer, which means there is a certain need for the regulatory protection of clients. There is a wide range of problematic and dishonest business dealings, from hidden exclusions from insurance in the insurance conditions to the cashing-in of an insurance premium with a resulting departure from the market.

Both the insurance sector and the banking sector are characterised by their high leverage stemming from a low share of capital in liabilities, which, for the state regulatory bodies, implies that banks and insurance companies handle the financial resources of clients who, as a rule, have neither the possibility nor the financial education to monitor effectively the financial position of the financial institution. From an expert point of view, the limitation of a client's choice of insurer and a higher level of market orientation for less educated and less financially literate clients, as well as client protection, especially in the area of long-term life insurance, appear to be totally market-appropriate.

9.3 The effectiveness of special built-in stabilizers to stabilize the economy of the insurance business and reduce the possible transfer of systemic risk

In order to stabilise its own economy, especially in the non-life business, which is specifically affected by difficult to predict events caused by the random mechanism in indemnity insurance, the insurance sector created its own system of built-in stabilizers, which, to a large extent, shield it both from the impact of volatile fluctuations, which are typical for random variables, and from any other impacts, including those caused by the economic cycle. Those historically proven and effective built-in stabilizers are: the creation and use of technical insurance reserves, reinsurance (the insurance of an insurance company) and, more recently, institutions of intersectoral integration (multifunctional financial conglomerates).

If we look at this specific problem of the insurance sector from the point of view of the business risks of commercial insurers, then the most serious business risk, representing, according to expert estimates, about two thirds of the threats to the success of a commercial insurance company, is the already mentioned insurance technical risk. This risk is defined as the possibility of a positive or negative deviation from an insurance company's a priori calculation of the total costs of its own insurance activity – that is, the projected, provisionally calculated claims history and projected overhead costs. Setting the insurance premium correctly in the calculation model for non-life insurance products is the first precondition for ensuring the stability (low volatility) of an insurance company's economic results. If the random generator causes a significant negative deviation in the claims history, it is essential that, in the second plan, the impact on the economic result should be balanced out by an appropriate built-in stabilizer (The Geneva Association, 2008).

What is specific about the non-life segment is that, in an insurance company's financial management system, because of the volatile choice of the random generator, it is not possible to rely only on regular income from insurance premiums; it is necessary to balance out the material, temporal and local fluctuations from the calculation model through the creation and use of financial reserves. Definitions of the insurance business refer to its close connection with the functioning of fluctuation reserves, whose historically proven, effective mechanism is, in its basic principle, very simple: at times of positive deviations from the modelled values in the calculation of insurance premiums, the fluctuation reserves are boosted, while at times of negative deviations, the company draws on them (Snopková, 2015).

One historically tried and tested built-in stabilizer is reinsurance. Reinsurance is a very effective, traditional diversifier of random fluctuations in the claims histories of insurance company clients, both within the framework of the economy of one country, and, above all, internationally (Zweifel, 2012). Like insurance itself, reinsurance does not reduce the scale of material losses, but it does make their financial consequences more bearable for an insurance company, and it mitigates their overall impact on the insurance sector and the economy as a whole.

Reinsurance represents a very important method for eliminating the insurance technical risks of an insurance company, and is also a direct application of the process of risk management to a specific company, in this case an insurance company. In practical terms it means that if an insurance company takes on an insurance risk whose catastrophic occurrence might cause damage too great to be covered by the company's financial resources, part of the risk is transferred for a payment – reinsurance – to a special institution of the insurance market – a reinsurance company. In this way the insurance company, in line with the aims of the Solvency II regulatory project, implements the division of the accepted risks into one part, which the company itself covers out of its own available financial resources (the normal income from insurance premiums plus resources from the insurance technical reserves), and another part which it transfers to insurance, or, in the case of an insurance company, to reinsurance (Berliner, 1982).

In recent decades, a further economic stabilizer for the insurance sector has been intersectoral integration, which can be seen in the creation of banc assurance companies, or multifunctional financial conglomerates. In these institutions there is further level of the diversification of business risks and the smoothing out of the overall results of integrated financial services. Even in this area with a short history, the previous premises regarding the strength of the resistance of the insurance business to cyclical fluctuations have been confirmed: in the last crisis, when integrated banc assurance companies and financial conglomerates got into trouble, that trouble was always caused by problems arising in the banking sector. The insurance sector was more likely to stabilise institutions.

9.4 Current changes in the tax deductibility of a built-in stabilizer of insurance technical reserves in the current Czech environment

According to the hitherto valid methods, all the tax-deductible insurance technical reserves of insurance companies were created according to the law on accounting. According to the changes proposed in a draft bill, for tax purposes all reserves calculated according to the regulations of the Solvency II regulatory project will be taken into account. The regulations of the project were created for the setting of a minimum and optimal safe level of capital required by an insurance company for its business activities.

This method of calculation is fundamentally, conceptually different from, and in conflict with general accounting principles, including the requirement of the prudent, conservative behaviour of financial institutions. This is glaringly obvious, especially in the case of life insurance reserves created as a mathematically calculated resource required for future insurance pay-outs. A characteristic feature of both commercial insurance companies and banks is their high leverage stemming from their low share of own capital in liabilities, due to the fact that they handle the resources of other entities – their clients.

Mathematical solvency models generally limit the need for reserves to the level required to deal with the worst situations of the past. Those models cannot be used to predict future needs. The introduction of a solvency rule based on such models was once the reaction of the EU to the problems which some insurance companies in the Eastern European countries had in attaining a safe level of capital.

We have already mentioned serious reservations about this approach from the point of view of Solvency II and the methodological viewpoint. Mathematical solvency models are based on historical probabilities, and cannot, therefore, reflect any future major change in the behaviour of the random generator. Logically, they therefore reduce the need for reserves to the level required to deal with the worst situations of the past. They cannot be used to predict future requirements. Ample insurance technical reserves stabilise the insurance sector and limit the domino effect of a default in the financial sector. A clumsy intervention in their functioning may, in an extreme case, lead to the default of the insurance company, which then affects the surrounding economy – in other words, a systemic risk event occurs (The Geneva Association, 2010).

9.5 Conclusions

Regarding potential collapse, the insurance business differs from other segments of the financial markets in one significant respect: it does not create a systemic risk which can be transferred directly to the real economy. The insurance sector has relatively high resistance to typical crisis triggers thanks to the basis of the way it functions. This was seen during the last crisis too, when, once again, the insurance business's low potential for triggering systemic risk in the economy was demonstrated. While in banking, the occurrence of systemic risk and its subsequent transfer to the real economy is a phenomenon of key importance, in the insurance business it is of almost no significance at all.

The status and effectiveness of the commercial insurance sector, including the issue of setting the limits of insurability, are impacted, in a significant way, by state regulation. Although the sector is one of the most stable financial sectors and has, historically, never been the trigger of systemic risk transferrable to the real economy, the regulator applies the same strict controls to it that it applies to all segments of the financial market, irrespective of their distinct characteristics.

The currently implemented Solvency II project is in conflict with the generally valid axiom about the unpredictability of the external world and the impossibility of making the future the object of scientific research, when, as an object, it does not yet exist. This qualitative contradiction cannot be solved mathematically.

The implementation of change in the tax deductibility of insurance technical reserves on the basis of a solvency rule in the current Czech environment will lead to a serious reduction in the creditworthiness of the Czech insurance sector and its potential resistance to catastrophic and other negative events. In an extreme case it could even lead the occurrence of a systemic risk event in the economy.

List of Abbreviations

BCBS	Basel Committee on Banking Supervision
BIS	Bank for International Settlements
BRRD	Bank Recovery and Resolution Directive
BVAR	Bayesian Vector Autoregression
CAR	Capital Adequacy Ratio
CCyB	Countercyclical Capital Buffer
CDS	Credit Default Swaps
CERTIS	Czech Express Real Time Interbank Gross Settlement system
CET1	Common Equity Tier 1
CNB	Czech National Bank
CRD IV	Capital Requirements Directive IV
CRR	Capital Requirements Regulation
DSGE	Dynamic Stochastic General Equilibrium model
D-SIFIs	Domestic Systemically Important Financial Institutions
D-SIN	Domestic Systemically Important Bank
EAD	Exposure at Default
EBA	European Banking Authority
ECB	European Central Bank
EIOPA	European Insurance and Occupational Pensions Authority
EL	Expected Loss
EMSE	Emerging Market and Small Economies
ESRB	European Systemic Risk Board
EWSs	Early Warning Systems
FSB	Financial Stability Board
G-SIBs	Global Systemically Important Banks
G-SIFIs	Global Systemically Important Financial Institutions
IAS	International Accounting Standards
IFRS	International Financial Reporting Standards
IRB	Internal Ratings-Based Approach
LCR	Liquidity Coverage Ratio
LGD	Loss Given Default
LTI	Loan-to-Income
LTV	Loan-to-Value Ratios
NPL	Non-Performing Loan

MREL	Minimum Required Eligible Liabilities
NSFR	Net Stable Funding Ratio
O-SII	Other Systemically Important Institutions
PD	Probability of Default
RWA	Risk Weighted Assets
SCR	Solvency Capital Requirement
SCSs	Systemic Capital Surcharges
SIFI	Systemically Important Financial Institutions
TLAC	Total Loss Absorption Capacities
VECM	Vector Error Correction Model

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Summary

Systemic Risk in Post-Crisis Financial Markets focuses on the environment in advanced economies that resulted from political, regulatory and macroeconomic policy response to the global financial crisis. It comes from the finding that the response to the crisis mitigated number of problems, it nevertheless failed to address fully the sources of systemic risk. In addition, some new sources of systemic risks emerged often associated with accommodative monetary policies of central banks.

Firstly, we look at the consequences of accommodative monetary policies by major central banks that created environment of exceptionally low interest rates. The outcome has been strong demand for riskier financial assets, residential and commercial real estate. Higher demand for foreign assets in advanced economies enabled large nonfinancial companies from advanced and emerging economies to tap large funds through corporate bond issues. Easy access to, and the low cost of, loans for house purchase, coupled with expectations of continued growth in house prices, have created a potential for spiralling between property prices and loans for house purchase. All this contributed to spreading of systemic risk in global financial system. We warn against excessive reliance on macroprudential policy tools to prevent excessive credit growth and asset prices misalignments. We call for a more holistic approach that would base on co-ordination of wider array of economic policies.

Secondly, Basel III regulatory framework established as one of the key macroprudential instruments in the banking sector a countercyclical capital buffer. This instrument is designed to reduce the consequences of worsened access of firms and households to banking credit in bad times. We propose comprehensive approach to the countercyclical capital buffer. The decision-making process starts from assessing the position of the economy in the financial cycle through detailed analysis of particular risks to setting the buffer rate. The approach that can be labelled discretion guided by multiple-factor analysis builds upon the signals from both individual and composite indicators of financial cycle and systemic risk. The approach to releasing the buffer in times of stress is also dealt with.

Thirdly, we pay attention to the interrelationship between solvency and liquidity risk and interconnectedness through liquidity flows within and across financial system. We suggest liquidity stress–testing framework based on parsimonious models with metrics similar to the two Basel liquidity regulatory standards the LCR and the NSFR. The model takes into account the one year stress period with a gradual impact of a credit shock on banks´ liquidity position. The test includes also endogenous reactions of banks to the initial shock, creating some additional shocks in the second round. We argue that in a stress test, both shorter and longer horizons should be explored to assess the extent of bank´s sensitivity.

Fourthly, currency markets appear to be prone to contagion owing to occurrence of extreme events taking place in different countries simultaneously. We start with the examination of the potential for a "bubble" contagion. Next, the extreme values of the differences between actual daily exchange rates and their monthly equilibrium values determine the episodes associated with large departures from equilibrium. Using tools from extreme value theory, we analyse the transmission of both standard crisis and "bubble" formation events in the examined currency markets. The results reveal a significant potential for contagion in the currency markets of Central Europe. Next, we explore as a source of financial instability the currency crises (foreign exchange, speculative) associated in particular with fixed exchange rate regimes. We express some worries regarding the stay of an economy in the ERM II regime.

Fifthly, we explore some issues related to credit risk in financial markets. In particular, an innovative approach based on implied ratings defined by CDS spreads is applied. For those countries where the credit rating and implied credit rating are different, the chapter shows how implied rating can serve as a signal for potential upgrade or downgrade of the credit rating provided by rating agencies. This is especially important when some ratings are investment-grade and others are speculative-grade.

Finally, we investigate into the risks to which the insurance industry is exposed to. Banks and the insurances have different nature of their financial business. These two branches thus behave very differently when the economic cycle reaches a period of negative growth, and they have, therefore, diverse characteristics with regard to the triggering of events in the current complex, global world marked by highly feared systemic risk, which can affect the whole economy. While in banking, the occurrence of systemic risk and its subsequent transfer to the real economy is a phenomenon of key importance, in the insurance business it historically has been of almost no significance at all. However, current macroeconomic environment characterised by exceptionally low nominal yields may some capacity to change the historical patterns.