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FACULTY OF SOCIAL SCIENCES

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Diploma thesis

2012 **Jakub Chleboun**

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Interbank contagion under the Basel III regulatory framework

Diploma thesis

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Abstract

This study assesses the impact of the Basel III regulatory framework on interbank contagion. It focuses on the direct interbank contagion that spreads via interbank foreign claims among national banking sectors. A balance sheet-based network model employs the quarterly consolidated banking statistics, collected by the Bank for International Settlements, to simulate the consequences of credit and funding shock under stressed market conditions. Compared to the Basel II, the Basel III regulatory framework reduces the probability of interbank contagion (following a simulated default of one banking sector) from 31% to 14% and lowers the impact of contagion by 63% in terms of average loss for a banking sector. The simulations under both regulatory frameworks show that relatively smaller banking sectors can trigger severe interbank contagion comparable to large banking sectors. Throughout the 2005-2009 period, the Basel III regulatory framework stabilizes the fluctuations of the scope of interbank contagion.

Keywords

Interbank contagion, network simulation, Basel II, Basel III, consolidated foreign claims.

Abstrakt

Tato studie hodnotí dopad regulatorního rámce „Basilej III“ na mezibankovní nákazu. Studie se zaměřuje na přímou mezibankovní nákazu šířící se skrze mezibankovní zahraniční pohledávky mezi národními bankovními sektory. Síťový model založený na rozvahách bankovních sektorů využívá čtvrtletní konsolidované bankovní statistiky shromažďované Bank for International Settlements k simulaci úvěrového šoku a šoku financování za nepříznivých tržních podmínek. V porovnání s „Basilejí II“ regulatorní rámec „Basilej III“ snižuje pravděpodobnost mezibankovní nákazy (následující po simulované insolvenci jednoho bankovního sektoru) z 31 % na 14 % a snižuje dopad nákazy o 63 % měřeno průměrnou ztrátou bankovního sektoru. Simulace při obou regulatorních rámcích ukázaly, že i poměrně malé bankovní sektory mohou vyvolat závažnou nákazu porovnatelnou s velkými bankovními sektory. Během období 2005 až 2009 stabilizoval regulatorní rámec „Basilej III“ výkyvy v rozsahu mezibankovní nákazy.

Klíčová slova

Mezibankovní nákaza, síťová simulace, Basilej II, Basilej III, konsolidované zahraniční pohledávky.

Rozsah práce: 142 955 znaků.

Declaration

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

Prague, January 9, 2012 Jakub Chleboun

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Master Thesis Proposal

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Notes: The proposal should be 2-3 pages long. Save it as "yoursurname_proposal.doc" and send it to both mejstrik@fsv.cuni.cz and tomas.havranek@ies-prague.org. Subject of the e-mail must be: "JEM124: Thesis Proposal Yoursurname".

Proposed Topic:

Financial Contagion in Banking Sector under Changing Regulatory Framework

Topic Characteristics:

The 2008 financial crisis demonstrated clearly the vulnerability of global banking sector. In particular, the speed the financial contagion spilled over was astonishing. As a reaction to the crisis, the Basel Committee on Banking Supervision proposed several changes (sometimes called Basel III) in order to strengthen global capital and liquidity regulations with the goal of promoting a more resilient banking sector. The aim of this diploma thesis is to answer the question, whether the new regulations prevent the contagion to spread so heavily and so quickly. Since the implementation of "Basel III" is not expected to be finished as soon as this thesis, an impact of Basel II on banking sector will be examined carefully for the purpose of comparative analysis vis-à-vis "Basel III".
I consider international financial statistics provided by Bank for International Settlements as an important source of data.

Hypotheses:

1. Hypothesis #1: Vulnerability of banking sector to financial contagion increased during a past decade.
2. Hypothesis #2: Basel II regulatory framework reduces the risk of financial contagion in banking sector.
3. Hypothesis #3: "Basel III" regulatory framework reduces the risk of financial contagion in banking sector.

Methodology:

There are many definitions of financial contagion as well as many ways to model a contagion. The choice of an appropriate model, therefore, must be subject of a detailed analysis. However, to start with, I draft some methods. If we define *contagion* as a significant increase in the correlation of financial variables during a crisis - after controlling for fundamentals and common shocks – then the often used econometric technique utilized to measure contagion is an autoregressive model. Other performed methodologies are based on simple OLS or principal component analysis.

Outline:

1. Introduction and motivation
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    1.3. Basel III – regulations related to financial contagion
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3. Related literature
    (see section „Core Bibliography")
4. Methodology
    (see section „Methodology")
5. Data
6. Results
7: Conclusions

Core Bibliography:

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Author

Supervisor

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I Introduction

The recent financial crisis has revealed the fragility of global financial system. Despite the well-known fact that the global financial system is more interconnected than ever before, the speed of spread of the crisis was surprising. The quick spread of the crisis has been boosted by financial contagion. Financial contagion generally refers to the set of mechanisms in the financial system that propagate the crisis further and worsen its impact. This study focuses solely on a direct interbank contagion. The direct interbank contagion affects banks through their exposures to other banks in the interbank market. Only the direct channel of interbank contagion is considered here, i.e. the interbank contagion propagated exclusively through actual losses, which bank suffers in the interbank market. As opposed to direct interbank contagion[1], the indirect interbank contagion is propagated through the expectations of banks. A bank run by depositor banks driven by their expectations about the depositing bank's financial health can serve as an example of the indirect interbank contagion.

This study aims to investigate the direct interbank contagion under different regulatory frameworks. Particularly, it compares the Basel II regulatory framework with the newly proposed Basel III regulatory framework. The study presents a series of empirical results on the direct interbank contagion. The simulation indicates systemically important banking sectors and estimates the scope, pattern and path of the interbank contagion. Moreover, it shows how the direct interbank contagion evolves over a 5-year period of time. The main contribution, however, is the comparison between the banking system under the Basel II and the Basel III regulatory framework for all of the above mentioned empirical results. The Basel Committee on Banking Supervision (BCBS) proposed the Basel III regulatory framework to enhance the resiliency of banks and banking systems and to address the shortcomings of the previous Basel II regulatory framework. This study answers the question whether and how the fully implemented Basel III regulatory framework reduces the direct interbank contagion.

[1]There are more definitions of financial contagion. One of the definitions does not consider the direct contagion as a contagion, since it is driven by actual economic fundaments and only the indirect contagion is considered as a contagion, since it is driven by expectations that may have a self-fulfilling effect. Refer to Forbes and Rigobon (2001) for a conceptual overview of contagion research.

The interbank contagion risk module forms an integral part of stress testing of financial systems. Stress tests analyze the resilience of financial systems to adverse events. The methodology and results presented herein can be incorporated into stress testing to assess the resiliency of the whole banking system (not only the resiliency against the direct interbank contagion) on the international level.

The balance sheet-based network simulation model constitutes a natural candidate for investigating the interbank contagion under different regulatory frameworks, since the Basel III package's impact can be conveniently translated into the changes on bank's balance sheet. The first application of the balance sheet-based network simulation model assessing the interbank systemic risk was probably done by Sheldon and Mauer (1998) for Switzerland. Since then, the model has been improved and applied to many other countries. Nevertheless, to the author's best knowledge, the balance sheet-based network simulation model has not been used to investigate the interbank contagion under different regulatory frameworks so far. This study considers the simulation, where credit and funding shocks and their combination are modelled. Moreover, the funding shock is modelled under stressed market conditions that pretty much correspond to the situation in the current financial crisis when the liquidity has been dried up and banks have been experienced to funding problems. Chan-Lau et al. (2009) suggest the methodology of the funding shock under stressed market conditions.

In this study, the balance sheet-based network simulation model employs banking statistics of the Bank for International Settlement (BIS) on interbank exposures of 20 mostly developed countries for the period from 2005:Q1 to 2009:Q4. The Organization for Economic Co-operation and Development (OECD) provides statistics on aggregate national banking sectors' balance sheets complementing the BIS data. Using aggregate data for banking sectors (i.e. treating banking sectors as single banks) constitutes a significant drawback of this study, which might cause an underestimation of interbank contagion.[2]

The remainder of this study proceeds as follows: Chapter II puts this research into context of financial stability research and surveys the literature devoted to the balance sheet-based network simulations; Chapter III describes the simulation model and possible types of shocks

[2] Refer to Chapter V.7 for a comprehensive discussion of shortcomings of this study.

to banks; Chapter IV summarizes the changes under the Basel III regulatory framework and shows the estimation of hypothetical Basel III banking sectors' balance sheets; Chapter V describes in detail the data and presents the results of the simulation model; and finally, Chapter VI concludes.

II Literature survey

The interbank contagion risk module forms an integral part of stress testing of financial systems. Stress tests analyze the resilience of financial systems to adverse events. Stress testing has become a popular analytical tool for central banks and regulatory authorities. The applied stress testing research is based on Čihák (2007). In his stress testing framework, Čihák considers credit risk, interest rate risk, foreign exchange risk, liquidity tests, and interbank contagion risk. Schmieder, Puhr, and Hasan (2011) extend the stress testing framework developed by Čihák (2007). Schmieder, Puhr, and Hasan also build on Boss et al. (2006), who propose a Systemic Risk Monitor tool as a part of the Austrian National Bank's effort to develop tools for systemic financial stability analysis.[3] Schmieder, Puhr, and Hasan contribute to stress testers with increasing the risk-sensitivity of stress testing by capturing changes in risk-weighted assets (RWA) under stress. They also allow running multi-year scenarios and they provide a platform to determine various scenarios using satellite models. The stress tester proposed by Schmieder, Puhr, and Hasan also enables to simulate the impact of implementation of the Basel III package based on the outcome of quantitative impact study by the BCBS (2010) which is also used for this study.

This study uses the balance sheet-based network simulation to assess the interbank contagion risk and the impact of the Basel III package on interbank contagion risk. Although a substantial body of empirical literature on the balance sheet-based network simulations has been written, the theoretical results are not abundant. Allen and Gale (2000) show that spread of financial contagion depends on the structure of interbank exposures. Allen and Gale use a term *complete network structure* that refers to network structure where all banks are exposed to all other banks and the banking system becomes therefore well diversified. Although Allen

[3] Since Austrian banks have foreign branches in many countries, the effort by the Austrian National Bank to monitor the systemic financial stability from the international perspective was substantial.

and Gale find the complete network structure more resilient to spread of financial contagion, some empirical results does not fully support this hypothesis. Elsinger, Lehar, and Summer (2006) find that the complete market structure in case of Austrian banking system leads to a slight increase in scenarios with contagious defaults compared to the incomplete network structure. Similarly, Mistrulli (2007) empirically verified on the Italian banking sector that under certain settings of structure of interbank linkages, recovery rates, and banks' capitalization the maximum entropy approach can actually overestimate the scope for contagion.

In a similar vein, Freixas, Parigi, and Rochet (2000) argue that the tiered banking systems dominated with money-centre banks are susceptible to contagion. In a tiered banking system with money-centre banks in lower tiers only have interbank linkages to the money-centre bank in a next tier, but do not have interbank linkages among themselves. The money-centre banks are then connected among themselves. Such a structure of a banking system is incomplete as the lower tier banks do not have direct interbank links among themselves and among the upper tier money-centre banks except their money-centre bank.

Nier et al. (2007) and Gai and Kapadia (2010) further develop the idea that the structure of banking system affects the scope of contagion. They construct an artificial banking system and investigate the relationship between contagion and degree of connectivity in the banking system, which is a number of bank's linkages to other banks. Gai and Kapadia find that in their artificial banking system of 1000 identical banks the frequency of contagion grows sharply together with increasing degree of connectivity up to a certain break point. When the degree of connectivity exceeds the break point the frequency of contagion starts to decline. The similar hill-shaped relationship is reported by Nier et al. who look at the number of defaults while changing the probability of connection between any two banks[4] in their artificial banking system of 25 banks.

An increase in degree of connectivity has two opposing effects. First, when a bank is more connected to other banks, the chance that one of its counterparties becomes insolvent increases, hence the probability of contagion rises. Second, when a bank is more connected to

[4] More specifically, the authors use an Erdös-Rényi probability of connection between any two banks.

other banks its exposure is better diversified, which reduces the probability of contagion. Results of Nier et al. (2007) and Gai and Kapadia (2010) suggest that the first effect dominates until the degree of connectivity reaches a certain threshold value, when the second, diversification effect becomes predominant.

Importantly for this study, Nier et al. (2007) and Gai and Kapadia (2010) also examine how the level of capitalization in their artificial banking systems influences the probability of contagion. Both studies come to conclusion that increasing level of capitalization reduces the number of contagion defaults in a very similar, non-linear way. When the banking system is poorly capitalized, every incremental increase in capitalization reduces significantly the number of contagion defaults up to certain threshold value. Increasing the level of capitalization above the threshold value brings no significant effect to the number of contagion defaults.

To the author's best knowledge, Nier et al. (2007) and Gai and Kapadia (2010) are the only researchers investigating the contagion in banking systems with different capitalization level using the balance sheet-based network simulations. The empirical literature on balance sheet-based network simulations does not consider a banking system's level of capitalization effect on contagion at all.

Two streams of research on balance sheet-based network simulations

A data input constitutes a cornerstone of balance sheet-based network simulations. A necessary building block for each of such simulation is a matrix of banks' mutual exposures, called interbank exposure matrix. The availability of data inputs forms two streams of application of balance sheet-based network simulation. The first stream of research investigates the contagion in banking systems comprised of individual banks. The second stream uses aggregate data of national banking sectors reported by the BIS. A comprehensive survey of empirical literature on balance sheet-based network simulations could be found in Upper (2007).

The first stream of balance sheet-based network simulations is very often developed at central banks to assess the national banking system's resiliency. The researchers use supervisory internal data on interbank exposures within the national banking systems. Bech, Madsen, and

Natorp (2002) investigated the interbank contagion in Denmark, Blavarg, and Nimander (2002) in Sweden, Elsinger, Lehar, Summer (2006) in Austria, Chan-Lau (2010) in Chile, Mistrulli (2007) in Italy, Lublóy (2005) in Hungary, and Wells (2004) in the United Kingdom. All of them find a very limited scope of contagion following a simulated default of one bank. In Sweden, the contagion does not occur even assuming worst-case scenarios. If the contagion occurs, the impacts are modest – affected banks create 16% of total banking system's assets in Italy and the United Kingdom and 0.2% in case of Hungary. Table 12 in appendix provides a comprehensive interbank network simulation literature overview together with a more detail description of the simulation considered.

Not all central banks collect detailed data on interbank exposures. Researchers try to use alternative sources of data, then. Furfine (2003) extracts interbank exposures from the US Fedwire transfer system. His sample counts 719 commercial banks, which form 14% of the US banking system. 31 banks default (8% of total assets) as a consequence of contagious credit shock in the worst-case scenario. Wells (2004) and Degryse and Nguyen (2007) take advantage of a bank regulatory obligation to report a large interbank positions that exceed certain value. Based on the large exposure data, they build the interbank exposure matrices for their banking systems – the United Kingdom and Belgium. Simulating credit shock, the contagion causes defaults of 4 out of 33 banks (16% of total assets) in the former case and 21 small banks (4% of total assets) in the latter case.

The interbank exposure data are not always available even to the central bankers and banks' publicly available balance sheets do not report the distribution of interbank exposures to their debtors and creditors since there is not such a disclosure rule in place to force banks to do so. Yet, methods to estimate the interbank exposure matrix have been developed. It has become a standard to estimate the interbank exposure matrix using the maximum entropy algorithm. The maximum entropy method is an information theory concept that yields the most likely structure of interbank exposures. Additionally, the maximum entropy algorithm returns a unique estimate of matrix of interbank exposures (Upper 2007). The resulting distribution of mutual exposures tends to be similar for all banks varying only with the size of a bank. Since the maximum entropy algorithm always returns a non-zero exposure between each pair of banks in the system, it biases the estimate of interbank exposures distribution towards a complete network structure.

Banking sectors in reality tend to have different than complete structure. Banks have reasons not to distribute their interbank claims proportionally to other banks as the maximum entropy algorithm would suggest. There are significant transaction costs involved in originating interbank loans and managing a portfolio of them, i.e. for smaller interbank claims the transaction costs may become prohibitively high. Moreover, hardly observable factors such as relationship lending also determine the actual structure of interbank exposures. The evidence, for example by Cocco, Gomez, and Martins (2009), suggests the existence of relationship lending in the interbank market. The relationship lending and the effect of transaction costs contribute to a formation of tiered banking systems with money-centre banks, which in general reduce their resiliency to contagion compared to complete banking systems. Hence, the maximum entropy method might underestimate the potential of contagion.

Although the comparison of different national banking systems is not accurate, the researchers using the maximum entropy method do not find a significantly milder scope of contagion. Mistrulli (2007) compares the scope of contagion in Italian banking sector using actual reported data and data estimated by the maximum entropy method. He finds that under certain parameters settings the scope of contagion, using the maximum entropy, data exceeds the scope of contagion using the actual reported data, although in general the maximum entropy algorithm reduces the scope of contagion. Elsinger, Lehar and Summer (2006) find a probability of contagious default of 6.8% in the Austrian banking sector assuming a macroeconomic shock (shock to more banks at the same time). Sheldon and Mauer (1998) assume a shock to a group of banks and report the probability of contagious default of 1.6%. Also van Lelyveld and Liedorp (2004) use the maximum entropy method to investigate a Dutch banking sector on the sample of 605 banks and find that in the worst-case scenario a contagion from a credit shock induces 45 defaults, which creates 7% of banking system’s assets. Similarly in the study by Upper and Worms (2004), the credit shock induces 115 banks defaults, which creates 15% of banking system’s assets. The balance sheet-based network simulation performed by Wells (2004) with interbank exposure matrix also estimated by the maximum entropy method yields 4 defaults out of sample of 33 banks, which is 16% of banking system’s assets.

The danger of contagion does not seem very high in the national banking systems. However, simulations on banks within one country omit cross-border interbank exposures, what constitutes a major drawback as the today's banking is globally interconnected.

The second stream of balance sheet-based network simulations relies on the BIS banking statistics that include the aggregated interbank exposures of reporting countries' banking sectors. The BIS collects the only publicly available data on interbank exposures. The banking statistics are aggregated to banking sector level for 25 reporting countries on a quarterly basis. The BIS data allow, accepting minor assumptions, to build the interbank exposure matrix for banking sectors consisting of up to 25 countries. Chan-Lau et al. (2009) publish probably the first contagion study using the aggregate banking sector data for network simulation. In similar vein, Chan-Lau (2010) and Espinosa-Vega and Solé (2010) contribute to the recent literature by introducing a new feature in the balance sheet-based network simulation. Except the standard credit shock, they also assume a funding shock. While the credit shock is connected with the asset side of balance sheet, the funding shock constitutes a shock to the liability side of the bank. The bank affected by a funding shock loses a fraction of its sources of funding and therefore has to find other sources of funding for replacement or it has to sell some assets. Under normal market conditions, the funding shock does not directly impair a bank's capital. However, under the stressed, a bank may only be able to replace a fraction of lost sources of funding. To cover the funding gap, the bank has to sell its assets on discount because of stressed market conditions. Selling assets for a price below book value implies capital losses, which may result in a default of the bank and may cause a subsequent contagion.

The simulations using aggregate data of national banking sectors imply a very similar major result – once the contagion occurs, its impact is far-reaching. The triggered contagion commonly wipes out all of the banking system's capital and most of the national banking sectors default considering the credit and funding shock scenario. Based on (Chan-Lau et al. 2009), all 15 analyzed national banking sectors default after the simulated failure of the United Kingdom and the United States, assuming a credit and funding shocks as of 2008:Q1. The contagion wipes out all of the banking system's capital. Chan-Lau (2010) reports that 18 out of 20 national banking sectors default following a default of the United Kingdom, the United States, and Germany as of 2009:Q1. The full amount of banking system's capital is lost in these three cases. Espinosa-Vega and Solé (2010) find relatively milder scope of contagion on their sample of 18 countries as of the end of 2007. However, the contagion is triggered by defaults of 6 national banking sectors. France, Germany, Italy, Spain, and the United Kingdom trigger individually a contagion that causes defaults of 14 other countries and capital losses of 50%. The United States trigger a more severe contagion inducing 17 defaults and 100% capital losses.

Advantageously, the second stream network simulations using aggregate data capture the exposures of banks from an international perspective. It might give an important overall figure of the contagion risk concentration from international point of view. On the contrary, the network simulation model treats the banking sector as an individual bank and the contagious processes that happen within the national banking sector are omitted. Since the structure of interbank exposures matters according to both theoretical and empirical results, the shock to two national banking sectors, which have the same interbank exposures on the aggregate level, can have different consequences – the aggregation of data may bias the contagion estimate downwards. Thus the aggregation to national banking sector data limits the reliability of results.

The results show that the way from remaining stable to collapsing due to contagion after the simulated initial default of one bank or banking sector is very short. This is given, to some extent, by the binary nature of simulation outcome, i.e. the bank either defaults or not. The small changes to parameters in the simulation model may therefore impact the results very significantly. In order to smooth the transition between bank's default and non-default, Fungáčová and Jakubík (2011) assign a probability of default to each level of bank capital. A decreasing bank's capital adequacy ratio increases the probability of the bank's default.

III Model

The balance sheet-based network simulation model constitutes a natural candidate for investigating the interbank contagion under different regulatory frameworks, since it works with banks' balance sheets capturing changes of regulatory environment. Sheldon and Mauer (1998) are probably first who apply the model to assess the interbank systemic risk in Switzerland. Since then, the model has been improved and applied to many other countries.

As the name suggests, the simulation model builds on the stylized balance sheets. Due to the fact that Basel III package's impact can be conveniently translated into the changes in bank's balance sheets, the balance sheet-based network simulation model fits to investigate the interbank contagion under different regulatory frameworks. Nevertheless, to the author's best knowledge, the balance sheet-based network simulation model has not been applied to investigate the interbank contagion under different regulatory frameworks so far.

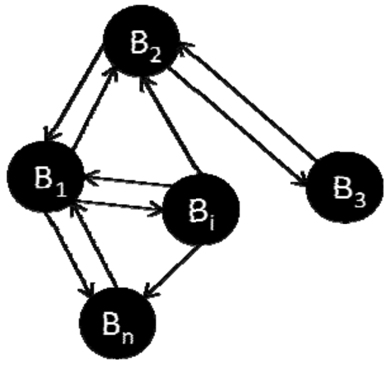
The interbank exposure matrix constitutes a basic building block of the balance sheet-based network simulation since it captures the links that contagion may potentially go through. Stylized banking sectors' balance sheets complement the interbank exposure matrix. The simulation model considers three types of shocks. The type of shock and a set of exogenous parameters determine losses on banking sector's capital which are induced by a simulated default of one banking sector. If the losses are big enough, another default occurs and the contagious process is initiated. This chapter explains the balance sheet-based network simulation model in detail.

III.1 Construction of interbank exposure matrix

Constructing a matrix of interbank exposures is very straightforward once a complete set of data on interbank exposures is obtained. Suppose there are *n* banking sectors (B_1, B_2, ..., B_n) that may lend to and borrow from each other. Figure 1 – Panel A, where the outward arrows depict claims and inward arrows liabilities, shows an example of international interbank network. The network can also be represented by an *n* x *n* matrix form shown in Panel B.

Figure 1: Construction of the interbank exposure matrix

Panel A:



Panel B:

$$X = \begin{vmatrix} 0 & \dots & x_{1j} & \dots & x_{1n} \\ \vdots & \cdot & \vdots & \cdot & \vdots \\ x_{i1} & \dots & 0 & \dots & x_{in} \\ \vdots & \cdot & \vdots & \cdot & \vdots \\ x_{n1} & \dots & x_{nj} & \dots & 0 \end{vmatrix} \quad \begin{matrix} \Sigma_j \\ \mathbf{a_1} \\ \\ \mathbf{a_i} \\ \\ \mathbf{a_n} \end{matrix}$$

$$\Sigma_i \quad \mathbf{l_1} \quad \dots \quad \mathbf{l_i} \quad \dots \quad \mathbf{l_n}$$

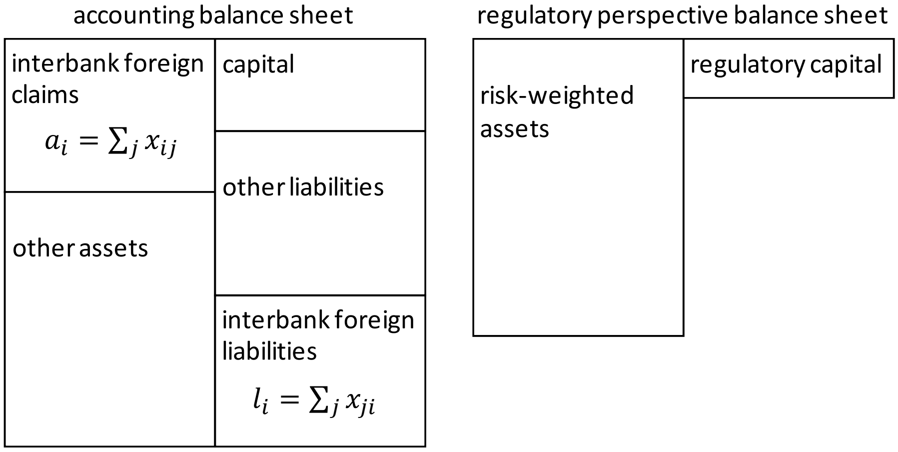
Source: Panel B reproduced from Upper (2007)

The always positive element x_{ij} is the claim of banking sector j on banking sector i. The row sums stand for banking sector i's total claims on other banking sectors. Analogically, since every claim within the system also originates a liability for other banking sector, the column sums stand for banking sector j's total liabilities to other banking sectors. The main diagonal consists entirely of zeros, because banking sector cannot lend to itself. The matrix in Figure 1 – Panel B is called interbank exposure matrix.

III.2 Stylized balance sheet of banking sector

To run the balance sheet-based network simulation, aggregate national banking sectors' balance sheets has to complement the interbank exposure matrix. For a basic simulation, the size of total balance and capital together with the interbank exposure matrix suffice to perform the simulation to assess the banking system soundness. However, this study simulates the impact of regulatory changes on the banking system soundness. Therefore, the accounting balance sheet needs to be extended by a regulatory perspective items – most importantly by regulatory capital and RWA. Figure 2 presents the structure of the stylized balance sheet enriched by regulatory perspective items.

Figure 2: Stylized country *i*'s banking sector balance sheet



Source: The author based on Chan-Lau et al. (2009)

The national stylized balance sheets are built using the OECD statistical database. The data present consolidated annual income statements and balance sheets for 14 out of 20 countries in the sample. Advantageously, OECD also reports regulatory items as RWA and regulatory capital in a Tier 1 and Tier 2 breakdown. The missing balance sheet data for the remaining 6 countries (Australia, Brazil, Greece, Japan, Portugal, Turkey, and the United Kingdom – although most of them are OECD members) are taken from the national central bank's statistical databases. Surprisingly, problems arise when collecting the regulatory perspective balance sheet data. Although RWA, regulatory capital or capital ratio are basic indicators of the national banking sector soundness, the lack of data in this area forces the author to run the network simulation in no greater detail than the level of total regulatory capital and RWA. The author finds inappropriate to accept assumptions to divide the regulatory capital between Tier 1 and Tier 2 capital. The data on regulatory capital and RWA, if missing in the OECD database, are taken from databases of national supervisory authorities and (mostly for the EU countries) from Committee of European Banking Supervisors. The still missing values are either calculated, if the available data enable it (e.g. risk weighted assets can be calculated from regulatory capital and capital ratio), or estimated based on the previous or next period available data. The same structure of a banking business is assumed – i.e. the share of RWA in total assets is expected to remain the same in order to estimate the missing data.

To summarize, the final sample of national stylized balance sheets consists of annual data from 2005 to 2009.

III.3 Simulation

With the complete interbank exposure matrix and the prepared corresponding banking sector stylized balance sheets, the balance sheet-based network simulation can start. The network simulation consists of the following steps:

1. A country *i*'s banking sector defaults by assumption (this step is referred to as direct contagion round).
2. A country *j*'s banking sector suffers a loss if it is exposed to country *i*'s defaulted banking sector. The amount the banking sector *j* loses depends on the magnitude of mutual exposure and on exogenously given parameters. The parameters reflect the type of shock to the banking sector, general market conditions, and the terms of mutual lending and borrowing. The parameters are loss given default ratio (LGD), funding replacement ratio, and fire sale loss ratio. They are discussed in detail later. The loss decreases the country *j*'s banking sector capital by the full amount of the loss multiplied by LGD, since banks' capital absorbs the losses. If the country *j*'s banking sector's capital drops below a certain level –called *default level of capital* in this study – the banking sector defaults.

   This step constitutes the first round of contagion, if any country *j*'s banking sector defaults.
3. The second round of contagion takes place if any country *k*'s banking sector generates losses from the previous rounds, such that country *k* banking sector's capital drops below the *default level of capital*. Importantly, the losses generated in previous rounds consist of losses from exposures to all defaulted banking sectors in previous rounds. This is the important channel of financial contagion this model captures: while the initial impact of bank 1's default may not cause a default of bank 2, the total impact of subsequent defaults may induce a default of bank 2.

   If any country *k*'s banking sector defaults in this round, the next round takes place. Otherwise, the simulation algorithm terminates and the interbank contagion ceases.

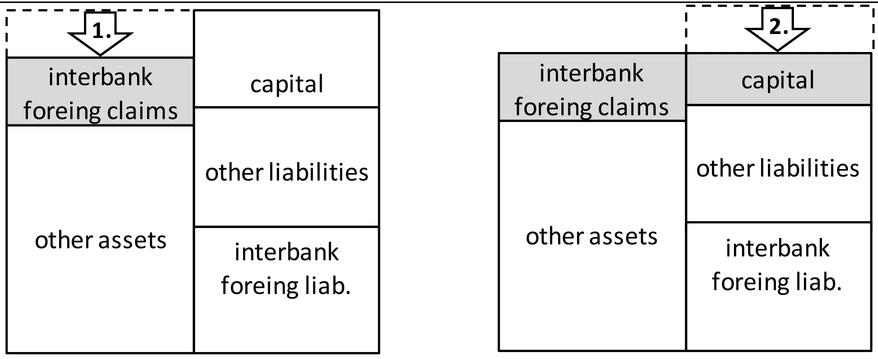
III.4 Types of shocks

The dynamics of financial contagion depends on a type of shock assumed. It has become a standard in balance sheet network simulation literature to assume two common types of shocks and their combination. The two basic shocks are credit and funding shocks. This study also simulates the effect of a funding shock under stressed market conditions and its combination with the credit shock. The mechanism of each of the shocks is described bellow together with an illustrative scheme of the shock's impact on stylized balance sheet of a banking sector. The schemes are based on similar schemes presented by Chan-Lau (2010) and adjusted for the purposes of this study.

Credit shock

The credit shock occurs when a bank suffers losses in the assets side of its balance sheet. Particularly in this network simulation model, the banking sector suffers losses in the interbank foreign claims resulting from default(s) of banking sector(s) in previous contagion rounds. The loss suffering banking sector loses amount equal to the sum of its interbank foreign claims on all defaulted banking sectors from the previous rounds. The loss suffering banking sector usually does not have to write off the full amount of interbank foreign claims on defaulted banking sectors, since it has a right to be preferentially satisfied as a creditor. On the other hand, the interbank loans are usually unsecured by a collateral and junior (subordinated) to other bank's claims. Hence, the full value of claims is never recovered and therefore LGD is applied on the total amount of defaulted claims to determine the actual loss for the banking sector – depicted in Figure 3 (arrow no. 1). The affected banking sector has to write off the actual loss what causes the banking sector's capital to shrink by the same amount (arrow no. 2).

Figure 3: Credit shock scheme



Source: The author based on Chan-Lau (2010)

Default if: $\sum$ *interbank foreign claims on defaulted banks x LGD > capital buffer*[5] (1)

In case that the sum of actual losses on interbank foreign claims exceeds the capital buffer (expression 1) the affected banking sector defaults and triggers a next contagious round. Expression (2) defines capital buffer as the maximum loss a banking sector can absorb – i.e. the maximum loss, such that capital does not fall below the default level of capital:

capital buffer = capital – default level of capital[5] (2)

Funding shock

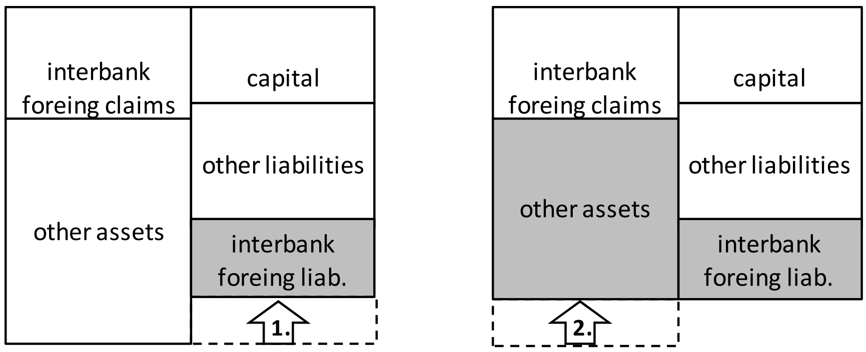
As opposed to the credit shock, a funding shock first affects the liability side of banking sector's balance sheet. In this model, the funding shock occurs when a creditor banking sector suddenly withdraws its interbank foreign claims. This causes the affected banking sector's interbank foreign liabilities to decrease – Figure 4 (arrow no. 1) depicts the reduction of the liabilities. The reasons for a banking sector to suddenly withdraw its interbank foreign claims may be the worsening economic conditions in the debtor country, mistrust, or own shortage of liquidity. In the model, the trigger banking sector withdraws its interbank foreign

[5] The definition of capital buffer and default level of capital is not clear-cut and vary in the literature. Refer to Chapter III.5, section *Default level of capital*, for a detailed discussion how the default level of capital is determined.

claims by assumption. Then, the further mechanism of a funding shock depends on market conditions.

The funding shock under the normal market conditions does not impair the capital of banking sector. The sudden withdrawal of interbank foreign claims by the trigger banking sector means a loss of funding source for the affected banking sector. Since the loans are funded through liabilities, the affected banking sector can either try to replace the funding gap or is forced to sell assets. Under normal market conditions, the banking sector needs to sell other assets worth right the amount of lost interbank foreign liabilities that the banking sector is unable to replace – Figure 4 (arrow no. 2). The exogenously given *funding replacement ratio* determines a fraction of funding gap that the banking sector is able to replace.

Figure 4: Funding shock scheme – normal market conditions



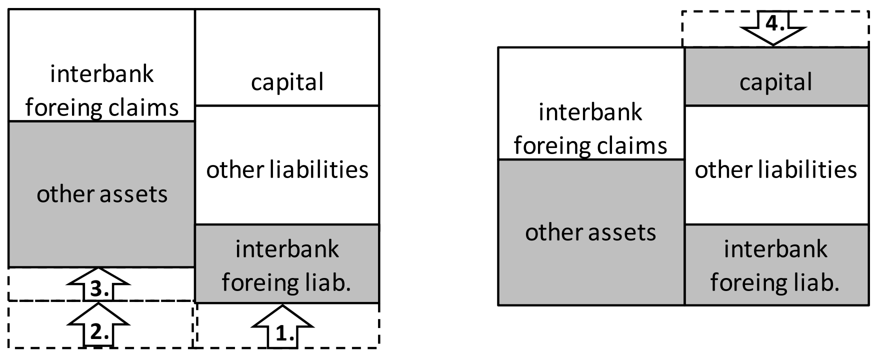
Source: The author based on Chan-Lau (2010)

Importantly, the funding shock under normal market conditions does not influence the capital of a banking sector. Moreover, the banking sector's leverage (capital-to-assets ratio) increases[6] as a result of a funding shock. The funding shock under the normal market conditions cannot directly cause a banking sector's failure and the effect does not differ under the Basel II and Basel III. From this reason, this study does not simulate the funding shock under the normal market conditions.

[6] As opposed to the accounting capital-to-assets ratio, the ratio of regulatory capital to risk-weighted assets may remain on the same level if assets with a zero risk-weight are sold.

However, since a substantial share of interbank market works on an unsecured basis, the banks tend to react very sensitively on every sign of distress. A sudden withdrawal may represent such a sign of distress. Under these circumstances, a bank seeking for a liquidity to cover its funding gap has to offer a substantial discount when selling its assets, since the potential buyers know about the instant liquidity needs of the bank. In the model, the *fire sale loss ratio* captures the loss for the bank from selling the assets on discount. The bank's capital absorbs this loss. Moreover, as in the case of funding shock under the normal conditions, the banking sector is only able to replace part of the funding gap. Chan-Lau et al. (2009) suggest this methodology. Figure 5 depicts the whole situation of funding shock under the stressed market conditions. The beginning of the funding shock is the same as under the normal market conditions – banking sector's interbank foreign liabilities suddenly decline as a consequence of other banking sector's withdrawal (arrow no. 1). The banking sector is able to replace a part of its funding gap (according to the funding replacement ratio). To cover the rest of the funding gap some of the other assets have to be sold (arrow no. 2). Given the stressed conditions in the market, the banking sector has to sell a higher book value of other assets to cover the rest of the funding gap, because the book value is discounted to a current market value. The difference between the market and book value of assets (arrow no. 3) constitutes a loss for the banking sector absorbed by capital (arrow no. 4).

Figure 5: Funding shock scheme – stressed market conditions



Source: The author based on Chan-Lau (2010)

The funding shock under stressed market conditions can lead to a banking sector's failure. Therefore, the simulation model includes this type of shock. The default occurs when the sum of funding losses exceeds the banking sectors capital buffer (expression 3).

Default if: $\sum$ *funding withdrawal x (1-funding replacement ratio) x fire sale loss ratio* (3)
> capital buffer

The way of simulating the funding shock raises a natural question: Why does the affected banking sector sell other assets to fill the funding gap instead of withdrawing its interbank foreign claims?

Firstly, the withdrawal of interbank foreign claims on the banking sector that caused the funding gap (by withdrawing its interbank foreign claims on the affected banking sector – a counter-withdrawal) need not be possible. It is important to keep in mind that the data for the banking sectors are aggregated. Suppose a banking sector A and B, both represented by two banks 1 and 2. Bank A1 holds a $100 interbank foreign claim on bank B1, and bank B2 holds a $100 interbank foreign claim on bank A2. No other interbank foreign claims between those two countries are held. In aggregation, banking sector A has a $100 claim on banking sector B and banking sector B has also a $100 claim on banking sector A. From an aggregated point of view, if banking sector A withdraws its $100 claim on banking sector B, banking sector B can counter-withdraw, in return, its $100 claim on banking sector A and no funding gap occurs. However, if A1 withdraws its $100 claim on B1, B1 does not hold any claim on A1 and it cannot respond in the same way. Thus, B1 has a $100 funding gap. Since it does not make much economic sense to lend money to and borrow money from the same bank, the structure of foreign interbank market described in the example is likely similar to the actual structure of the foreign interbank market. This makes the counter-withdrawals impossible.

Secondly, the banking sector can still withdraw or sell interbank foreign claims on other banking sectors instead of other assets. However, the withdrawal of interbank foreign claims on other banking sectors may not suffice the liquidity needs. Despite the shorter maturities in the interbank market, the immediately available interbank foreign claims may not cover the funding gap. The option to sell the interbank claims seems also problematic. The regulatory authority or terms of interbank lending contract do not need to allow selling interbank claims to non-banks. And also, selling interbank claims in the interbank market under the stressed conditions and liquidity squeeze is very costly and in case of more serious distress impossible at all.

Credit and funding shock

The credit and funding shocks can appear simultaneously. The credit shock easily induces a distress in the market, which, in turn, causes banks to withdraw interbank claims, to hoard liquidity and prepare for the expected worse times. The model in this study simulates the combination of credit and funding shock. A banking sector defaults if its losses from a funding and credit shock exceed its capital buffer. Expression (4) defines the default condition:

Default if: ∑ *interbank foreign claims on defaulted banks x LGD* (4)
+∑ *funding withdrawal x (1-fund. replacement ratio) x fire sale loss ratio*
> *capital buffer*

III.5 Exogenous parameters

The results of the balance sheet-based network simulation model depend to a large extent on exogenously given parameters – default level of capital, LGD, replacement ratio, and fire sale loss ratio. LGD influences the results substantially and the interbank network simulation literature discusses vividly its value. By far, not such an attention is paid to the default level of capital, although it has a comparable influence as LGD. Especially in this study, setting the appropriate universal default level of capital is not straightforward, since, besides other issues, the definitions of capital differ under Basel II and Basel III regulatory framework. The other two parameters – replacement ratio and fire sale loss ratio – relate exclusively to funding shock, which does not generate large losses for banks compared to credit shock. Thus, replacement and fire sale loss ratios do not affect the results of network simulation significantly. Also, a bank's decision how much capital they raise and by how much they reduce RWA to meet the Basel III criteria influences indirectly the network simulation results. This applies the building of the hypothetical Basel III balance sheet and is discussed in Chapter IV.3. The remainder of this chapter discusses the setting of the exogenous parameters.

Default level of capital

In this study, the *default level of capital* is defined as the minimum level of capital for a banking sector not to default. The issue how to set the appropriate default level of capital comprises of two dimensions. Firstly, what kind of capital is considered and secondly, what is its appropriate level. A number of authors (see Table 1) consider capital in the form as it appears on banks' balance sheets – book capital – and a bank defaults first when it depletes all of its book capital. This simplistic solution causes a significant underestimation of the impact of financial contagion from two reasons: i) cautious market players can effectively cause a default of a bank, although it still has some capital left and ii) the book capital consists of all equity items, although some of them are not capable to fully absorb the losses. From this reason the book capital differs from regulatory capital. In principle, the book capital is reduced to the regulatory capital which should fully absorb potential bank's losses. In practice, however, even the regulatory capital consists of "better" and "worse" quality capital as reflected by regulatory division of the capital to Tier 1 capital and Tier 2 capital. Further on, the Tier 1 capital includes a portion of "top quality" common equity Tier 1 capital. The 2008 financial crisis has revealed that even the Basel II definition of capital has not guaranteed the high quality of capital. The Basel III package addresses the issue of capital quality by tightening the definition of capital and by increasing the share of high quality common equity Tier 1 capital and Tier 1 capital in total regulatory capital.

Table 1: Threshold default level of capital in literature

Reference	Threshold default level of capital[1]
Bech, Madsen, and Natorp (2002)	n/a
Blavarg and Nimander (2002)	4% of Tier 1 capital
Degryse and Nguyen (2007)	0% of Tier 1 capital
Elsinger, Lehar, Summer (2006)	0% of net value of bank
Furfine (2003)	0%[2]
Chan-Lau (2010)	0% of book capital
Chan-Lau et al. (2009)	0%[2]
Lublóy (2005)	0% and 4% of modified Tier 1 capital[3]
Mistrulli (2007)	0%[2]
Sheldon and Mauer (1998)	0% of book capital and reserves
Upper, Worms (2004)	0% of book capital
van Lelyveld and Liedorp (2004)	0% of Tier 1 capital
Wells (2004)	0% of Tier 1 capital
[this study]	**4% of regulatory capital (Basel III definition)**

[1])Minimum level of capital for a banking sector not to default. E.g. 0% of Tier 1 capital implies a default when all of the Tier 1 capital is depleted.
[2])Form of capital not stated in the paper.
[3])Modified Tier 1 capital equals Tier 1 capital plus estimated retained profit at the end of the year.

The required amount of regulatory capital is set relatively in respect to total exposure of a bank. Following the same logic as in case of capital, the amount of on-balance sheet assets does not reflect correctly the true bank's exposure. Therefore the regulators use RWA as a measure of bank's total exposure and as a base to determine absolute amount of required regulatory capital for each bank. The Basel III package adjusts the computation of RWA, too. The Basel III regulatory capital and RWA are supposed to capture better the true amount of fully loss absorbing capital and the true exposure measured by RWA.

Therefore, the default level of capital for the purposes of this network simulation model is determined as a percentage of the Basel III regulatory capital relative to the Basel III RWA. To remain consistent in the network simulation model, the actual regulatory capital and RWA of the Basel II stylized balance sheets are adjusted to the Basel III standards to determine the default level of capital. This guarantees the comparability of the Basel II and Basel III network simulation results.

Setting the appropriate value of default level of capital requires considering multiple perspectives. The economic perspective suggests that a bank defaults first when it depletes all of its capital. On the other hand from a regulatory point of view, a bank, whose capital drops below the minimum required regulatory capital ratio, loses its banking license, which effectively means a default. In practice however, a central bank (or other national regulator) will likely not take away a banking license immediately when the regulatory capital of a bank drops below the required level. For the sake of financial stability the central bank will rather give the bank some time to recover and increase its capital ratio.

The generally required capital ratio under the Basel III regulatory framework is set at 8% of RWA. The elementary minimum capital ratio is complemented by capital conservation buffer up to 2.5% of the common equity Tier 1 capital, countercyclical buffer and three other backstop ratios - leverage, liquidity coverage and net stable funding ratio. How the banks will be forced to satisfy the additional buffers and ratios depends on the national legislation, since the Basel III is a soft law. Nevertheless, the 8% required capital ratio represents a cornerstone in the regulatory framework. Looking at default levels of capital used in the interbank network simulation literature (see Table 1), other authors either consider a simplistic 0% of book capital, or 0% to 4% of Tier 1 capital default levels. In this study the default level of capital is set to 4% of Basel III eligible regulatory capital.

The underlying logic of setting such default level of capital is as follows. This study supposes that a bank defaults when it depletes all of its high quality capital – i.e. the Tier 1 Basel III eligible capital. As long as the complete aggregate Tier 1 capital data are not available, it is not possible to set the default level of capital to 0% of Tier 1 capital. Therefore, this study has to consider the total regulatory capital. Depending on the bank's capital structure (i.e. the fraction of Tier 1 capital in total regulatory capital), the default level of capital used in this study corresponds with default level of capital in range from 0% to 4% of Tier 1 capital. Under the Basel II regulatory framework, at least 4% out of 8% of elementary regulatory capital ratio must create Tier 1 capital, which fully absorbs the losses. Suppose the case that a bank holds exactly the minimum required Tier 1 capital ratio (i.e. 4%) and the minimum required total regulatory capital ratio (i.e. 8%). Then the 4% of total regulatory capital default condition is equivalent to 0% of Tier 1 capital. This is because when a bank depletes all of the Tier 1 capital, 4% of total regulatory capital remains. In reality, banks usually hold slightly more Tier 1 capital than required to have a cushion in case of an adverse event. The default level of capital set in this study might therefore overestimate the contagion, since in utmost case the defaulted bank may hold up to 4% of Tier 1 capital. Nevertheless, the 4% of total regulatory capital default condition still seems like a reasonable solution when no data on Tier 1 capital are available.

LGD

If a banking sector defaults on its interbank foreign liabilities, the affected banking sector never gets back the full amount of its claim on the defaulted banking sector. The ratio of actual loss to the book value of a claim is LGD. The choice of LGD influences substantially the results of the network simulation model. This finding fully corresponds with virtually all of the network simulation studies published so far (for a comprehensive list see Table 12 in appendix). Upper (2007, pp. 7) in his comprehensive survey on interbank network simulations-related literature states that *LGD-parameter is crucial for whether or not contagion arises*.

In principle, the LGD can be computed from the balance sheet and endogenised as in Elsinger, Lehar, and Summer (2006). However, many unrealistic assumptions have to support the endogenisation of LGD. The most problematic issues concern the assumptions about the existence and the market value of a collateral, netting agreements, the seniority of foreign interbank claim relative to other claims, the administrative costs of bankruptcy, and the time of bankruptcy administration Upper (2007).

Given the problematic assumptions, the LGD is determined exogenously in this study. Since the theoretical results on LGD are scarce and bank failures do not occur frequently, it is very difficult to find an appropriate LGD benchmark in literature. James (1991) publishes one of the exceptional papers on losses realized in bank failures. James finds that the loss on assets creates on average 30% of the book value of the failed bank's assets. Additionally, the average direct expenses associated with bank closures amount to 10% of bank's assets. On the contrary, the creditors of Continental Illinois got full 95% of their claims after its 1984 default (Kaufman, 1994). The outdated and mixed results cause that most of the researchers try out a large range of values of LGD parameter and report the results for varying level of LGD. Table 2 presents the LGD parameters used in the literature.

Table 2: LGD parameters used in literatures

Reference	LGD		
Bech, Madsen, and Natorp (2002)	n/a	Lublóy (2005)	100%
Blavarg and Nimander (2002)	100%	Mistrulli (2007)	10 - 100%
Degryse and Nguyen (2007)	10, 40, 70, 100%	Sheldon and Mauer (1998)	100%
Elsinger, Lehar, Summer (2006)	endogenous	Upper, Worms (2004)	0 - 100%
Furfine (2003)	40% and 5%	van Lelyveld, Liedorp (2004)	25, 50, 75, 100%
Chan-Lau (2010)	70%	Wells (2004)	20 - 100%
Chan-Lau et al. (2009)	100%	**[this study]**	**baseline: 80%**

This study also reports the results for a range of LGD parameters. Still, it is useful to come up with a certain benchmark value of LGD parameter. Wells (2004) gives some intuition for setting LGD parameter. He argues that LGD parameter should be set rather higher because even if a bank can achieve relatively high recovery rate over the long run, in the short run the recovery rate is uncertain, thus exposing the affected bank to risk of future losses. In the end, the bank with capital at risk in the market may be forced to write off the whole claim to continue its operations. In line with the latter, Furfine (1999) adds that lower LGD parameters should rather be thought of as an immediate support to the loss affected bank from a central bank that expects higher recovery rate in the future after the bankruptcy resolution. Moreover, it seems reasonable to set the LGD parameter higher in the simulations of many countries' banking sectors compared to country-focused individual banks simulations, since the cross-border enforcement of bankruptcy law may be complicated and more time-consuming. Finally, most of the interbank lending runs on an unsecured basis (no collateral), which also implies rather higher LGD parameter. The Basel II regulatory framework provides banks using the Internal-ratings based approach with guidance on the level of LGD. *A LGD parameter is recommended to set at 45% for senior claims on banks that are not secured by recognised collateral. The 75% LGD parameter is recommended for the subordinated claims on banks* (BCBS 2004, §287-88).

Reflecting LGD parameters in the literature and the discussion in this subsection, the baseline scenario LGD for this study is set to 80%.

Funding replacement ratio

The funding replacement ratio is defined as a fraction of funding that a banking sector can replace in case of the funding shock. The level of funding replacement ratio depends crucially on the market conditions. Under normal market conditions a bank covers its funding gap in the interbank market quite easily. The simulation model, however, considers a hypothetical default of the whole national banking sector, which would inevitably cause a serious market distress. Under the stressed market conditions, banks tend not to lend to each other and instead they hoard liquidity to avoid its shortage in uncertain future. Thus, replacing a funding gap is difficult and banks are only expected to replace less than a half of the funding gap. The funding replacement ratio is set to 40% in this study, what corresponds to Chan-Lau (2010) and Chan-Lau et al. (2009) who use the funding replacement ratio of 40% and 65%, respectively.

The Basel III package addresses the issue of liquidity evaporation in the stressed market by the introduction of net stable funding ratio and by liquidity coverage ratio. The former *requires a minimum amount of stable sources of funding at a bank relative to the liquidity profiles of the assets [...] over a one year horizon* (BCBS 2011, pp. 9). The latter requires enough high quality liquid assets to bear a 30-day funding stress scenario (BCBS 2010). The BCBS designed these measures to help to withstand isolated stress episodes. Nevertheless, a failure of the whole national banking sector goes beyond the scope of the measures. Therefore, the simulation model considers the same funding replacement ratio under the Basel

II as under the Basel III regulatory framework. A robustness check of different values of funding replacement ratio is performed and presented as a part of sensitivity analysis.

Fire sale loss ratio

The fire sale loss ratio is defined as a discount on assets that a banking sector covering its funding gap has to accept to sell immediately those assets in the stressed market. The choice of fire sale loss ratio relates closely to the previous discussion on funding replacement ratio. The market conditions play the main role. Given the unpredictability of the market, the fire sale loss ratio is set quite arbitrarily to 50% according to other network simulations by Chan-Lau (2010) and Chan-Lau et al. (2009), who also choose the 50% fire sale loss ratio. A robustness check of different values of fire sale loss ratio is performed and presented as a part of sensitivity analysis.

IV Basel III regulatory framework

The Basel III regulatory framework addresses the shortcomings of the previous Basel II regulatory framework that revealed during the 2008 financial crisis. Although most of the banks complied with the Basel II regulatory criteria, the global banking system exhibited a great fragility. The shortcomings of the Basel II regulatory framework appeared on both institution-specific (microprudential) and system-wide (macroprudential) levels.

On the microprudential level, the Basel II regulatory framework fails to eliminate the high effective leverage of banks. The high effective leverage of banks resulted primarily from banks' off-balance sheet activities related to complex securitization, derivatives and other trading activities. Risks arising from these actions are not fully integrated in the Basel II regulatory capital requirements despite the threat of large potential losses from off-balance sheet operations. Also, the insufficient quality of required capital contributed to the poor effective capitalization of banks. Banks could have hold as little as 2% of common equity Tier 1 capital to RWA, even though common equity and retained earnings should create a base for Tier 1 capital.

Further on, the Basel II regulatory framework failed to ensure a robust liquidity profile of banks. Before the crisis, banks could usually obtain sufficient liquidity almost immediately in the wholesale market, but the liquidity evaporated very quickly with the first sign of stress in the market. The 2008 financial crisis has revealed the adequate level of capital constitutes a necessary, but not sufficient condition to ensure bank's resilience.

On the macroprudential level, the Basel II regulatory framework failed to respond on a rapid credit growth before the crisis. A combination of unprecedentedly low interest rates, loose lending standards, and expansionary economic climate boosted the credit growth rapidly.

The Basel III regulatory framework aims to address the above-mentioned shortcomings of the Basel II regulatory framework. This study shows how big the risk of contagion under the Basel II regulatory framework is and how the Basel III regulatory framework contributes to reduction of the contagion risk. The study compares the results of balance sheet-based network simulation performed on actual data – the interbank exposure matrix and national banking sectors' stylized balance sheets – and hypothetical data corresponding to the Basel III regulatory framework. This chapter aims to estimate how the stylized balance sheet will look like after the full implementation of the Basel III package. The BCBS plans this to happen by the end of 2019. The Basel III regulatory framework affects substantially the whole banking business, because the banks are expected to find ways to mitigate the costly impacts of the new Basel III regulatory framework. Herein, only such Basel III impacts are considered that can be reasonably estimated and implemented in the balance sheet-based network simulation. The Basel III regulatory framework contains two sources of such impacts. The first source of impact on banks consists of a capital impact of new definition of capital and a new way of calculation of RWA. The second source of impact consists of increased minimal capital adequacy ratios and establishing of new required buffers and ratios.

IV.1 New definition of capital and risk-weighted assets

The new definition of capital and changes in RWA affect substantially the regulatory balance sheet of banks. The BCBS (2010) conducted a comprehensive quantitative impact study to find out the true impact of the Basel III regulatory package. The study uses the consolidated banking data as of the end of 2009. A total of 263 banks from the 23 BCBS member countries participated in the study and 14 out the 23 countries are included in the network simulation in this thesis. In terms of banks' total assets, the 14 countries create 85% of the 23 countries participating in the quantitative impact study and 92% of 20 countries included in the network simulation in this thesis. It is therefore realistic to assume the same quantitative impact on the sample of 20 national banking sectors included in the network simulation in this thesis.

The quantitative impact study assumes full implementation of the Basel III package and also assumes no management actions of banks to mitigate the impact of the package, such as changes in bank capital or balance sheet composition. However, *the actual impact of the new Basel III requirements will likely be lower as the banking sector adjusts to a changing economic and regulatory environment* (BCBS 2010).

Table 3: Results of the quantitative impact study by the BCBS

	G1 banks[1]	G2 banks[1]	Average
Overall changes in reg. capital ratios			
Total	-40.0%	-19.5%	-29.8%
Common equity Tier 1 ratio	-48.6%	-27.1%	-37.9%
Tier 1 ratio	-40.0%	-17.3%	-28.7%
Impact of new definition of capital			
Change in total capital	-26.8%	-16.6%	**-21.7%**
Change in RWA[3]	7.3%	3.2%	5.3%
Change in common equity Tier 1 capital	-41.3%	-24.7%	-33.0%
Change in Tier 1 capital	-30.2%	-14.1%	-22.2%
Change in RWA			
Overall change in RWA	22.9%	4.1%	**13.5%**
Definition of capital[4]	6.0%	3.2%	4.6%
Counterparty credit risk	7.6%	0.3%	4.0%
Securitization in banking book	1.7%	0.1%	0.9%
Stressed value-at-risk	2.3%	0.3%	1.3%
Equity standard measurement method	0.2%	0.1%	0.2%
Incremental risk charge and securitization in trading book	5.1%	0.1%	2.6%
Leverage ratio (as of 2009[2])	0.028	0.038	0.033
Liquidity coverage ratio (as of 2009[2])	0.830	0.980	0.905
Capital conservation buffer	n/a	n/a	-
Net stable funding ratio (as of 2009[2])	0.930	1.030	0.980

[1])Group 1 banks are defined as well diversified, internationally active banks with Tier 1 capital in excess of €3 bn. All other banks are considered Group 2 banks.

[2])The ratio shows the current state – it is not a % change as the previous numbers.

[3])Exclusively the impact of new definition of capital on RWA (from applying risk-weighted treatment to exposures deducted from capital or vice versa).

[4])Exclusively the impact of changes in RWA on new definition of capital (from applying risk-weighted treatment to exposures deducted from capital or vice versa).

Source: BIS Quantitative impact study (BCBS 2010) and own calculations

Table 3 presents the results of the quantitative impact study by the BCBS. The results show changes in capital and RWA, and implied changes in capital ratios resulting from the new Basel III package designed to raise the quality of capital base and enhance risk capture. The impacts are quite significant, especially in group 1 banks[1], where the total regulatory capital ratio is expected to drop by 40%, the capital ratio of group 2 banks[1] drops by 20%.

The quantitative impact study is based on comprehensive, very detailed data on request by the BCBS. Given the public unavailability of such data, the conclusions presented in the quantitative impact study represent the only clue to estimate the impact of the Basel III package on individual national banking sectors for purposes of the network simulation. The Basel III RWA and regulatory capital are estimated from the Basel II regulatory perspective balance sheet (Figure 2) by application of average total changes in capital and RWA – highlighted in bold in Table 3. By assumption, all national banking sectors in the sample have the same structure of group 1 and group 2 banks as in the quantitative impact study. Given that, the average of changes in group 1 and group 2 banks can be applied. The estimation of the Basel III stylized balance sheet implicitly reflects the changes in common equity Tier 1 capital, Tier 1 capital, definition of capital, counterparty credit risk, securitization in the banking book, stressed value-at-risk, equity standard measurement method, and incremental risk charge and securitization in the banking book.

IV.2 Increased and newly introduced required ratios

Besides the newly defined capital and changes in RWA, the new Basel III package also increases some of the minimal required regulatory ratios and introduces new minimal required ratios to enhance the resilience of the banking system. Table 4 presents the changes of minimal required ratios together with newly introduced ratios. The last column of Table 4 shows whether they are implemented in the network simulation model. This section goes through the changes that are possible to implement when estimating the Basel III stylized balance sheet.

As indicated in Table 4, total capital minimal required ratio increases by 2.5 pp. from 8% to 10.5%. The difference is given by a newly introduced capital conservation ratio. Banks have to retain certain part of their earnings depending on a common equity Tier 1 capital ratio. Having the common equity Tier 1 capital ratio above 7.0% or the capital conservation buffer above 2.5% means no further obligation for a bank to retain earnings. All banking sectors in the sample are assumed to reach the 2.5% capital conservation buffer by the end of implementation period.

Table 4: Basel III regulatory package

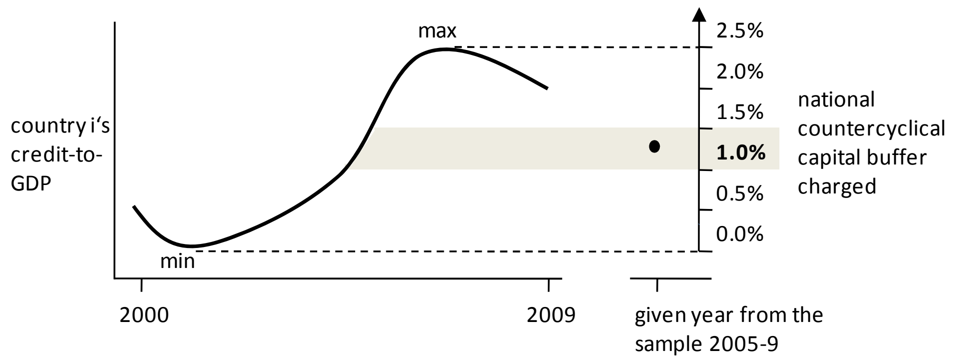
Regulatory requirement	Basel III target (%)	Formula	Basel II (%)	BIII change (pp.)	Transitional period	Full effectiveness	Implemented ?
Total capital	10.5	Total cap./RWA	8.0	2.5	2016 – 2018	2019	Yes
Total cap. excl. cap. conservation buffer	8.0	Total cap./RWA	8.0	0.0	–	already effective	Yes
Tier 1 capital	6.0	T1 cap./RWA	4.0	2.0	2013 – 2014	2015	No
Common equity Tier 1 capital	4.5	CET1 cap./RWA	2.0	2.5	2013 – 2014	2015	No
Capital conservation buffer	2.5	CET1 cap./RWA	–	2.5	2016 – 2018	2019	Yes
Counterparty credit risk	internal model	CVA risk cap. charge	–	4.0[4]	n/a	2013	Yes[6]
Countercyclical buffer	0–5.0	CET1 cap./RWA	–	0–5.0	2016 – 2018	2019	Yes
National countercyclical buffer	0–2.5	CET1 cap./RWA	–	0–2.5	2016 – 2018	2019	Yes
Bank specific countercyclical buffer	0–2.5	CET1 cap./RWA	–	0–2.5	2016 – 2018	2019	Yes
Leverage ratio	expected: 3.0	T1 cap./exposure	3.3[4]	n/a	2013 – 2017[1]	2018[3]	No
Liquidity coverage ratio	100.0	liquid assets/net cash outflows[5]	90.5[4]	n/a	2011 – 2014[1]	2015[2]	No
Net stable funding ratio	100.0	% of stable sources of funding	98.0[4]	n/a	2011 – 2017[1]	2018[2]	No
New definition of capital	*see QIS results for a detailed breakdown of impact – Table 3*				2013 – 2017	2018	Yes
Changes in RWA	*see QIS results for a detailed breakdown of impact – Table 3*				2009 – 2010	2011	Yes

[1])Observation period. [2])Minimum standard introduction. [3])Migration to Pillar I. [4])BCBS quantitative impact study as of 2009. [5])Ratio defined as high quality liquid assets over net cash outflows in stress scenario. [6])Implemented via changes in RWA.

Source: BCBS (2011) and BCBS (2010)

To reduce the risks connected with the excessive credit growth, the Basel III package implements a countercyclical capital buffer. The buffer consists of two components: the national countercyclical capital buffer and the bank specific countercyclical capital buffer. A national supervisory authority can require an additional common equity Tier 1 capital for all banks in the country in case of *excess credit growth potentially leading to the build up of system-wide risk* (BCBS 2011). The additional capital requirement ranges from 0 to 2.5% of common equity Tier 1 capital relative to RWA. The national supervisory authority assess the excess credit growth based on the country *i*'s evolution of non-bank private sector credit-to-GDP ratio. To cover the full credit cycle, countercyclical capital buffer is determined based on non-bank private sector credit-to-GDP ratio in the period from 2000 to 2009 in this study. The minimum and maximum ratios for this period create lower and upper bounds for the countercyclical buffer capital charges. The actual country *i*'s non-bank private sector credit-to-GDP ratio in the given year from the 2005 – 2009 sample is then assigned to the corresponding 20% quantile between the lower and upper bound as shown in the illustrative example in Figure 6. If the credit-to-GDP ratio exceeds the upper bound, the national countercyclical buffer of 2.5% is charged.

Figure 6: Estimation of national countercyclical capital buffer



Source: Own illustrative figure, actual credit-to-GDP data for calculations taken from the World Bank statistical database.

Importantly, to assess the credit cycle correctly, the credit-to-GDP ratio must not include a trend. Developing countries, where the financial services develop faster than GDP, commonly exhibit the rising credit-to-GDP ratio trend. The sample of 20 countries in this study includes two developing countries – Brazil and Turkey – where the trend in credit-to-GDP ratio might be an issue. However, the 2000 – 2009 credit-to-GDP ratio does not suggest any trend development in case of Turkey. A slight upward trend in credit-to-GDP ratio appears in case of Brazil, which may, to a limited extent, impair the estimate of Brazil's required countercyclical capital buffer.

The second component of the countercyclical capital buffer is the bank specific countercyclical buffer. The Basel III requires each bank to hold the bank specific countercyclical buffer calculated as a weighted average of national countercyclical buffers of other countries, where the weights are non-bank private sector foreign claims of that particular bank. In extreme cases, a bank specific countercyclical capital buffer up to 2.5% is charged.

IV.3 Banks' adjustment to meet the Basel III criteria

As described in two previous parts, the Basel III new definition of capital means that regulatory capital drops by 21.7% compared to actual Basel II regulatory capital and the changes in RWA cause them to grow by 13.5% compared to actual Basel II RWA. In dollar terms for all 20 sample countries, a total of $1 849 bn of Basel III eligible capital has to be raised just to achieve the same level of regulatory capital ratio as under the Basel II regulatory framework. Moreover, the Basel III package increases some of the existing minimal regulatory ratios and introduces new minimal ratios. The total capital regulatory ratio increased by 2.5 pp. to 10.5% (including conservation buffer) and the introduction of countercyclical capital buffer imply that the banks in 20 sample countries have to raise additionally $128 bn of Basel III eligible capital. To sum up, as of 2009:Q4 the banks in 20 sample countries need to raise $1 977 bn of Basel III eligible capital to meet the Basel III criteria.[7]

[7] The division of a total capital to raise worth $1 977 bn into $1 849 bn due to the changes in definition of capital and the changes in RWA, and $128 bn due to the increased and newly introduced minimal ratios should not serve as a measure to compare the severity of these two regulatory steps. The division depends critically on the capitalization level in the given period. For example, in 2007 is the division far different – $1806 bn and $641 bn.

Principally, there are three options how to meet the Basel III criteria. Banks can either raise the regulatory capital or reduce RWA or combine both. The following paragraphs describe the three options in detail.

Raising capital

This option expects that banks are able to raise enough capital to meet the Basel III criteria. The banks can either attract investors to inject new capital or increase capital through retained profit, or any combination of both. Raising the capital depends a lot on the circumstances in the market and on the financial condition of a bank. Raising the capital affects the stylized balance sheet in a following way: On the liability side of balance sheet, both accounting and regulatory capital increases by the amount of capital raised and, on the asset side, other assets grow by the same amount.

Reducing risk-weighted assets

This option expects that banks reduce RWA. Under the Basel framework, each claim of a bank has a certain weight. The weight ranges from 0 to 100% according to the risk profile of the assets – the riskier the asset is, the higher the weight it has. Extremely risky assets can have the weight even higher than 100%. The risk weight is either set in the Basel II regulatory framework according to the credit rating agency grade, or an internal ratings-based model, which is run by individual banks and supervised by the national regulatory authority, determines the risk weight. The notion of risk-weights is important, since a bank may liquidate a claim, but RWA only decrease by less than the accounting value of that claim. For example, a bank holds a \$100 claim on an A+ rated firm. Suppose the bank does not use an internal ratings-based model, then the risk weight is 50%. It means the risk-weighted value of that claim is \$50 and the bank is required to hold \$4 of capital for that claim (assuming Basel 8% capital ratio). A higher risk-weight requires higher capital charge. If the bank decides to reduce its balance sheet by selling the \$100 claim, it only reduces RWA by \$50.

If a bank needs to reduce RWA, it considers the trade-off between the risk-weight of the asset and its return. Provided that a bank will most likely not reduce its balance sheet (size) more than necessary, it will try to restructure its portfolio of claims towards less risky assets with lower risk-weight, and thus reduce RWA. However, if the lower return from less risky assets does not cover bank's costs, the bank is forced to reduce its balance sheet size. The question is, whether reducing RWA can affect the interbank foreign claims? This study assumes that reducing RWA does not affect interbank foreign claims from three reasons: First, the interbank foreign claims have in general low risk-weights, so liquidating them does not bring much reduction in RWA. Second, interbank lending is not a core business of banks – banks use the interbank market mainly in case of temporary excess or shortage of liquidity, so it need not even be technically possible for a bank to limit its interbank lending and borrowing. And finally – third, banks do not switch the portfolio of its assets significantly towards interbank lending (as it has low risk-weight) because of low return.

Reducing RWA affects the stylized balance sheet in a following way: Accounting capital and regulatory capital remain unchanged. Interbank foreign claims remain unchanged by a reasonable assumption (the discussion in the previous paragraph). This implies the interbank foreign liabilities remain unchanged as well, since the claim of one bank is a liability for other. A bank may choose either to change the structure of other assets (to lower the portfolio risk profile) or to reduce its balance sheet. The former changes the structure of other assets, the latter reduces other assets by the amount equal to the reduction in RWA divided by the average risk-weight of reduced assets. The former does not change other liabilities, the latter reduces other liabilities by the same amount.

Raising capital and reducing risk-weighted assets

This option combines of the two preceding options and assumes that banks raise part of the capital needed and partly reduce RWA by the amount such that the Basel III requirements are met. This is the most likely scenario, because banks will probably not attract enough investors to raise the full amount of needed capital and the option of increasing capital from retained profits is also limited. The average annual net income after tax in the period of 2005 – 2009 for all 20 sample banking sectors was approx. 12% of the total capital needed to raise. Even assuming an increased profit retention ratio of 50% (in the period of 2005 – 2009 it was 26%), the required capital would be built up first in 2025 (rough estimate) – 6 years later than the Basel III requirements became valid in 2019. Or the same in other terms, sample national banking sectors are able to raise approx. 60% of capital needed to meet the Basel III criteria by the end of the implementation period (2019), given the same average profits as in 2005-2009. Obviously, the banks will have to find ways to restructure their business models in order to reduce their RWA. As a baseline scenario for the simulation model, the banking sectors are expected to raise the mentioned 60% of needed capital and the residual Basel III requirements will be achieved by reducing RWA. This estimate seems reasonable given the though expected market conditions and cautious behaviour of investors in the future.

V Empirical analysis

The empirical analysis is conducted using the balance sheet-based network simulation model. The simulations run on a MS Excel VBA based application developed by the author.

V.1 Data

This study analyzes interbank foreign claims based on the BIS consolidated, immediate borrower basis banking statistics for the period from 2005:Q1 to 2009:Q4. The five-year period captures well the changes in interbank exposure pattern during the pre-crisis boom as well as the consequences of the 2008 financial crisis.

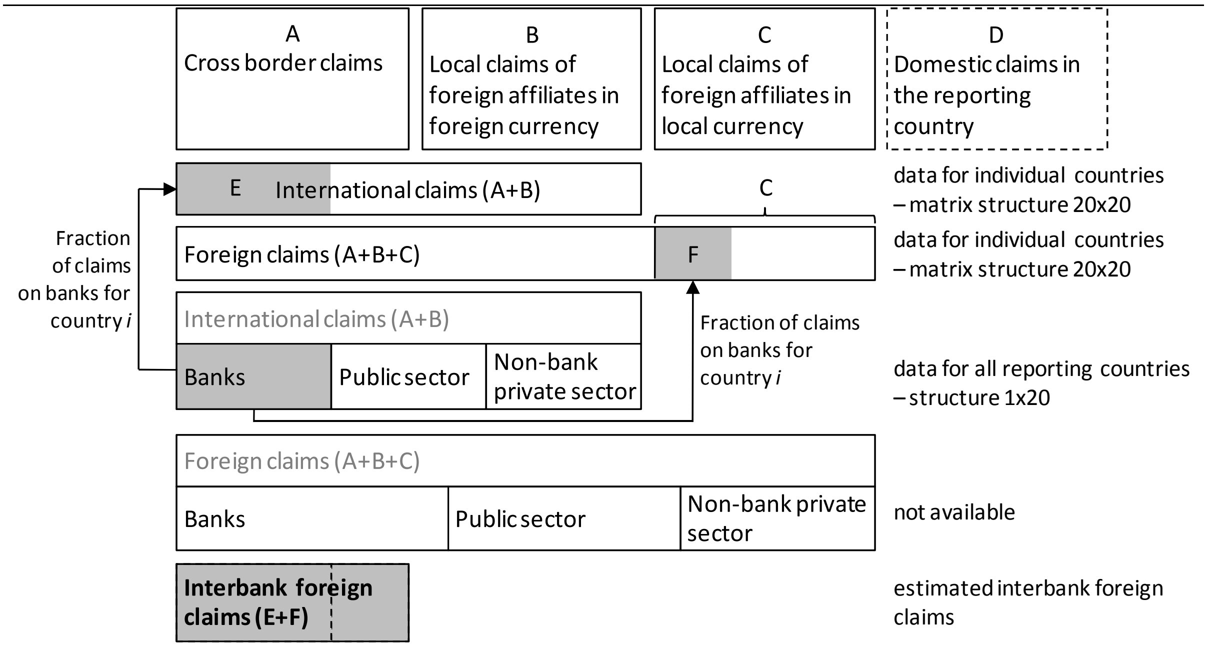
The BIS collects banking statistics on a consolidated and locational basis. The consolidated BIS banking statistics provide data on international financial claims of domestic bank head offices on a worldwide consolidated basis, so the statistics include the exposures of own foreign offices but exclude inter-office positions (BIS, 2009). For example, a position of German head office to its US located foreign office is excluded from the consolidated statistics (as opposed to BIS locational banking statistics) since this position does not add up to the total risk exposure of German banking system. On the other hand, a claim of the US located German foreign office on a US bank adds up to the total risk exposure of German banking system and enters the consolidated statistics (while it does not enter the locational statistics). Additionally, the head office of the bank eventually bears the profit or loss of its foreign affiliate. Thus, in this study used consolidated statistics can better capture the total risk exposure of a reporting country's banking system than locational statistics. Although nobody has published a balance sheet-based network simulation study using the BIS locational banking statistics, it can be argued that subsidiaries in some host jurisdictions are required to operate as a stand-alone institutions with their own capital which is prevented from withdrawal of the subsidiary's head office (Chan-Lau, 2010). These circumstances would favour using the BIS locational banking statistics.

The consolidated statistics further split into two broader types of claims: international claims and foreign claims. As displayed in Figure 7, international claims consist of cross border claims and local claims of foreign affiliates in foreign currency. Foreign claims include all international claims and, additionally, local claims of foreign affiliates in local currency. Cross border claims are defined as claims granted or extended to non-residents. (For example, a claim of a German bank to a US affiliate located in Germany is still reported as a cross border claim, because the head office of the affiliate resides outside Germany.) Local claims of foreign affiliates (in both local and foreign currency) refer to claims of domestic banks' foreign affiliates (branches or subsidiaries) on the residents of the host country, i.e. country of residence of affiliates (BIS, 2009).

The BIS reports banking statistics on foreign claims and international claims in the required matrix structure. However, foreign and international claims do not only consist of claims on banks, but also include claims on public sector and non-bank private sector, which do not enter the interbank exposure matrix. Unfortunately, the BIS does not report the bank/public sector/non-bank private sector breakdown of either foreign or international claims in the required matrix structure. The BIS only reports interbank international claims of all BIS reporting banking sectors (together as one sum) on individual counterparties. It is only known from the data that for each country a certain fraction of all BIS reporting banking sectors' claims on that given country are claims on banks – i.e. interbank claims (recalling Figure 1, only $l_1, \ldots, l_n$ are available). To estimate the interbank international claims for individual banking sectors, this study assumes the same fraction of interbank international claims on a given banking sector as the fraction of all BIS reporting banking sectors' interbank international claims on the given banking sector.

Local claims of foreign affiliates in local currency are also assumed to follow the same structure and the same fractions are applied to determine the interbank local claims of foreign affiliates in local currency. Letters E and F in Figure 7 depict the interbank international claims and the local claims of foreign affiliates, respectively, together with the BIS consolidated banking statistics breakdown. The sum of E and F forms *interbank foreign claims* which enter the interbank exposure matrix.

Figure 7: The BIS consolidated banking statistics structure and interbank foreign claims estimation approach



Source: Figure reproduced from BIS (2009) and extended by the author

The BIS further collects the banking statistics on immediate borrower basis and ultimate risk basis. Financial claims collected on immediate borrower basis are allocated to the country where the original risk lies. On the contrary, *ultimate risk claims identify the country of residence of the counterparty that will ultimately be held responsible for repayment of the claim* (BIS 2009, pp.12). The difference between those two lies in the net risk transfer. For example, a German bank grants a $10 mil credit to its US counterparty and buys a credit default swap (CDS) from a French bank. In case of statistics on immediate borrower basis, German risk exposure to the US increases by $10 mil. In case of ultimate risk basis German risk exposure remains the same because the risk is transferred to France (which is an ultimate guarantor of the credit) and French risk exposure to the US increases by $10 mil. For this reason the ultimate risk banking statistics can theoretically better capture the country's risk exposure.

Yet, this study uses the immediate borrower basis statistics. The reason for this lies in the risk transfers included in ultimate risk data. More specifically, it is not clear how to treat the risk transfers if the ultimate guarantor defaults. Using the previous example, suppose that the French banking sector defaults. Since the French CDS no longer protects Germany (France presumably also defaults on obligations to Germany resulting from CDS), the German risk exposure increases by $10 mil. However, the BIS does not report the risk transfers among individual countries. It seems counterproductive to the author to add an assumption on the distribution of countries' risk transfers to get the interbank exposure matrix. Moreover, the total volume of net risk transfers only account for 1.3% of foreign claims for the period from 2005:Q1 to 2009:Q4. Chan-Lau (2010), Chan-Lau et al. (2009) and other researchers use the immediate borrower basis data, too. Further on, Chan-Lau et al. (2009) founds the difference in results of balance sheet-based network analysis using ultimate risk data and immediate borrower data insignificant.

To sum up, the interbank exposure matrix is constructed from the interbank foreign claims estimated using the method described above from the BIS consolidated banking statistics, immediate borrower basis data. To keep the data sample as large as possible, all 25 reporting countries' foreign claims are initially considered. Then, 5 countries are dropped due to large amount of missing values in the BIS database. These countries are Panama, Chile, Chinese Taipei (Taiwan), Finland, and Mexico. All of the excluded countries account individually for less than 0.8% of all reporting countries' (30 countries including the largest financial centres) total foreign claims globally, except of Mexico that accounts for 1.2%. The 20 countries included in the data sample account for 72.6% of total foreign claims of all reporting countries globally. Table 5 lists the 20 sample countries considered in this study.

Table 5: Sample countries sorted by foreign claims

#	Country	Foreign claims ($ bn)	Share in total foreign claims	#	Country	Foreign claims ($ bn)	Share in total foreign claims
1.	United States	5 485	18.2%	11.	Canada	578	1.9%
2.	United Kingdom	3 486	11.6%	12.	Switzerland	571	1.9%
3.	Germany	2 056	6.8%	13.	Belgium	525	1.7%
4.	France	1 802	6.0%	14.	Brazil	508	1.7%
5.	Japan	1 131	3.8%	15.	Denmark	343	1.1%
6.	Italy	1 099	3.7%	16.	Sweden	290	1.0%
7.	Netherlands	970	3.2%	17.	Austria	286	1.0%
8.	Spain	847	2.8%	18.	Portugal	224	0.7%
9.	Ireland	651	2.2%	19.	Turkey	180	0.6%
10.	Australia	642	2.1%	20.	Greece	161	0.5%
					Sample total	**21 835**	**72.6%**

Source: The BIS consolidated banking statistics as of 2009 and author's calculations

There are still some values missing in the sample of 20 countries, especially in case of Ireland and Denmark, although 5 countries are excluded because of missing values. To estimate missing values and complete the interbank exposure matrix, the gaps in the data are extrapolated from previous or next available quarters.

V.2 General results

In general, the results confirm the robust-yet-fragile nature of banking systems when exposed to credit and funding shock via interbank exposures. Once the contagion occurs, it has a far-reaching consequences and it induces defaults of most of the banking sectors. Further on, some countries turn out to be systematically important for the sample banking system despite their relatively smaller size. As expected, the Basel III regulatory framework helps to significantly reduce both, the probability of contagion occurrence and the impact of contagion once it happens. Interestingly, the effect of increased capital on the contagion scope is non-linear and a relatively small increase in banking sector's capitalization prevents defaults of number of national banking sectors. Moreover, the simulation results suggest that the scope of contagion is consistent with the banking sectors' capitalization in the long-term, but the scope of contagion fluctuates widely from quarter to quarter in the short-term.

The probability that credit and funding shock induce a contagious default after the simulated default of a trigger country's banking sector is 31% under the Basel II and 14% under the Basel III regulatory framework. Under the Basel II regulatory framework, once the contagion occurs it spreads within 3-5 contagion rounds and causes defaults of all sample countries except Brazil, since Brazilian interbank links to the other sample banking sectors are small. Conditional on the contagion outbreak, total losses from contagion amount to 1.5 – 2.3 multiple of total banking system's regulatory capital and up to 18 national banking sectors default. Not surprisingly, the hypothetical banking system meeting the Basel III requirements significantly reduced the scope of contagion as it is better capitalized. Interestingly, the results suggest that an additional capital improves the banking system's resiliency more than proportionally until the capitalization reaches a certain threshold value of capital when the effect slows down and the effect of additional capital becomes less than proportional. Nier et al. (2007) find a very similar non-linear effect of capitalization on banking system's resiliency. Under the Basel III regulatory framework, conditional on the contagion outbreak, 13 to 14 banking sectors default as a consequence of losses from contagion, which usually equal the total banking system's regulatory capital.

A pure credit shock has a substantially lower impact on the sample banking system. Not only the incidence of contagious episodes decreases, but also their impact lowers. The probability that the credit shock induce a contagious default after the simulated default of a trigger country's banking sector is 19% under the Basel II and 10% under the Basel III regulatory framework. Conditional on the contagion outbreak, in general, 13 to 15 banking sectors default under the Basel II regulatory framework and 8 to 10 banking sectors default under the Basel III regulatory framework. The losses from contagion stemming from the credit shock amount approx. to 0.7 – 1.5 and 0.4 – 0.5 multiple of total banking system's regulatory capital, in the respective cases.

Furthermore, the banking system seems resilient to the pure funding shock as no contagious defaults occur throughout the period 2005 – 2009. The pure funding shock only causes isolated direct defaults of Belgium in 2005 and 2006 under the Basel II regulatory framework. The model does not detect any pure funding shock defaults under the Basel III regulatory framework.

Interestingly, although the pure funding shock's impact is negligible, together with the credit shock is the impact far more serious than just in case of credit shock. This supports the idea of robust-yet-fragile nature of banking systems that behave stable up to a certain break point, but then only a small change do to cause a wide-spread contagion.

V.3 Baseline scenario

The baseline scenario constitutes the simulation model output, such that the exogenous parameters are set to their most likely values given the discussion in Chapter III.5. The baseline scenario simulation therefore gives also the most likely results, which are discussed in this part. Because of problematic setting of a few exogenous parameters, a sensitivity analysis is carried out in the next part. To summarize, the baseline scenario parameters are set as follows:

- default level of capital: 4.0% of the Basel III eligible regulatory capital,
- LGD: 80%,

- funding replacement ratio: 40%,
- fire sale loss ratio: 50%,
- raised capital: 60% of capital to raise to meet the Basel III criteria.

The initial period for the analysis is 2009:Q4, since the quantitative impact study (BCBS 2010) presents the impact of the Basel III package adoption as of 2009:Q4. Thus, the simulation results of hypothetical banking system under the Basel III regulatory framework might be biased in other periods due to a different balance sheet structure and business models.

Table 6 presents comprehensive results of credit and funding shock and credit shock baseline simulations. The credit and funding shock contagion occurs following simulated defaults of the United Kingdom, the United States, and Germany under the Basel II regulatory framework. The defaults of those three countries have the three highest direct impacts among the sample countries. The direct loss from the three countries' defaults amounts to \$1 437 bn, \$1 167 bn, and \$992 bn, respectively (in Table 6 expressed as a fraction of total pre-shock capital of the sample banking system). Under the Basel III regulatory framework only the default of the UK banking sector causes a contagion. Very often the sample does not contain a country that does not cause a contagion and, at the same time, has a higher direct impact than any of the contagious countries. This empirical regularity, however, does not hold in general. To see this, consider a case in Table 8 where the Belgium's direct impact under the Basel II regulatory framework is 10.5% of total banking system pre-shock capital and Belgium does not trigger a contagion. On the contrary, the direct impact of Spain and Ireland is 10.3% and 10.1%, respectively; and both Spain and Ireland do trigger a severe contagion. This finding suggests the importance of structure of interbank exposures.

For a detailed output of the simulation refer to Table 10 and Table 11 in the appendix. The tables show the post-simulation losses of each banking sector under the Basel II and the Basel III regulatory framework in the matrix structure.

Table 6: Baseline scenario: Credit and funding shock and credit shock comprehensive results as of 2009:Q4

Credit and funding shock	Direct impact[1]		Loss from contagion[2]		Induced defaults		Contagion rounds		Absolute hazard[3]	
Trigger country:	BII	BIII	BII	BIII	BII	BIII	BII	BIII	BII	BIII
Australia	5.1%	3.9%	-	-	-	-	-	-	3	-
Austria	4.1%	3.2%	-	-	-	-	-	-	3	1
Belgium	6.3%	4.9%	-	-	-	-	-	-	3	1
Brazil	1.9%	1.5%	-	-	-	-	-	-	-	-
Canada	4.7%	3.6%	-	-	-	-	-	-	3	-
Denmark	3.4%	2.6%	-	-	-	-	-	-	3	1
France	19.7%	15.3%	-	-	-	-	-	-	3	1
Germany	24.1%	18.7%	140%	-	18	-	4	-	2	1
Greece	1.3%	1.0%	-	-	-	-	-	-	3	1
Ireland	7.9%	6.1%	-	-	-	-	-	-	3	1
Italy	9.5%	7.4%	-	-	-	-	-	-	3	1
Japan	13.7%	10.7%	-	-	-	-	-	-	3	1
Netherlands	10.0%	7.7%	-	-	-	-	-	-	3	1
Portugal	2.4%	1.9%	-	-	-	-	-	-	3	1
Spain	11.2%	8.7%	-	-	-	-	-	-	3	-
Sweden	2.9%	2.2%	-	-	-	-	-	-	3	1
Switzerland	6.6%	5.1%	-	-	-	-	-	-	3	1
Turkey	0.7%	0.5%	-	-	-	-	-	-	3	-
United Kingdom	34.9%	27.1%	136%	74%	18	13	2	3	2	-
United States	28.4%	22.0%	144%	-	18	-	3	-	2	-
Credit shock (default inducing countries only)										
United Kingdom	29.3%	22.8%	64%	35%	13	8	3	3	1	-
United States	22.1%	17.1%	100%	-	16	-	5	-	-	-

[1])Total loss impact on all other countries given the trigger country's default – expressed as a % fraction of total pre-shock capital.
[2])Total loss from contagion (excl. direct impact) triggered by a trigger country as a % fraction of total pre-shock capital.
[3])Absolute hazard is a number of how many times a country defaulted as a result of all other trigger countries' defaults. The measure was introduced by Chan-Lau et al. (2009).

Source: Output of the simulation model

Although the assumed stress scenario is quite severe – an instant default of the whole national banking sector – the contagion in the baseline scenario only outbreaks in three cases under the Basel II regulatory framework and in one case under the Basel III regulatory framework. However, once the contagion outbreaks, the consequences are far-reaching. In all of the three cases under the Basel II, 18 countries in the sample default within 2 – 4 contagion rounds. The contagion spreads rapidly immediately in the first contagion round. This may suggest a limited possibility for stabilization or remedial actions by banks or governments, although the time dimension of a contagion round is unknown. The Basel III package prevents the spread of contagion following the simulated defaults of the United States and Germany. Although it does not prevent the spread of contagion following the simulated default of the United Kingdom, the number of induced defaults declines by 5 to 13 countries, reducing the losses from contagion approx. by one half.

Interestingly, while the countries with a higher direct impact are more likely to trigger a contagion, they are not likely to trigger a larger contagion. The loss from contagion following a default of the United Kingdom (the highest direct impact of 34.9% in Table 6) amounts to $5 596 bn or 136% in terms of pre-shock sample banking system's capital. Nevertheless, a contagion loss stemming from the US default exceeds the loss from the UK default by $322 bn, while the US direct impact is lower by 6.6%. Refer to Table 8 to see the same nature but more substantial difference in the level of direct impact and subsequent loss from contagion – the cases of Ireland, Italy or Spain compared to the United Kingdom or the United States document the issue very well.

From a national perspective, it is important to know how vulnerable the country is to the credit and funding shock following a simulated default of national banking sector. The absolute hazard measure (last two columns in Table 6) introduced by Chan-Lau et al. (2009) gives an idea about the country's vulnerability. The absolute hazard measures incidence of country's defaults resulting from all other trigger countries' defaults. In the baseline scenario, all countries defaulted three times as a result of the simulated default of Germany, the United Kingdom, and the United States. Brazil constitutes the only exception and remains virtually unaffected by their simulated defaults, because of its looser interbank links to other sample countries. Thus, Brazil has a zero absolute hazard measure.

To the author's best knowledge, nobody has so far published a study using the balance sheet-based network simulation model to assess the effect of the Basel III package on contagion. However, there exists a research comparable with the baseline scenario simulation under the Basel II regulatory framework. And importantly, the existing research yields very similar results as in this study. Chan-Lau (2010) performs an interbank simulation on 20 countries using literally the same data set by BIS (the data sets differ in one country) as in this study and 70% LGD parameter. Chan-Lau reports his results as of 2009:Q1 and 2009:Q3 and finds that funding shock does not trigger a contagion in either of the cases.[8] Further on, the simulated defaults of both the United Kingdom and the United States trigger a system-wide contagion inducing 18 (compared to 18 in this study) defaults in case of credit and funding shock and 10 and 15 (compared to 12 and 15 in this study), respectively, in case of credit shock. Also, the German default triggers a contagion inducing 18 subsequent contagious defaults (compared to 18 in this study) and a French default induces 2 subsequent contagious defaults (compared to 17 in this study) in the credit and funding shock scenario. In a similar vein, Chan-Lau et al. (2009) come up with comparable results on contagion. In their model with a lower default level of capital the simulated defaults of both the United Kingdom and the United States trigger 15 default as of 2008:Q3 compared 18 defaults in this study. The similar results suggest reasonable settings of the exogenous parameters and a proper performance of the simulation model.

The contagion pattern

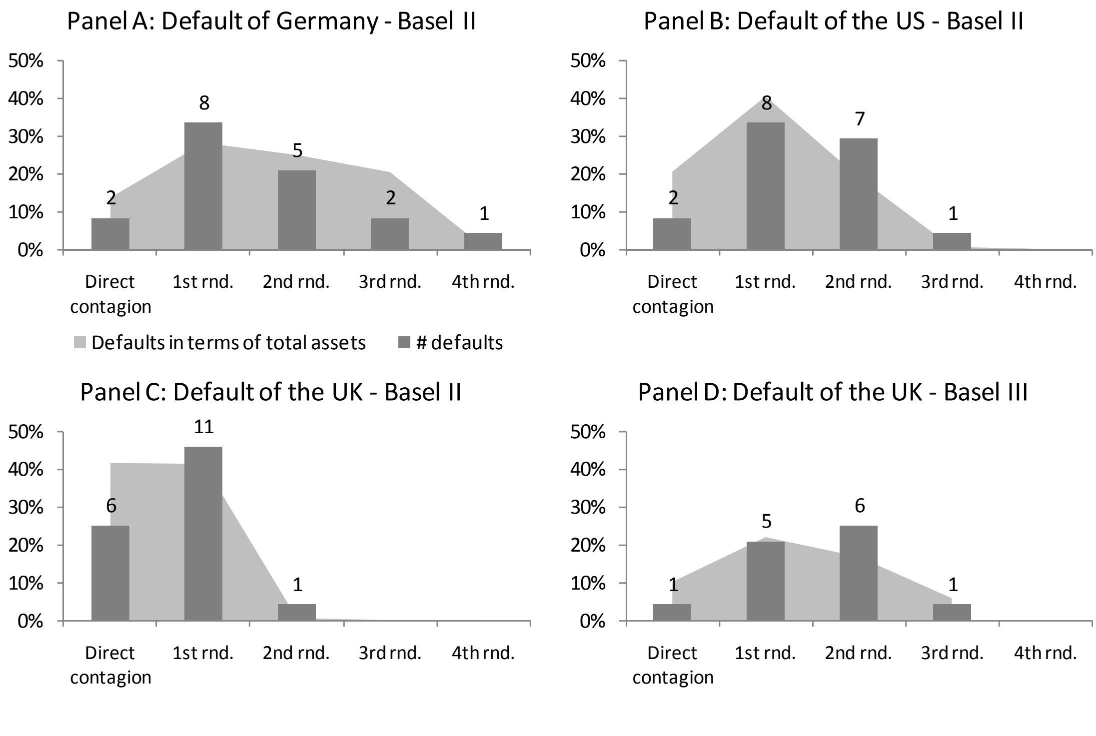
The balance sheet network simulation models enable to follow the pattern of contagion in individual contagion rounds. The contagion pattern is a very useful output from a financial stability perspective. Although the contagion rounds in the model has no time dimension meaning, it allows observing the severity of the contagion spread. Figure 8 displays the baseline scenario contagion patterns of three contagion cases under the Basel II and one case under the Basel III regulatory framework. In all of the three contagion cases under the Basel II regulatory framework (Panels A, B, and C), the number of defaults culminates in the first contagion round as well as total assets of defaulted national banking sectors. It indicates a quick spread of a severe contagion with limited possibilities for banks, regulatory authorities and also governments to take any actions. The contagion begins to die away after the first contagion round, however with a significantly different intensity. Panels A, B, and C suggest that the pattern of contagion might be related to the magnitude of initial direct impact – the stronger the initial direct impact is, the less contagious rounds occur. The contagion pattern in case of default of Germany, whose direct impact is 24% (recall Table 6) reaches the fourth round and losses from contagion are spread out more evenly. The simulated default of the United Kingdom causes losses of 35% of total pre-shock banking system's capital and most

[8] Chan-Lau (2010) actually reports the default of Chile triggered by a funding shock contagion originated in Spain. Chile, however, does not appear in the sample of this study.

of the banking sectors default right in the first contagion round. The United States with direct impact of 28% is between the latter two cases supporting the relationship of direct impact and contagion pattern.

During the simulation, banks do not take any actions to prevent the contagion such as raising capital or withdrawing from interbank market. In reality, however, banks take actions to mitigate the impact of contagion and the more even distribution of losses over the contagious rounds gives banks more space to deal better with the contagious episode. Panel D suggests that in case of the United Kingdom the Basel III package lowers the impact of contagion and pushes the culmination of defaults to the second contagion round. However, the defaults in terms of total banking sectors' assets still peak in the first round.

Figure 8: Contagion pattern – baseline scenario



This figure only shows the contagion pattern under the Basel III regulatory framework for the United Kingdom, since only the United Kingdom trigger a contagion in the baseline scenario under the Basel III regulatory framework. Germany and the United states do not.

Source: Output of the simulation model

To complement the previous discussion on the contagion pattern Table 7 presents a detailed contagion path round by round. For each contagious episode in Figure 8, Table 7 shows which national banking sectors defaulted in individual contagion rounds.

Table 7: Contagion path – baseline scenario

Trigger country		Defaulting banking sectors: Direct defaults	1st round	2nd round	3rd round	4th round	Total
Germany	Basel II (Panel A*)	FR, IR	BE, DK, GR, IT, JP, NL, PT, CH	AU, AT, ES, SE, UK	CA, US	TR	18
United Kingdom	Basel II (Panel D*)	FR, DE, IR, JP, NL, CH	AU, AT, BE, CA, DK, GR, IT, PT, ES, SE, US	TR	-	-	18
	Basel III (Panel C*)	DE	DK, FR, IR, NL, CH	AT, BE, GR, JP, PT, SE	IT	-	13
United States	Basel II (Panel B*)	DE, JP	CA, DK, FR, IR, NL, PT, CH, UK	AU, AT, BE, GR, IT, ES, SE	TR	-	18

This figure only shows the contagion pattern under the Basel III regulatory framework for the United Kingdom, since only the United Kingdom trigger a contagion in the baseline scenario under the Basel III regulatory framework. Germany and the United states do not.

*)Panels A, B, C, and D refer to the corresponding Panels in Figure 8.

Source: Output of the simulation model

V.4 Contagion throughout the 2005 – 2009 period

The simulation results indicate that the scope of contagion varies substantially over the 2005 – 2009 period. Moreover, large swings in the scope of contagion can be explained neither by the capitalization level of the whole banking system nor by the average direct impact of default. Although the correlation coefficient between the level of capitalization and average losses from contagion is -0.72 in the long term, this relationship cannot sufficiently explain the large short term volatility of contagion. Neither can the magnitude of direct impact (measured as a fraction of total banking system's capital), which has a positive correlation coefficient of 0.44 with the level of banking system's capitalization in the long term. Figure 9 provides a short term counterexample, where the latter two correlations does not hold. Particularly, between 2006:Q4 and 2007:Q1 the average Basel II losses from contagion drop by more than one half, however, the capitalization level decreases by 0.1 pp. and the average direct impact increases by 0.4 pp. This suggests that the short term swings in scope of contagion are more likely driven by temporary changes in the structure of interbank exposure network. This finding highlights the importance of analysing the banking system as a whole, besides looking at the soundness of each individual institution, because the structure of the interbank network is unobservable at the level of individual institution.

Further on, looking at Figure 9, the 2005 – 2009 period can be divided into three periods. The first – "pre-crisis[9]" – period takes place between 2005:Q1 and 2006:Q4. The scope of contagion is very high but relatively stable. On average more than 7 banking sectors default under the Basel II regulatory framework inducing contagious losses that amount to more than 0.8 multiple of the total banking system's capital. During the first period, the banking system under the Basel III regulatory framework loses on average 0.2 multiple of its total capital as a result of 2.8 induced defaults on average. The increased volatility of contagion, especially in case of banking system under the Basel II regulatory framework, characterizes the second – "crisis" – period from 2007:Q1 to 2008:Q3. In the third – "post-crisis" period – from 2008:Q4 to 2009:Q4, the scope of contagion stabilizes on the levels lower than in pre-crisis period. Under the Basel II regulatory framework the average number of induced defaults drops by 4 to 3.4 induced defaults and contagious losses decrease to the 0.3 multiple of total capital. Under the Basel III regulatory framework, the induced defaults average on 1.1 banking sectors producing a contagion loss of 0.1 multiple of total banking system's capital.

The results suggest that in pre-crisis and post-crisis periods the scope of contagion is relatively stable, thus the impact of a contagious episode may be predictable, but the volatility of scope of contagion increases substantially in the crisis period, when it is difficult to predict the scope of contagion. Unluckily, the contagion is likely to outbreak in crisis periods and its impact is therefore hardly predictable. Luckily, the Basel III package seems to reduce the scope of contagion and also the volatility of contagion, what may support the predictability of contagious impact.

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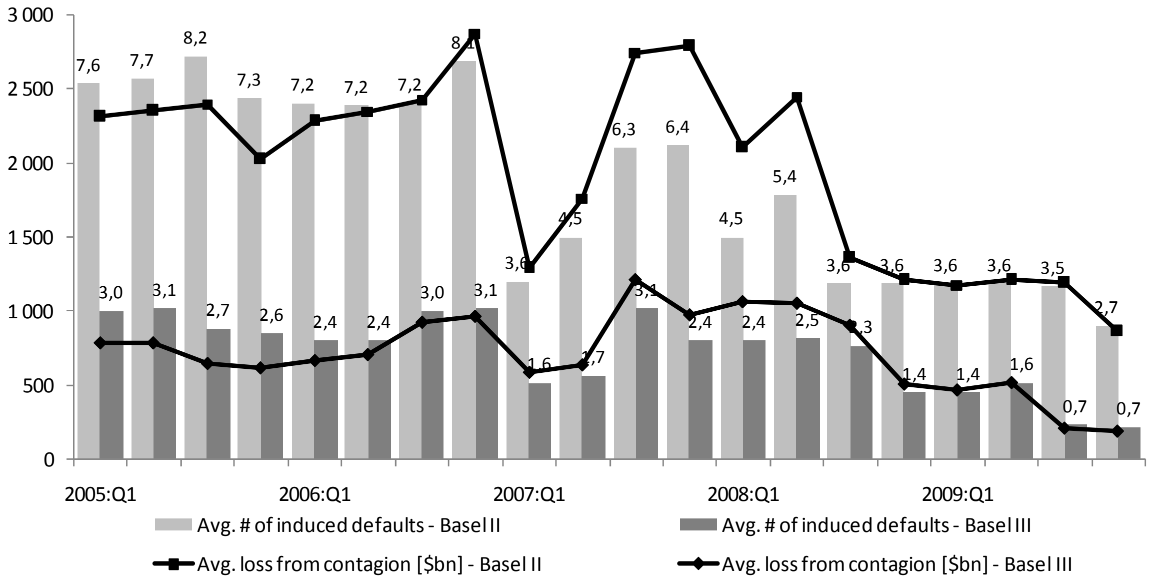
[9] The term "crisis" refers to the 2008 – 2009 global financial crisis. The pattern of scope of interbank contagion seems to take place slightly in advance of when the crisis is generally acknowledged to start and to end.

Figure 9: Losses from contagion and induced defaults over the time



Source: Output of the simulation model

The baseline scenario presents the simulation results as of 2009:Q4, when the quantitative impact study is carried out. In 2009:Q4 the banking system experiences the smallest contagious episode compared to the other observed periods (see Figure 9). On the other hand, the banking system experiences the worst contagious episode in 2006:Q4, when on average 8 national banking sectors default inducing contagious losses of 90% of total banking system's capital. Table 8 presents the worst case scenario in detail. It captures the impacts of credit and funding shock and credit shock using the simulation model set at the baseline parameters. Table 8 documents that conditional on the contagion outbreak the magnitude of direct impact does not entirely influence the losses from contagion. Even though the banking sectors of Italy, Ireland, Netherlands, and Spain are much smaller than e.g. the UK banking sector, the defaults of these smaller banking sectors induce on average by $1850 bn larger losses from contagion than the simulated UK default, which is a half of the pre-shock total banking system's capital.

Table 8: Credit and funding shock and credit shock – comprehensive results as of 2006:Q4

Credit and funding shock	Direct impact[1]		Loss from contagion[2]		Induced defaults		Contagion rounds		Absolute hazard[3]	
Trigger country:	BII	BIII	BII	BIII	BII	BIII	BII	BIII	BII	BIII
Australia	4,7%	3,5%	-	-	-	-	-	-	9	1
Austria	2,8%	2,1%	-	-	-	-	-	-	9	4
Belgium	10,3%	7,8%	-	-	-	-	-	-	9	6
Brazil	1,3%	1,0%	-	-	-	-	-	-	-	-
Canada	4,2%	3,2%	-	-	-	-	-	-	9	1
Denmark	3,4%	2,6%	-	-	-	-	-	-	9	4
France	22,1%	16,8%	160%	93%	17	13	2	4	8	3
Germany	26,1%	19,8%	157%	94%	18	14	2	4	8	3
Greece	1,1%	0,8%	-	-	-	-	-	-	9	4
Ireland	10,0%	7,5%	203%	-	18	-	3	-	8	4
Italy	10,6%	8,0%	205%	7%	18	1	3	-	7	3
Japan	11,8%	9,0%	193%	-	18	-	4	-	8	4
Netherlands	13,3%	10,1%	192%	7%	18	1	3	-	8	4
Portugal	2,1%	1,6%	-	-	-	-	-	-	9	4
Spain	10,1%	7,6%	205%	-	18	-	3	-	8	4
Sweden	3,0%	2,2%	-	-	-	-	-	-	9	4
Switzerland	8,7%	6,6%	-	-	-	-	-	-	9	4
Turkey	0,6%	0,5%	-	-	-	-	-	-	9	1
United Kingdom	45,7%	34,6%	147%	85%	18	14	1	2	8	3
United States	32,3%	24,5%	171%	129%	18	18	2	3	8	-
Credit shock (default inducing countries only)										
France	14,4%	10,9%	86%	3%	13	1	5	-	4	1
Germany	13,2%	10,0%	80%	4%	13	1	5	-	4	2
Ireland	7,4%	5,6%	6%	-	1	-	-	-	5	2
Italy	9,1%	6,9%	115%	-	14	-	5	-	-	-
Japan	5,7%	4,4%	3%	-	1	-	-	-	5	2
Netherlands	7,9%	6,0%	6%	4%	1	1	-	-	5	2
United Kingdom	39,9%	30,2%	69%	43%	13	10	2	2	4	-
United States	28,8%	21,8%	115%	32%	17	7	3	3	-	-

[1])Total loss impact on all other countries given the trigger country's default as a % fraction of total pre-shock capital.

[2])Total loss from contagion (excl. direct impact) triggered by a trigger country as a % fraction of total pre-shock capital.

[3])Absolute hazard is a number of how many times a country defaulted as a result of all other trigger countries' defaults. The measure was introduced by Chan-Lau et al. (2009).

Source: Output of the simulation model

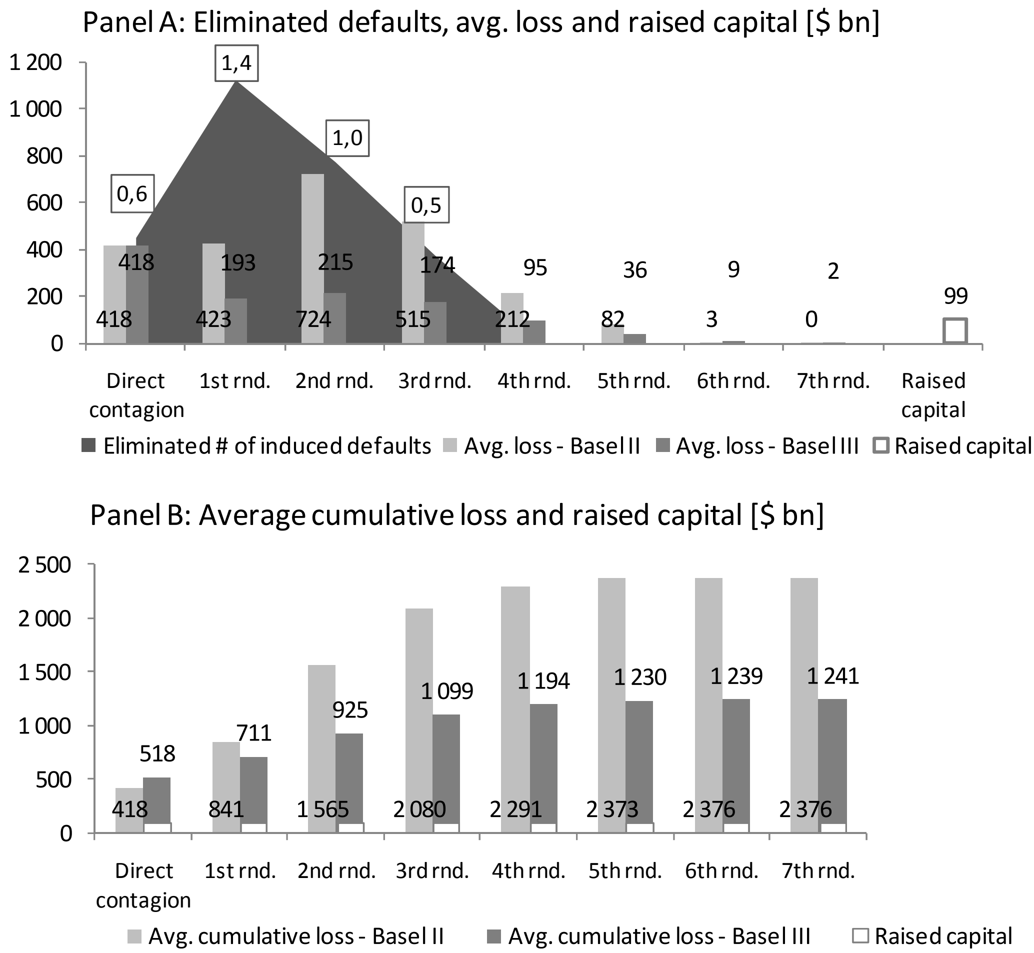
As of 2006:Q4, the defaults of 9 out of 20 sample banking sectors trigger a severe contagion via credit and funding channel under the Basel II regulatory framework. The Basel III package reduces a number of contagious episodes to 4, saving a 135% of the banking system's pre-shock capital. Assuming a credit shock only, 8 countries trigger a contagion under the Basel II compared to 2 countries under the Basel III regulatory framework. Thus, implementing the Basel III package reduces the losses from contagion by 49 pp. from 60% to 11% in terms of total banking system's capital.

V.5 Effect of the Basel III package on contagion

The Basel III package improves the resiliency of banking system to credit and funding shock and to credit shock. The package helps to reduce significantly both, the probability that contagion occurs and the impact of contagion once it occurs. The Basel III regulatory framework reduces the probability of contagion from 31% to 14% and lowers the average contagious impact by 63% or by $1 142 bn in dollar terms. Interestingly, the effect of increased capital on the contagion scope is non-linear and a relatively small increase in banking sector's capitalization prevents number national banking sectors' defaults. The following subsection tries both to quantify the improvement of banking system's resiliency to contagion and find qualitative changes given by hypothetical implementation of the Basel III package.

The Basel III package eliminates the contagious impact of every sample banking sector's default on average by $1 142 bn. This amount of contagious losses would otherwise increase the average number of induced defaults by 3.5. Panel A in Figure 10 depicts the distribution of losses under the Basel II and the Basel III regulatory framework over the contagion rounds together with the average number of induced defaults eliminated thanks to the Basel III package. Under the Basel II regulatory framework, the losses in the contagious rounds exceed the losses in the direct contagion round. The average banking sector suffers highest contagious losses in the second and third round – $724 bn and $515 bn, respectively. The loss in the first round is still very high – $423 bn – and corresponds to the direct impact loss. The Basel III package significantly reduces the losses in each contagion round, such that in every round the contagious loss does not exceed the initial direct impact loss. Also the scope of the contagion spread is reduced (the distribution of contagious losses is flatter over the contagion rounds), what gives the still surviving but endangered banking sectors some chance to adopt measures to mitigate the contagious impact.

Figure 10: Number of induced defaults eliminated and average losses compared to the raised capital



Herein, "Raised capital" denotes 100% of capital needed raise to meet the Basel III criteria (not 60% as assumed in the baseline scenario) in order to rather overestimate the costs of Basel III package implementation.

Source: Output of the simulation model

The benefits of the Basel III package regarding the interbank contagion are substantial. But what are the costs? It is far beyond the scope of this study to estimate the costs related to implementation of the Basel III package. However, taken from a financial contagion point of view, the direct costs of implementing the Basel III package can be approximated by the amount of capital that banking sectors have to raise. Of course, this approximation disregards all side-effects of the new regulatory framework implementation, such as possible spill-overs to the real economy via reduced lending activity of banks, administrative costs etc. Panel B in Figure 10 gives a rough idea about the possible costs and benefits. The light-grey columns depict cumulative average losses under the Basel II regulatory framework. White columns depict costs of implementing the Basel III package (approximated by the amount of raised capital), and dark-grey columns represent cumulative average losses under the Basel III regulatory framework. The total height of both columns can be interpreted as total costs of preventing further contagion spread in each contagion round – the later the investor or government steps in, the further the contagion develops and the higher are the costs. In case an investor or the government is able to step in right after the direct contagion round, the costs to prevent further spread of contagion are \$418 bn under the Basel II regulatory framework but \$518 bn under the Basel III regulatory framework. Thus, lower costs favour the Basel II regulatory framework. However, already in the first contagion round the total costs of preventing further contagion spread are lower under the Basel III than the Basel II regulatory framework. And further on, the later the bail-out comes, the more advantageous the Basel III package is.

V.6 Sensitivity analysis

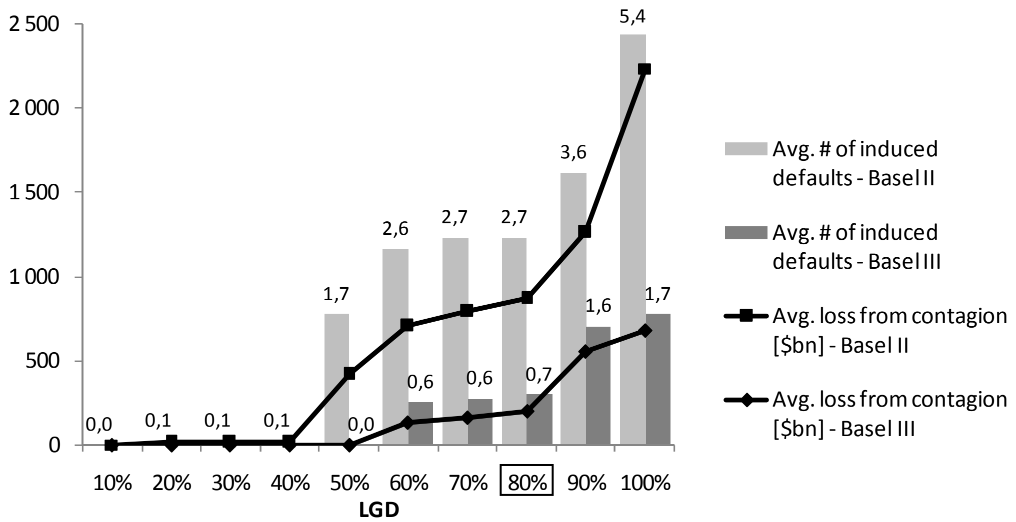
Whether the contagion outbreaks or not depends to a large extent on the set of exogenously determined parameters, especially on LGD and the default level of capital. This section presents the sensitivity of the simulation model to changes in the exogenous parameters. The credit and funding shock baseline scenario as of 2009:Q4 serves as a basis for the sensitivity analysis. One by one parameter varies and the simulation outcome, all else equal, is investigated.

LGD sensitivity

Figure 11 presents the sensitivity of the simulation model to changes in LGD. The banking system seems resilient to interbank contagion when the LGD ratio does not exceed 40% under the Basel II and 50% under the Basel III regulatory framework. In the former case the contagion outbreaks when the LGD ratio exceeds 40% level. Beyond this point the scope of contagion grows rapidly. Already with 45% of LGD the defaults of the UK and the US induce each 17 defaults. The Basel III package reduces the scope of contagion significantly – the first contagious episode of 11 induced defaults appears with LGD of 60%. In the range from 60%

to 80% of LGD, the average number of induced defaults and contagious losses remains stable, slightly increasing, under both regulatory regimes. Nevertheless, the LGD of 80% constitutes a break point beyond which the contagion spreads widely. The LDG higher than 80% leads to a sharp increase in contagious losses and induced defaults, too. Within the LGD range of 80 – 100%, the contagion spreads quickly even under the Basel III regulatory framework. Still, the Basel III package eliminates two thirds of the Basel II contagious impact at the maximum level of LGD.

Figure 11: Losses from contagion and induced defaults – varying LGD



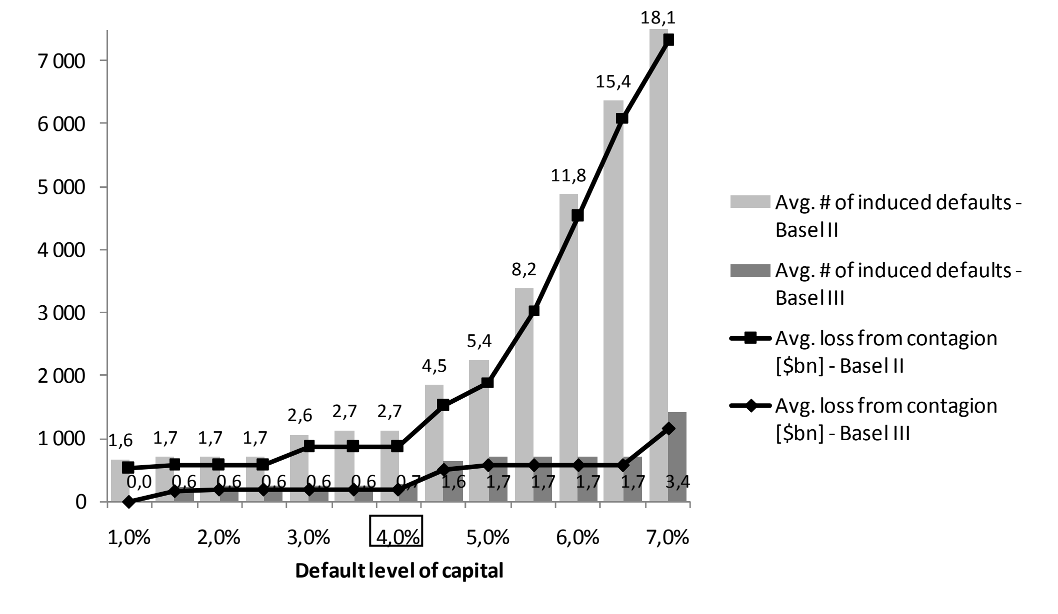
Source: Output of the simulation model

Default level of capital sensitivity

The sensitivity to the default level of capital especially rises under the Basel II regulatory framework, since the banking system is poorly capitalized in terms of the Basel III eligible capital, which is considered as a measure of default level of capital. Figure 12 documents the robust-yet-fragile nature of the banking system regarding to contagion. Up to 4% of default level of capital, only the United Kingdom and the United States trigger a contagion, from the 3% level also Germany triggers a contagion. Under the Basel III regulatory framework, only the United Kingdom triggers a contagion and even beyond the 4% default level of capital is the scope of contagion relatively limited. Up to the default level of capital of 6.5%, only the United Kingdom and the United States trigger the contagion.

Under the Basel II regulatory framework the scope of contagion grows rapidly beyond the break point of 4%. In the extreme situation of 7% default level of capital every single country triggers a contagion that causes a collapse of the whole sample banking system (18 to 19 countries default). Alternatively, a decrease in default level of capital can be equivalently thought of as the same increase of capitalization level in the banking system. Then, Figure 12 can also be interpreted as a measure of how the contagious impact lowers when a new capital is added. A certain threshold value of capitalization exists. Above this threshold value, an incremental increase in capital does not does not bring much effect. Below the threshold value however, every incremental increase in capitalization level in a poorly capitalized banking system improves the banking system's resiliency substantially. In 2009:Q4, every 0.5 pp. increase in capitalization level saves on average as much as $1 076 bn, which is a quarter of the total pre-shock banking system's capital. This finding corresponds to Nier et al. (2007), who investigated the scope of contagion on an artificial interbank network.

Figure 12: Losses from contagion and induced defaults
– varying default level of capital



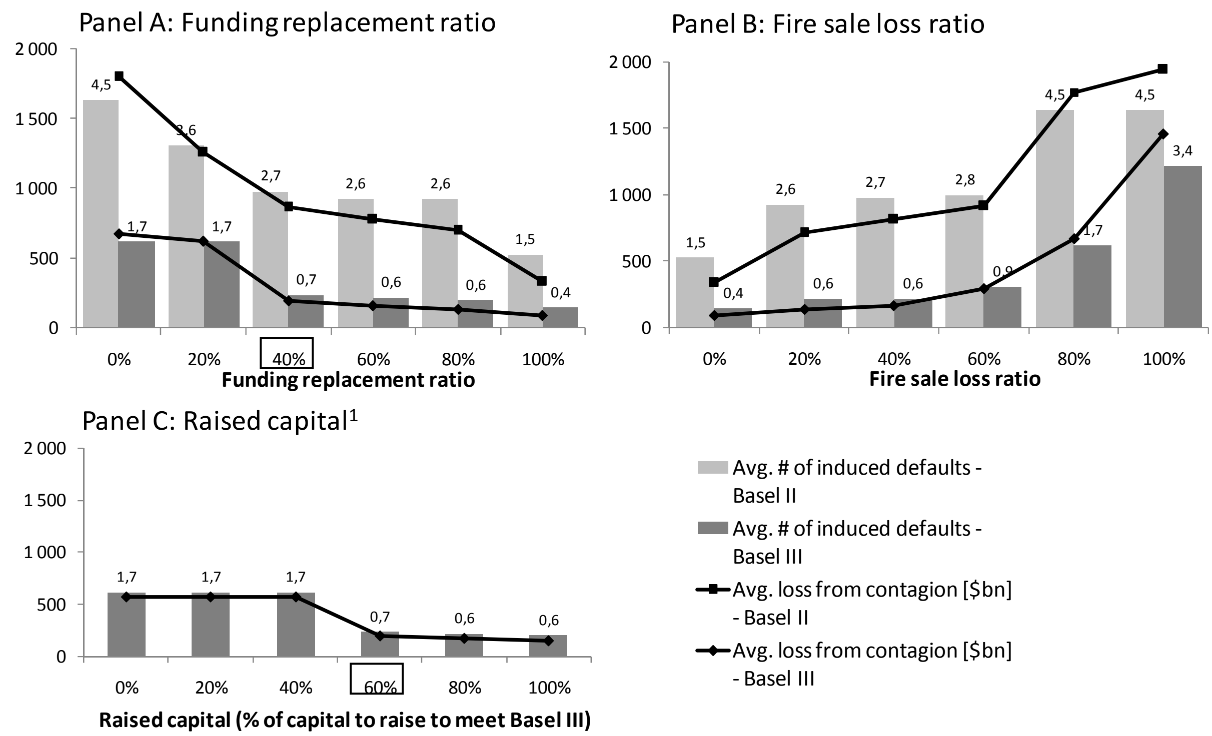
Source: Output of the simulation model

Although, the sensitivity of results to default level of capital is at least comparable with the sensitivity to LGD, the related literature does not pay much attention to the setting of default level of capital.

Funding replacement ratio and fire sale loss ratio

The funding replacement ratio and the fire sale loss ratio significantly influence the final impact of funding shock. If a bank can replace the whole funding gap, so it does not have to sell any assets, the fire sale ratio is not applied and the bank does not suffer any loss. The fire sale loss ratio needs to be interpreted in context of the funding replacement ratio, since their combination yields the final loss. As shown in Panel A of Figure 13, the full range of impact of funding replacement ratio varies from 1.5 to 4.5 and from 0.4 to 1.7 average induced defaults under the Basel II and the Basel III regulatory framework, respectively. The sensitivity to the fire sale ratio (Panel B) is very similar, but the scope of contagion is growing with increasing fire sale loss ratio. Note that by definition, 100% funding replacement ratio as well as 0% fire sale loss ratio mitigate completely the losses from a funding shock hence they make a pure credit shock from the credit and funding shock scenario.

Figure 13: Sensitivity analysis – Funding replacement ratio, fire sale loss ratio, and raised capital



[1])Raising capital only relates to the estimating of Basel III package impact, thus, it does not affect Basel II simulation results.

Source: Output of the simulation model

Raised capital

The raised capital parameter represents a capital that banks raise in a reaction to the Basel III package as a percentage fraction of capital the banks have to raise to meet the Basel III criteria, supposed that they do not decrease their RWA (i.e. the banks achieve the higher capital requirements by raising capital only). The fraction of capital raised only applies to the Basel III regulatory framework. The sensitivity of the model to the fraction of capital raised (Panel C in Figure 13) is comparable to the Basel III funding replacement ratio sensitivity in Panel A. The limit values of average induce defaults range between 0.6 and 1.7. The bank's choice whether to raise capital or reduce RWA does not change the results of the simulation substantially.

V.7 Shortcomings

The simulation model presented in this study provides an insight into the banking system's contagion spread under different regulatory regimes. Nevertheless, the simulation outcomes bear a series of shortcomings. The lack of data limits this type of research most. The interbank exposure data are only available in the aggregation for whole banking sectors and for just 20 BIS reporting countries. Using aggregate data for banking sectors (i.e. treating banking sectors as single banks) constitutes a significant drawback of this study, which might cause an underestimation of interbank contagion. In aggregation, a banking sector can meet the regulatory capital requirements as a whole, while a number of its banks has insufficient capital adequacy. These banks make – via variety of channels including the direct interbank contagion – the whole banking sector more vulnerable than the aggregate statistics would suggest.

Moreover, the available statistical data does not capture some important features of interbank market such as transfers of credit risk, collateralization, netting agreements, or seniorities of interbank claims, although it would help to relax some assumptions (e.g. endogenise LGD) and provide more reliable results. A more detailed complete data on banks' balance sheet structure and regulatory items would enable to estimate the impact of the Basel III package more accurately and to draw more reliable conclusions on the differences in contagion spread under the Basel II and the Basel III regulatory frameworks. The nature of the simulation model allows incorporating many extensions, when the appropriate data are available. One possible extension is allowing a shock from off-balance sheet exposures to complement the credit and funding shocks as another contagion channel. In that case a bank defaults when the off-balance sheet exposures exceed the sum of capital buffer and provisions for off-balance sheet items. Similarly, the government action preventing the spread of contagion could be simulated. Considering any extension requires to carefully judge the potential benefits of the extension, on the one hand, and a quality of data and consequences of accepted assumptions on the other. Taking into account this trade-off, this study does not go any further, given the current data sources, than simulating credit and funding shocks in the Basel II and the Basel III regulatory environment.

Besides the primary data issues a series of assumptions may bias the results. Table 9 provides a summary of sources of potential contagion estimation bias. The biases influence the results in both directions, so the results can neither be interpreted as a worst-case scenario nor as an optimistic scenario.

Table 9: Sources of potential contagion estimation bias

Source of bias	Direction of bias
Banks are not allowed to take any actions to mitigate the impact of contagion (interbank market withdrawal, raising capital, ...)	upward
Neglecting the measures of regulatory authority and government (too big to fail, government's bail-out)	upward
Netting agreements are not possible in the model	upward
The initial assumption of sudden default of a whole banking sector	upward
Ignoring the safety net	upward
Using aggregate data for banking sectors (treating banking sectors as single banks)	downward
Ignoring other than interbank on-balance sheet channels of contagion (spill-over effects of a country's banking sector default to the real economy, off-balance sheet exposures channel, exchange rate channel, mistrust, etc.)	downward
Banks are not allowed to adjust their business models to the Basel III package	unknown
The risk transfers are not considered	unknown
Constant LGD	unknown
Constant default level of capital	unknown
Ignoring the development of contagion within a banking sector	unknown
Limited data set of 20 countries	unknown

Source: Related literature and own observations

One of the influential sources of potential contagion estimation bias is that banks, government or the regulatory authorities are not allowed to step into the contagion process. In reality this usually happens, since the default of a systemically important bank constitutes the very last option for the government. Ignoring the possibility to take "anti-contagious" actions biases the estimate of contagion upward. On the contrary, a substantial underestimation of the danger of contagion spread arises from ignoring other than interbank on-balance sheet channels of contagion. The model only simulates the on-balance sheet interbank exposure channel, while during contagious conditions the bank is most likely affected by many other channels of contagion, such as off-balance sheet channel, stock market, and foreign exchange market channel, adverse changes in interest, or the contagious spill-over through the real economy channel, etc.

In the stream of interbank network literature, which considers individual banks in one country, the initial simulated default of one bank often questioned. Arguably, an assumed sudden default of one bank (a bank-specific shock) can represent an event such a fraud. These types of bank-specific events, however, occur rarely. More frequently adverse changes in macroeconomic variables or the developments in the markets affect a whole group of banks. The initial simulated default of one bank does not capture the possibility of a macroeconomic shock. The simulation model in this study uses aggregate data for the whole banking sectors. In that case, a simulated default of one country's banking sector corresponds with a macroeconomic type of shock, since banks operating in the one country tend to be exposed to similar risks, such as domestic currency risk, interest rate, condition of the real economy etc. The macroeconomic type of shock, however, does not come out of the blue, i.e. banks can expect, to some extent, the development of macroeconomic conditions. The simulated sudden default of the whole banking sector thus overestimates the true impact of contagion.

VI Conclusions

This study focuses on the direct contagion risk in the international banking system that spreads via the interbank exposure channel. The research on interbank contagion risk is an integral part of stress testing of financial systems. Stress tests analyze the resilience of financial systems to adverse events and have become a popular analytical tool for central banks and regulatory authorities. This study simulates the impact of the adoption of the Basel

III regulatory framework on the direct interbank contagion. This study shows a methodology how to draw reasonable inferences on interbank contagion under different regulatory regimes using exclusively publicly available data.

The balance sheet-based network simulation model is used to investigate the interbank contagion risk. The contagion may spread via interbank exposures due to both credit and funding shocks and their combination. Additionally the simulation allows modelling the funding shock in the distressed market, what reflects well the 2008 financial crisis. The simulation results depend on a set of exogenous parameters. Among them the most critical parameters are the default level of capital and LGD.

This study compares two sets of results. The simulation is performed on the data under the current Basel II regulatory framework and also under the Basel III regulatory framework. Since banks have to fully implement the Basel III regulatory framework by 2019, the impacts of the regulations are now unknown. The impact of the new Basel III package is estimated based on the results of quantitative impact study carried out by BCBS (2010). A hypothetical banking system that meets the Basel III regulatory criteria is built and enters the simulation in the same way as the actual banking system under the current Basel II regulatory framework does.

The sample banking system includes banking sectors of 20 – mostly developed – countries. The matrix of interbank exposures is constructed based on the 2005:Q1 – 2009:Q4 BIS consolidated banking statistics on an immediate borrower basis, which is the only (still incomplete) public source of data on international interbank exposures. The 20 countries included in the sample account for 72.6% of total foreign claims of all reporting countries globally. The data thus cover a solid part of the international banking flows despite the limited sample of 20 countries.

In general, the results confirm the robust-yet-fragile nature of banking systems when exposed to credit and funding shock via interbank exposures. Once the contagion occurs, it has a far-reaching consequences and it induces defaults of most of the banking sectors. The United Kingdom and the United States are the most systemically important countries from the sample. Nevertheless, a default of other much smaller countries (in terms of size of banking sector) also induce severe contagious losses comparable with those induced by the United Kingdom and the United States.

The Basel III regulatory framework helps to reduce significantly both, the probability that contagion occurs and the impact of contagion once it occurs. The Basel III regulatory framework reduces the probability of contagion from 31% to 14% and lowers the contagious impact by 63%, or equivalently saves total of $1 142 bn. Interestingly, the effect of increased capital on the contagion scope is non-linear and a relatively small increase in banking sector's capitalization prevents defaults of number of national banking sectors. Although the costs to implement the Basel III package are substantial, the risk and scope of contagion seems to be reduced.

Moreover, the simulation results suggest that in the long-term the scope of contagion is consistent with the banking sectors' capitalization. However, in the short-term the scope of contagion fluctuates widely from quarter to quarter, making it difficult to predict the contagion. The fluctuation's amplitude of scope contagion is reduced under the Basel III regulatory framework.

The balance sheet-based network simulation provides a useful insight in the dynamics of interbank contagion and identifies systemically important banking sectors. The model, however, bears a series of assumptions that limit the reliability of simulation outcomes. The insufficient data forms a main obstacle in this type of research. There are already voices to supplement the BIS banking statistics (e.g. by Hoggarth, Mahadeva, and Martin (2010) from the Bank of England) in a way that the data enable researchers and supervisors to keep pace with the development of the banking industry. Better data (not only the BIS statistics) would enable to relax some of the assumption, to incorporate more realistic scenarios and types of shocks, and to consider more countries in the sample. Only then the balance sheet-based network simulation models can yield reliable policy implications about the international contagion risk.

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OECD statistics: http://stats.oecd.org

World Bank databank: http://data.worldbank.org/topic/financial-sector

National statistical databases:

Reserve Bank of Australia: http://www.rba.gov.au/statistics/index.html

Central Bank of Brazil: http://www.bcb.gov.br/?TIMESERIESEN

Bank of England: http://www.bankofengland.co.uk/statistics/index.htm

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VIII Appendix

Table 10: Basel II post-simulation capital losses in % of affected country's pre-shock capital
(baseline scenario credit and funding shock as of 2009:Q4)

Affected country→ *Trigger country↓*	AU	AT	BE	BR	CA	DK	FR	DE	GR	IE	IT	JP	NL	PT	ES	SE	CH	TR	GB	US
Australia		1.7	3.5	0.0	5.5	0.7	6.6	6.5	0.2	5.9	1.0	17.7	5.0	1.4	1.1	2.8	4.0	0.0	4.6	1.9
Austria	0.7		5.2	0.2	0.6	1.1	6.1	22.2	2.2	4.7	7.2	1.2	4.3	2.8	1.4	1.9	5.4	1.0	1.1	0.5
Belgium	2.2	3.6		0.7	1.8	4.1	21.8	10.0	1.4	9.2	2.9	4.7	20.4	4.1	3.2	3.4	5.6	1.0	3.8	1.6
Brazil	0.0	0.2	0.5		1.0	0.5	2.2	1.7	0.0	1.4	0.3	3.9	1.8	8.5	2.7	0.6	2.6	0.0	0.7	1.5
Canada	4.9	1.1	3.7	0.7		1.5	5.8	7.8	0.2	8.1	1.1	9.4	2.9	0.8	0.7	2.3	8.9	0.3	3.4	3.0
Denmark	0.3	1.2	2.0	0.3	0.8		5.1	9.3	0.1	2.9	0.7	1.8	2.8	1.5	0.6	43.1	6.9	0.2	1.5	1.1
France	9.6	9.0	43.1	1.4	7.7	14.4		43.5	15.3	18.7	17.5	23.1	32.3	24.8	16.0	14.3	30.2	4.6	17.0	6.7
Germany	94.8	115.4	228.6	24.4	98.9	197.7	368.3		127.1	277.7	96.5	257.1	247.1	197.2	87.6	167.2	258.9	49.1	130.8	69.5
Greece	0.0	1.1	1.1	0.0	0.1	0.1	3.7	4.2		2.3	0.6	0.6	2.1	2.5	0.1	0.3	0.8	2.2	0.9	0.3
Ireland	2.9	4.0	17.8	0.3	3.1	5.4	10.6	26.3	4.0		5.1	5.0	6.0	27.6	3.7	3.8	5.0	0.6	7.1	2.5
Italy	1.3	12.9	17.4	0.3	1.4	2.0	36.0	24.6	3.0	21.9		7.8	13.0	10.8	6.0	2.5	5.8	1.5	4.2	1.9
Japan	17.6	1.4	7.7	2.9	7.8	4.9	29.9	16.1	2.3	11.7	3.6		5.8	2.4	1.8	4.7	23.9	0.9	12.2	13.3
Netherlands	4.1	7.1	25.4	0.8	2.7	6.1	24.8	22.9	10.6	8.7	6.0	6.1		17.8	6.4	6.2	10.2	5.0	8.6	3.1
Portugal	0.2	1.3	2.1	0.9	0.2	0.7	6.4	6.9	1.2	5.7	1.5	0.7	3.8		5.2	0.6	1.6	0.1	0.9	0.2
Spain	1.7	4.9	16.2	2.5	1.4	4.0	33.5	38.5	1.3	18.9	7.6	4.7	21.1	34.5		5.7	7.4	0.2	6.2	2.0
Sweden	0.8	1.2	1.6	0.1	1.1	41.5	4.1	7.0	0.3	2.5	0.7	2.7	2.4	1.9	0.9		3.5	0.4	1.9	1.0
Switzerland	2.5	5.6	4.0	1.0	3.8	10.1	15.8	14.3	2.8	3.7	2.5	7.5	6.4	5.3	2.0	6.5		1.0	5.8	2.8
Turkey	0.0	0.3	0.6	0.0	0.1	0.2	1.3	1.6	7.7	0.6	0.4	0.3	1.7	0.2	0.0	0.3	0.5		0.6	0.3
United Kingdom	94.8	115.4	228.6	24.4	98.9	197.7	368.3	401.5	127.1	277.7	96.5	257.1	247.1	197.2	87.6	167.2	258.9	49.1		69.5
United States	94.8	115.4	228.6	24.4	98.9	197.7	368.3	401.5	127.1	277.7	96.5	257.1	247.1	197.2	87.6	167.2	258.9	49.1	130.8	

Source: Output of the simulation model

Table 11: Basel III post-simulation capital losses in % of affected country's pre-shock capital (baseline scenario credit and funding shock as of 2009:Q4)

Affected country→ *Trigger country↓*	AU	AT	BE	BR	CA	DK	FR	DE	GR	IE	IT	JP	NL	PT	ES	SE	CH	TR	GB	US
Australia		2.0	4.5	0.0	5.4	0.8	5.9	6.9	0.2	5.6	0.9	13.0	5.1	1.2	0.9	3.5	4.6	0.0	5.4	1.8
Austria	0.6		6.6	0.2	0.6	1.2	5.5	23.8	2.0	4.4	6.6	0.9	4.3	2.3	1.2	2.4	6.2	0.9	1.3	0.5
Belgium	1.9	4.4		0.8	1.7	4.6	19.7	10.7	1.3	8.6	2.7	3.5	20.5	3.4	2.8	4.2	6.4	0.9	4.5	1.6
Brazil	0.0	0.2	0.7		1.0	0.5	1.9	1.8	0.0	1.3	0.3	2.9	1.8	7.0	2.4	0.8	3.0	0.0	0.9	1.5
Canada	4.3	1.3	4.7	0.8		1.7	5.2	8.3	0.2	7.6	1.0	6.9	2.9	0.6	0.6	2.9	10.1	0.3	3.9	2.9
Denmark	0.3	1.4	2.5	0.3	0.8		4.6	10.0	0.1	2.7	0.6	1.3	2.8	1.3	0.5	54.3	7.8	0.2	1.7	1.1
France	8.4	10.8	55.1	1.7	7.6	16.1		46.6	14.0	17.6	15.9	17.0	32.5	20.4	14.2	18.0	34.4	4.4	20.1	6.5
Germany	7.4	48.5	31.0	2.0	9.2	55.3	48.2		23.6	43.2	17.6	20.3	33.5	24.3	14.4	27.7	40.8	9.1	25.0	8.5
Greece	0.0	1.3	1.5	0.0	0.1	0.1	3.4	4.5		2.2	0.5	0.4	2.1	2.0	0.1	0.3	0.9	2.1	1.1	0.3
Ireland	2.5	4.8	22.7	0.4	3.0	6.0	9.6	28.2	3.7		4.6	3.7	6.0	22.7	3.3	4.8	5.7	0.6	8.4	2.4
Italy	1.1	15.4	22.2	0.4	1.4	2.2	32.5	26.4	2.8	20.6		5.7	13.1	8.9	5.3	3.2	6.5	1.4	4.9	1.9
Japan	15.4	1.7	9.8	3.4	7.7	5.5	27.0	17.3	2.1	11.0	3.2		5.9	1.9	1.6	5.9	27.2	0.9	14.4	13.0
Netherlands	3.6	8.5	32.4	0.9	2.7	6.9	22.4	24.6	9.6	8.2	5.5	4.5		14.7	5.7	7.8	11.6	4.8	10.1	3.0
Portugal	0.2	1.5	2.7	1.0	0.2	0.8	5.8	7.4	1.1	5.4	1.4	0.5	3.8		4.6	0.8	1.8	0.1	1.0	0.2
Spain	1.5	5.9	20.7	3.0	1.3	4.5	30.2	41.3	1.2	17.7	6.8	3.5	21.3	28.4		7.1	8.4	0.2	7.3	1.9
Sweden	0.7	1.5	2.1	0.2	1.1	46.5	3.7	7.5	0.3	2.4	0.6	2.0	2.5	1.6	0.8		3.9	0.3	2.2	1.0
Switzerland	2.2	6.7	5.1	1.2	3.7	11.3	14.3	15.3	2.6	3.5	2.2	5.5	6.5	4.4	1.8	8.2		1.0	6.9	2.8
Turkey	0.0	0.4	0.8	0.0	0.1	0.2	1.2	1.7	7.0	0.6	0.3	0.2	1.7	0.1	0.0	0.3	0.6		0.8	0.3
United Kingdom	66.6	121.6	234.3	16.1	61.2	194.8	260.6	312.2	98.3	193.4	72.0	95.2	195.1	125.8	70.5	173.8	220.2	42.3		60.7
United States	10.8	7.3	27.1	9.2	29.6	19.5	29.5	59.7	9.0	35.9	6.3	70.3	23.1	6.4	5.9	22.7	50.4	4.4	35.0	

Source: Output of the simulation model

Table 12: Comprehensive overview of research on interbank network simulations

Reference	Country	Data	Institutions/ banking sectors	Period	Default level of cap.	LGD	Type of shock	Worst-case-scenario/ % of bank. system assets lost
Bech, Madsen, Natorp (2002)	Denmark	Reported interbank netted settlements	67 banks	2001:12 - 2002:1	n/a	n/a	Bank-specific shock	None bank failed, 48 affected by domino effect
Blavarg, Nimander (2002)	Sweden	Reported interbank exposure data	4 largest banks (80% of total assets)	1999:9 - 2001:9	4% of Tier 1 capital	100%	Domestic shock, shock from abroad, foreign exchange shock	None of the 4 banks failed
Degryse, Nguyen (2007)	Belgium	Estimated interbank exposures (based on large exposure bilateral data)	65 banks (avg. during obs. period)	1992:12 - 2002:12	0% of Tier 1 capital	10, 40, 70, 100%	Bank-specific - credit shock	21 small banks defaults/ 4% of assets lost
Elsinger, Lehar, Summer (2006)	Austria	Central bank loan register and estimated (ME) exposures	all Austrian banks reported	2001:9	0% of net value of bank	endo-genous	Macroeconomic - interest and exchange rate shock, market movements	Probability of contagious default 6.8%
Espinosa-Vega, Solé (2005)	18 BIS reporting countries	BIS cons., immediate borrower and ultimate risk basis interbank claims	18 BIS reporting countries	2007:12	0% of book capital	100%	Banking sector - credit, funding, credit and funding shock	17 defaults (triggered by default of US), 14 defaults (triggered by UK, DE, FR, IT, ES)
Furfine (2003)	USA	Fedwire transfer system bilateral exposures	719 commercial banks	1998:2-1998:3	0% of book capital	40% and 5%	Bank-specific - credit shock	31 bank defaults/ 8% of assets lost
Gai, Kapadia (2010)	-	Artificial data	1000 artificial banks	-	0% of book capital	100%	Bank-specific - credit shock, liquidity risk incorporated	Frequency of contagion 35% (assuming avg. connectivity of 6)
Chan-Lau (2010)	Chile	Banks' exposures to domestic, central, and foreign banks, corporate, nonbank financial, and household sectors	25 banks	2009:1, 2009:7, 2009:12	0% of book capital	70%	Bank-specific - credit, funding, credit and funding shock	No defaults
Chan-Lau (2010)	20 BIS reporting countries	BIS consolidated, immediate borrower basis foreign interbank claims	20 BIS reporting countries	2009:Q1 and 2009:Q2	0% of book capital	70%	Banking sector - credit, funding, credit and funding shock	18 defaults (triggered by default of UK, US, DE)

Reference	Country	Data	Institutions/ banking sectors	Period	Default level of cap.	LGD	Type of shock	Worst-case-scenario/ % of bank. system assets lost
Chan-Lau et al. (2009)	16 BIS reporting countries	BIS consolidated, immediate borrower basis foreign interbank claims	16 banks	2008:Q1	0% of book capital	100%	Banking sector - credit, funding, credit and funding shock	15 bank defaults (triggered by default of UK, US)
Lublóy (2005)	Hungary	Reported interbank exposure data	39 banks	50 days in 2003	0% and 4% of modified Tier 1 capital	100%	Bank-specific shock and a group of banks (by common sector exposure) shock	1 bank default/0.2% of assets lost (bank-specific shock) 1 bank default/6% of assets lost (group of banks shock)
Mistrulli (2007)	Italy	Actual and estimated (ME) interbank exposures	759 banks	2003:12	0% of book capital	10 - 100%	Bank-specific shock	116 banks defaults/ 16% of assets lost
Nier et al. (2007)	-	Artificial data	25 artificial banks, 5% capitalization	-	0% of book capital	100%	Bank-specific – credit shock	Results vary according to the structure of artificial banking system.
Sheldon, Mauer (1998)	Switzerland	Estimated (ME) short-term interbank time deposits and loans	567 banks (average)	1987 - 1995	0% of book capital and reserves	100%	Shock to a group of banks (by type)	Probability of contagious default 1.6%
Upper, Worms (2004)	Germany	Estimated interbank exposures (ME)	3246 banks	1998:12	0% of book capital	0 - 100%	Bank-specific - credit shock	115 bank defaults/ 15% of the banking system assets lost
van Lelyveld, Liedorp (2004)	Netherlands	Estimated interbank exposures data(ME),	88 banks - large exposures data, 605 banks - central bank data	2002:12	0% of Tier 1 capital	25, 50, 75, 100%	Bank-specific – credit shock	17 bank defaults - large exposures data, 45 - central bank data/ 7% of assets lost
Wells (2004)	UK	Estimated interbank exposures - 3 data sets ME, based on large exposure bilateral data, and combined	33 - large banks exposure data	2000:12	0% of Tier 1 capital	20 - 100%	Banking group and bank-specific – credit shock	4 defaults/ 16% of assets lost
[this study]	**20 BIS reporting countries**	**BIS consolidated, immediate borrower basis foreign interbank claims**	**20 BIS reporting countries**	**2005:Q1 - 2009:Q4**	**4% of regulatory capital**	**80% (baseline scenario)**	**Banking sector - credit, funding, credit and funding shock**	**Basel II: 18 defaults (trigger: UK, US, DE), contagion prob. 31%; Basel III: 18 defaults (trigger: UK), contagion prob. 14%**