Charles University in Prague
Faculty of Social Sciences
Institute of Economic Studies

MASTER THESIS

Cross–Border Contagion in the Banking Sector: The Case of Nordic Countries

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Declaration of Authorship

The author hereby declares that he compiled this thesis independently, using only the listed resources and literature, and the thesis has not been used to obtain a different or the same degree.

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Prague, July 8, 2014

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Abstract

The objective of the thesis is to estimate the degree of cross–border contagion among the Nordic banking sectors. It analyzes a sample of sixteen largest listed Nordic banks from January 2004 to January 2014. Using a multinomial logit model we test whether there is any degree of contagion among the four banking sectors, whether it is more pronounced for larger banks and whether the recent financial crisis has exacerbated it. Our results are in line with similar studies conducted for other countries. In particular, we find that a shock in one banking sector is positively associated with an increase in shocks in another banking sector. Second, these shocks are larger and more significant for larger and more active international banks. Finally, the effect of the recent financial crisis has ambiguous effects on the cross–sectoral banking contagion. It appears that contagious links between some sectors weakened (Sweden and Denmark, Sweden and Finland). Other economies (Sweden and Norway) on the contrary became more dependent on each other. The results are robust to a wide variety of changes in specifications.

JEL Classification	F36, F40, G10, G15, G21
Keywords	Banking Sector, Contagion, Distance to Default, Coexceedance, Multinomial Logit Model

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Master Thesis Proposal

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Topic characteristics International financial markets have become significantly interconnected over the last two decades. Together with a number of advantages it has brought some negative effects as well. It has made it simpler to globally transmit economic shocks: financial event occurring in one part of the world does not take long to spread and influence the healthy economies around the world through international stock markets, trading of countless financial instruments or foreign bank loans. This process is known as cross−border contagion.

At the beginning of 1990s the Scandinavian countries experienced the banking crisis. It was a wake up call to implement better policies in banks together with new fiscal policies. As a result, today the Nordic countries have best ratings from the main credit rating agencies and are considered to be safe havens in financial markets. Banking sectors in Nordic countries are notably similar in the structural aspects. It constitutes a significant part of countries economies, although the relative size varies somewhat. Since 2001 the total assets from banking sector has increased significantly in every Nordic country. Moreover, each banking sector is dominated by few large banking groups. The Nordic countries are also highly integrated. Majority of foreign banks come from another Nordic country and banks from non−Nordic countries take only a small percentage of the market. According to official statistics, foreign branches constitute to a substantial part of the market in Norway, Sweden, Finland and Denmark. In Denmark the foreign banks take up to 30% of the market share, in Finland it reaches almost 60%, in Norway around 20% and in Sweden it constitutes only around 10% of market share (National Bank of Denmark, 2012).

So despite the similarities, some banking sectors in the Nordic region are more foreign–owned than the others. This raises a question whether the countries that have higher market share of foreign banks are more fragile to shocks than the ones that have banking sector dominated mainly by domestic banks. To answer this question, I will estimate the extent of cross-border contagion in the Nordic banking sector which will help us to understand the extent to which Nordic banking systems became interconnected and how problems could spread from one country to another.

I will mainly use NASDAQ OMX Nordic databases for stock prices of listed banks, Bankscope for banking statistics and other various databases such as Eurostat and OECD for country specific data.

Hypotheses

1. Hypothesis # 1: Cross–border contagion is present and statistically significant in the Nordic countries: collapse of banks in one Nordic country would have negative effect on banking sector in another Nordic country.
2. Hypothesis # 2: Recent financial crisis have intensified the cross–border contagion which resulted in increased number of linkages across Nordic countries.
3. Hypothesis # 3: Banking sectors with high share of large internationally active banks have higher exposure to cross–border contagion.

Methodology There is an extensive research done on the cross− border contagion risk for some of the regions like the Central and Eastern Europe by Jokipii & Lucey (2007). To contribute to the existing literature I will analyse the situation specifically in the Nordic countries in order to extent the research. To test the hypotheses I will methodologically follow other literature.

I will adopt extreme value theory to analyze contagion risk as proposed by Bae *et al.* (2003). Moreover, I will follow methodology proposed by Gropp *et al.* (2007) who claimed that contagion is related with extreme negative movements in bank's default risk and can be predicted using distance to default measure. The distance to default can be seen as the number of standard deviations away from the default point at which book value of liabilities are just equal to market value of assets. The DD incorporates the information about stock returns with market leverage and asset volatility that are the main determinants of default risk. The higher the distance to default, the lower the probability of default of the bank and vice versa. The advantage of using this approach is that one does not need to specify a particular channel of contagion, such as cross−border lending; rather it reflects interdependencies between banking sectors combining all possible channels of contagion.

The second step is to use a multinomial logit model to estimate the probability of number of banks in domestic country that experience large shocks on the same day ("coexceedances") as banks in foreign countries, after extracting country specific and global shocks that affect all banks simultaneously. Specific and common global shocks will be presented by four variables: systemic risk, stock market volatility in domestic and foreign countries, and interest rate shocks. I will employ GARCH process to estimate market volatilities. Changes in yield of government bonds in domestic countries will help to reflect interest rate shocks.

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1. Bae, K. H., G. A. Karolyi, & R. M. Stulz (2003): "A new approach to measuring financial contagion." *Review of Financial studies* **16(3)**: pp. 717–763.
2. Claessens, S., & K. Forbes (2004): "International Financial Contagion: The Theory." In "Evidence and Policy Implications/Conference 'The IMFs Role in Emerging Market Economies: Reassessing the Adequacy of its Resources' organized by RBWC, DNB and WEF in Amsterdam on November," pp. 18–19.
3. Crosby, P., & J. Bohn (2003): "Modeling default risk." *KMV Corporation.*
4. Dornbusch, R., Y. C. Park, & S. Claessens (2000): "Contagion: understanding how it spreads." *The World Bank Research Observer* **15(2)**: pp. 177–197.
5. Geršl, A. (2007): "Foreign banks, foreign lending and cross-border contagion: evidence from the BIS data." *Czech Journal of Economics and Finance (Finance a uver)* **57(1-2)**: pp. 27–40.
6. Gropp, R., M. Lo Duca, & J. Vesala (2007): "Cross–border bank contagion in Europe." *Technical report,* Johann–Wolfgang–Goethe–Universität Frankfurt am Main, Fachbereich Wirtschaftswissenschaften: Finance & Accounting.
7. Gropp, R., & G. Moerman (2004): "Measurement of contagion in banks' equity prices." *Journal of International Money and Finance* **23(3)**: pp. 405–459.
8. Jokipii, T., & B. Lucey (2007): "Contagion and interdependence: measuring CEE banking sector co–movements." *Economic systems* **31(1)**: pp. 71–96.
9. Van Rijckeghem, C., & B. Weder (1999): "Financial contagion: Spillovers through banking centers." *Technical report,* CFS Working paper.
10. Van Rijckeghem, C., & B. Weder (2001): "Sources of contagion: is it finance or trade?" *Journal of International Economics* **54(2)**: pp. 293–308.

Author Supervisor

Chapter 1

Introduction

International financial markets have become significantly interconnected over the last two decades. Together with a number of advantages it has brought some negative effects as well. It has made it simpler to globally transmit economic shocks. A financial event occurring in one part of the world does not take long to spread and influence the healthy economies in another part of the world through international stock markets, trading of countless financial instruments or foreign bank loans. This process is known as cross–border contagion.

International contagion is closely related to systemic risk and plays a crucial role in the banking sector crisis. Eichengreen *et al.* (1996) were among the first to observe adverse effects of contagion phenomenon. They found evidence that contagion contributed to currency crisis transmission mechanism. Since then, the causes of contagion and its transmission channels have attracted intense scrutiny. There is an extensive literature on how contagion relates to Asian, Russian and even current financial crises (Allen & Gale 1999). For example, Federal Reserve Bank of New York organized the bailout of Long Term Capital Management hedge fund which it justified on the premise of containing the contagion and limiting the spillovers to the largest extent possible (Lowenstein 2000). Padoa-Schioppa (2004) finds evidence that contagion which spread to the interbank market resulted in the collapse of Japanese economy in 1990s. Presently, in the context of the recent financial crisis the debate on contagion re–emerged. The main goal is to identify the channels of transmission that helped subprime mortgage crisis spread from U.S. market to Europe and then to all emerging economies around the globe.

International contagion plays a significant role in examining the global economy in times of financial recessions. However, there are different opinions on the transmission mechanism through which it works. Masson (1998) distinguishes two main types of contagion: pure contagion and spillovers. Pure contagion refers to the transmission of crises that cannot be explained by changes of macroeconomic fundamentals or any direct linkages and spillovers between the impaired economies. On the other hand, contagion can be a result of spillovers. Economic researches commonly distinguish between spillovers via trade (Eichengreen *et al.* 1996; Glick & Rose 1999) and via financial linkages (Van Rijckeghem & Weder 2001).

In our research – which relates to the literature on financial linkages – we use the distance to default as a measure of soundness of the bank (Crosby & Bohn 2003). The distance to default incorporates the information about stock returns with market leverage and asset volatility that are the main determinants of default risk. Following Bae *et al.* (2003) and Gropp *et al.* (2007), we concentrate on the behavior of the negative tail of the distribution of the daily change in the distance to default. Based on daily changes to distance to default, we define how many banks are simultaneously experiencing large shocks on the same day - "coexceedances". We then employ multinomial logit model to estimate the relationship between number of coexceedances in analyzed economies.

Our thesis aims to analyze whether there is contagion risk in the Nordic countries (Denmark, Sweden, Norway and Finland). At the beginning of 1990s, the Nordic countries experienced a severe banking crisis (Drees & Pazarbasioglu 1998; Sandal 2004; Koskenkylä 2000). It was a wake up call to implement better policies in banking oversight and regulation together with new fiscal policies. As a result, today the Nordic countries have best ratings from the main credit rating agencies and are considered to be "safe–havens" in financial markets. Banking sectors in Nordic countries are notably similar in the structural aspects. It constitutes a significant part of countries' economies, although the relative size varies somewhat. Since 2001, the total assets from the banking sector have increased significantly in each Nordic country. Moreover, each banking sector is dominated by a few large banking groups. The Nordic countries are also highly integrated. Majority of foreign banks come from another Nordic country and banks from non–Nordic countries represent only a small percentage of the market.

The main question in this thesis is whether cross–border contagion is present and statistically significant in the Nordic countries. The empirical research is based on a multinomial logit regression model. The data sample covers all continental Nordic countries, namely Denmark, Sweden, Norway, and Finland.

We also analyze what effect recent financial crises had on the cross–border contagion in Nordic countries. We aim to find out if contagion effects intensified and whether there appeared to be more linkages between the markets after the crisis hit. Last but not least, we discuss differences and similarities across all four continental Nordic countries and examine if some countries are more exposed to cross–border contagion risk than other depending on the structure of their banking sector.

The thesis is structured as follows: Chapter 2 provides and overview of the existing literature on cross–border contagion and explains all necessary terms and theories. The chapter is divided into two parts: the first part analyzes the contagion and its causes, whereas the second one is dedicated for the empirical evidence on contagion and its structured according to methodologies used. Chapter 3 introduces the reader to the Nordic banking sector. First, we shortly describe the banking sector and its distinctive features. Then we turn back to the Nordic banking crises in 1990s and briefly explain the impact on the Nordic countries. Subsequently, we discuss major improvements in the Nordic banking sector since the systemic crises and go deeper in analyzing the major problems with cross–border banks. Finally, we conclude the chapter with the facts why Nordic countries are considered to be "safe–havens" for international investors. Chapter 4 describes the model choice and its methodology, the examined data, hypotheses and assumptions. Finally, chapter 5 provides empirical analysis of the cross–border contagion in the Nordic countries during 2004 – 2014 period. It is based on multinomial logit model regression, where the dependent variable is the distance–to–default for the banks in our sample. The second part of the chapter is dedicated to statistical results explanation and interpretation. Chapter 6 summarizes our research and concludes.

Chapter 2

Theoretical Background and Literature Review

Before we start discussing different channels of contagion, it is vital to understand what is meant by contagion and how it can be defined. As an example we could refer to the 1998 Russian financial crisis. It had induced devaluation of Russian ruble, which had influence on the Polish zloty depreciation. However, shortly after the crisis hit Russia, the Brazilian stock market shrank by half of its size. Even without clear definition, we can conclude that what happened between these two markets was contagion. However, could we conclude the same for Polish market since these two countries have always been closely related in terms of international trades and financial interlinkages? Similarly, if the U.S. stock market falls by 5 percent and it directly influences Canadian stock market, does this account for contagion?

It is a challenging task to define contagion. On one hand, if the two countries have different market structures and have no direct trades, the transmission of a shock from one country to another could be straightforwardly accounted for contagion. On the other hand, it is more difficult to distinguish between contagion and only interdependence when it comes to countries that are closely related in terms of financial trades and market structures. Such economies are strongly financially connected during the stable periods as well as recessions. So the transmission of shock from one economy to another could be caused by interdependence and not be seen as a result of cross–border contagion.

Economists distinguish two types of contagion. The first one is so called shift contagion and it is a narrower definition of contagion (Forbes & Rigobon 2001). It is defined as a change in the normal relationship between economies after a shock to a certain country. Shift contagion causes a substantial increase in cross–border linkages in the crisis period. The second definition of contagion is broader and more inclusive. It captures the susceptibility of one economy to shocks that happen in other economies. In this case, it does not matter why that susceptibility occurs and if those economies are connected with financial links during tranquil as well as volatile periods (Claessens & Forbes 2004).

For a number of reasons, however, it is essential to differentiate between broader and narrower definitions. Economists have to define the type of contagion in order to evaluate the efficiency of intervention and financial support to the impaired economies. In case of shift contagion, if one country is influenced by a crisis that initiated in some other country and they do not have many financial linkages, short–term loan is likely to be the most effective tool to support the economy. In case of broader contagion, however, if the two countries were closely related through financial linkages, a crisis in one country would force the other economy to adjust to this shock. Most economists focus on the broader definition of contagion that captures the exposure of one country to financial events in the other countries. There is an extensive literature on causes of contagion. In the following sections we will discuss the possible sources and transmission channels of contagion.

2.1 Contagion and Its Causes

Dornbusch *et al.* (2000) define contagion as the spread of market disturbances. It is transmitted from one country to another through a number of different channels and it can be perceived through co–movements in macroeconomic. Forbes & Rigobon (2001) suggested dividing possible causes of contagion into two groups–fundamental causes and investors' behavior.

The first group considers spillovers that arise from interdependence among economies. If economies have real financial linkages, transmission of a shock from one economy to another is very likely to happen. This type of contagion is also referred to "fundamental–based contagion" (Reinhart & Calvo 1996). Normally such co–movement between asset prices in two different economies would not be called contagion, however, if it occurs during the recession and has negative effects, it still can be defined as contagion. Economists try to understand the degree of co–movements and the transmission mechanism of contagion, for instance, what causes a speculative attack on one currency to be transmitted to other currencies and how much it depends on financial linkages between them.

The second group considers a transmission of shock not as a result of economic interdependence but merely as a result of investors' behavior. This time it is not linked to changes in macroeconomic fundamentals and it arises even when there are no global shocks causing the recession in several economies. In this case, countries may not be financially interconnected since financial factors are not important. Investors' behavior causes a transmission of crisis from one economy to another – a decline in one economy induces investors to withdraw their investments not only from the deteriorated economy but from other economies as well without considering whether those economies are connected or have similar macroeconomic fundamentals that might cause occurrence of the crisis as well. Dornbusch *et al.* (2000) call this transmission a result of 'irrational" phenomena and conclude that is not related to macroeconomic fundamentals. It is merely a result of financial panics and increased risk aversion.

2.1.1 Fundamental Causes

Fundamental causes or "fundamental–based contagion" refers to global and domestic economic shocks that affect economies on an international level through various fundamental linkages.

2.1.1.1 Common Shocks

This group includes common macroeconomic shocks also known as "monsoonal effect" , that have repercussions on an international level and domestic shocks that are being spread to other economies through trade, competitive devaluation and other financial channels (Masson 1998). Due to monsoonal effect, a substantial economic shift in industrial countries, that could result in global growth slowdown, initiates crisis in emerging markets. For instance, Reinhart & Calvo (1996) observed that fluctuations in U.S. interest rate have resulted in fluctuations in capital flows to Central and South America. Corsetti *et al.* (1998) concluded that crisis in East Asia in 1997 was partly caused by strengthening of the U.S. dollar against yen which resulted in decline in exports and consequently evolved into crisis. Generally, common shocks result in co–movements in capital flows and asset prices. As an example we can also refer to Moreno & Trehan (2000) who seek to ascertain the extent to which common external shocks account for simultaneous crises. They define crisis on a country by country basis and take into account changes in volatility of exchange rates over the time across selected countries. They conclude that even a small number of common external shocks can explain quite a significant part of the variation in the total number of crisis over some periods. Moreover, they have found out that the global interest rates have an important role in generating global financial problems and causing currency crises in developing countries. Glick & Rose (1999) try to answer the question why currency crises tend to be regional. They analyze five different currency crises and find that currency crises negatively influence the groups of countries that are closely tied by international trade. On the contrary, they conclude that macroeconomic and financial factors cannot be directly associated with the frequency of cross–country speculative attacks. Finally, we can perceive Fed tapering policy as another type of common shocks and therefore it is important to analyze markets reaction to it. Mishra *et al.* (2014) analyzed how emerging markets react to 2013–2014 Fed announcements related to tapering. They find evidence that tapering announcements to asset purchases make markets behave differently during volatile periods. Countries that have stronger fundamentals, deeper financial markets, and more austere macroprudential policies experienced less significant currency depreciations and not so sharp increases in government bond yields. However, they also observed slighter differentiation in the stock markets – stock prices varied less based on fundamentals.

2.1.1.2 Links and Competitive Devaluation

This group considers trade linkages and competitive devaluation as a potential transmission channel for contagion. A crisis in one economy can have adverse effects on other economies through trade and currency depreciations. A country that is linked to a crisis country with depreciated currency would experience fall in asset prices and significant capital outflows. Moreover, recession in one country would result in decrease in income and this would lead to a reduced demand for imported goods. This would directly affect exports and trade balances of major trading partners. Drazen (2000) argue that possibility of contagion in currency crises across countries is very likely. They aim to explain how political factors can help explain contagion, especially the European Monetary System crisis of 1992–1993. If a country adopts fixed exchange regime, and it's main objective becomes maintenance of political integration with its neighbors, then a devaluation of currency in one country will stimulate speculative attacks on the neighboring countries. This arguments is especially relevant to EMS case.

Another possible transmission channel is competitive devaluation. If crisis causes devaluation of a currency in one country, this reduces the relative export of other countries that compete in third markets. Eventually, the effect of competitive devaluation could put pressure on the other currencies to devalue. Finally, a series of devalued currencies could result in even larger currency devaluations than required initially. Thus devaluation and crises in emerging markets become the source of entire economic collapse. This post–devaluation economic breakup is contradictory to the conservative view that devaluation is expansionary and therefore requires demand deflationary monetary and fiscal policies (Yang & Lim 2004). Finally, Yang & Lim (2004) conclude that real devaluation in Thailand was contractionary during the recession period, which was the "trigger" economy in the East Asian crisis in 1997–1998. The other prevailing view is that competitive Chinese market, particularly due to its currency devaluation in 1994, and strong export performance during 1994–1995 have contributed to the Asian crisis (Whitt 1999). However, Fernald *et al.* (1999) find evidence against this view. They conclude that the devaluation was not significant in economic terms, and that other Asian markets adjusted to China's strong export performance in 1994–1995. Corsetti *et al.* (1999) state that competitive devaluation game is non–cooperative and so it results in more severe depreciation than expected or what could be achieved in cooperative game equilibrium. If investors expect that a currency crisis in one country will evolve into a game of competitive devaluation, they will reconsider their investments and probably sell their assets in other countries as well. This theory is supported with the fact that during the East Asian crisis in 1997, economies such as Singapore and China experienced currency depreciation even though they did not seem to be vulnerable to a speculative attack based on their fundamentals.

2.1.1.3 Financial Links

The most common fundamental cause of contagion is financial linkages. If a group of countries is highly integrated, a crisis in one country would negatively affect the other countries. It would result in decrease of trade credits, foreign direct investments and other capital flows. More precisely, a crisis in one country could reduce its ability to supply capital to other countries such as bank lending and other forms of investment. This would extremely affect countries that are dependent on external funding since borrowing costs would increase sharply and currency would be forced to depreciate. Eichengreen *et al.* (1996) analyze why frequent speculative attacks seem to be temporarily correlated, or why currency crisis often appear to be contagious and spread from one economy to another. The research aims to answer the question what is the source or nature of contagious currency crisis. Authors conclude that contagion tends to spread more freely across economies which are highly connected with international trade linkages than to economies that have similar macroeconomic fundamentals. Haile & Pozo (2008) first test whether the currency crisis are really contagious and furthermore aim to identify the possible contagion channels that help to spread contagion across economies. A major contribution of the paper is the usage of extreme value theory to identify shocks and recession periods. Authors discuss four possible contagion channels instead of only trade and macroeconomic fundamentals (as tested by Eichengreen *et al.* 1996 and Glick & Rose 1999) or only trade and finance (as tested by Kaminsky & Reinhart 2000). Additionally, they consider the neighborhood effects channel. Moreover, the trade linkage weights are calculated based not only on bilateral imports and exports, as done in Eichengreen *et al.* (1996), but including third party export markets as well. Glick & Rose (1999) and Van Rijckeghem & Weder (2001) assume that crisis spread only from the "base countries" (countries were the crisis initiates). However, in reality there is a possibility of acceleration meaning that initially crisis spreads to a second economy, however, the third economy receives negative effects already from both previously impaired economies. Haile & Pozo (2008) do not have the same assumption used by Glick & Rose (1999) and Van Rijckeghem & Weder (2001) and allow for possibility of cascading effects. Finally, they conclude that trade channel is the most common contagion channel. Additionally, they confirm that the chance of crisis increases with the number of neighbor countries experiencing shocks which supports the assumption that neighbor effects contributed to contagion spread.

Baig & Goldfajn (1998) analyze the possibility of contagion between the financial markets of Thailand, Malaysia, Indonesia, Korea, and the Philippines. They find evidence that correlations in currency and sovereign spreads jump up substantially during the recession periods, however, behavior of equity market differentiate somewhat. After controlling for domestic and international market news and other fundamentals, they finally find contagion effects in cross–border equity markets as well. Caramazza *et al.* (2000) investigate what impact does the foreign, domestic, and financial limitation as well as trade and financial links have on financial crisis in emerging markets. They find that these indicators are significant in explaining the Mexican, Asian, and Russian crises. Moreover, indicators of vulnerability to cross–border financial spillovers (such as common creditors) and of financial instability (such as capital adequacy) are highly significant and can explain the observed regional concentrations of these crises. Studies conclude that trade linkages are important in analyzing shock transmission channels. Because countries in the same region are highly tied with intraregional trades, it commonly leads to conclusion that this helps explain why contagion is often regional rather worldwide. However, with a couple of exceptions, many studies failed to acknowledge the importance of financial sector linkages (Baig & Goldfajn 1998; Frankel & Schmukler 1996).

2.1.2 Investor's Behavior

Here we will discuss how investors' behavior can be a possible transmission channel of contagion. However, it is worth mentioning that some of the theories classified as investors' behavior can be linked to fundamentals and vice versa, so it is not always easy to distinguish between these two groups. In other words, if investors' behavior is rational individually as well as collectively, this can be subsumed to be fundamental cause of contagion because contagion is assumed to be transmitted through financial linkages. Nonetheless, it can be argued that investors' behavior, rational or irrational, contribute to spreading shocks across economies. Since investor's behavior can be just as important contagion channel as macroeconomic fundamentals and financial linkages, it is important to analyze all possible types of investors' behavior (see also Pritsker 2001). Investors' behavior can be *ex ante* individually rational but sometimes that can lead to exaggerated co–movements that cannot be justified by economic fundamentals. Through this channel of contagion, shocks are transmitted with the help of investors' behavior, although it is rational. Dornbusch *et al.* (2000) suggest this type of behavior can be further divided into liquidity, incentives, informational asymmetry and market coordination. Another explication of contagious behavior can be attributed to multiple equilibrium, which is often used to explain bank runs.

2.1.2.1 Liquidity and Incentive Problems

Rational behavior often leads to liquidity constraints. For instance, East Asian crisis resulted in currency depreciation and fall in equity prices in the impaired economies, which finally led to huge capital losses for large institutional investors. It has provoked investors to withdraw their investments in other economies to protect themselves from even higher losses, which created liquidity problems for the financial institutions. Banks may also experience liquidity problems if its operations are concentrated in certain regions. Assume there is a region that is highly reliant on one common creditor country, such as Latin America and United States. If banks from the United States experience a significant deterioration in the quality of their loans to one Latin American country, they may try to reduce the total risk of their loan portfolios by cutting their exposure to other high–risk investments in other countries. Peek & Rosengren (2000) test whether a shortage of loan supplies in Japan can have negative implications on real economic activities in the United States. The authors use geographical variation to examine supply shocks: Japanese banks deprived of capital as a result of bad loans issued in Japan. Finally, they conclude that the withdrawal of these banks from lending activities in U.S. had a negative slowing effect on US real estate markets. Nonetheless, it is not always realistic to attribute the decrease in real activity to demand side effects. Cetorelli & Goldberg (2008) show that the large internationally–oriented banks depend on domestic capital markets and use their foreign associates to help facilitate domestic liquidity shocks. Furthermore, they also show that the presence of such domestic capital markets contributes to an international dissemination of domestic liquidity shocks to lending by associate banks abroad. These results signify a significantly more active lending channel than presented in the initial work of Kashyap & Stein (2000), however, the lending channel within the U.S. is becoming of less importance since banking sector becomes more globalized. These results are confirmed by Cetorelli & Goldberg (2012), who also conclude that the presence of domestic capital markets with foreign bank associates contributes to transmission of domestic liquidity shocks to lending by affiliated banks abroad.

2.1.2.2 Information Asymmetries and Coordination Problems

Information asymmetries can be another possible cause of contagion. Whenever there is imperfect information problem and investors have different expectations, financial crisis can easily spread from one market to another one because investors believe that if crisis happen in one economy, this can lead to recession in another economy in no time. A recession in one country may result in currencies depreciations in the other countries that have similar fundamentals. If this is the case, investors will behave rationally and withdraw their investments in all countries with similar conditions and crisis that started this turmoil will be considered as contagious (Dornbusch *et al.* 2000). However, this type of transmission channel assumes the existence of imperfect information. Investors do not know the true characteristics of each country and make assessments based on expectations that are influenced by other economies rather than the true characteristics that reflect the condition of specific country's vulnerability to the crisis. This leads us to informational asymmetries problem. Whenever investors are limited to the information about the true conditions of each economy, it affects their investments. However, information collection and processing is often costly.

Calvo & Mendoza (2000) emphasize the significance of information asymmetries and costs in obtaining information about particular economies, which leads to herd behavior by international investors as a major cause of contagion. They propose a model where investors are separated into two groups: informed and uninformed. Considering the high expenses of collecting and processing the country specific information, many small investors cannot afford to do it individually. In this way, uninformed investors could base their decisions on informed investors actions, rather than their own expectations and beliefs.

Agénor & Aizenman (1997) interpret contagion as an increase in the volatility of shocks. They employ a model where domestic banks borrow from international capital markets and domestic producers borrow from domestic banks like this reducing the costs of information gathering. Uninformed investors such as domestic producers follow the patterns of larger investors who often are better informed. The same strategy applies to portfolio structuring where small investors follow the decisions of large investors in asset choices because their decisions incorporate market information. Kim & Wei (2002) suggest that investors are motivated to follow the herd to maintain the reputation. Investors are becoming more distinct over time and good reputation becomes rather expensive so their decision to follow the patterns of other investors is less costly. Since the reputation of investors depends on their managed portfolios, self–sustaining behavior can become quite risky. Fearing the risk of losing the reputation, institutional investors refuse to make decision first, even if market growth approves a composition of new portfolio. In order to be on the safe side, they rather follow decisions of the other investors. Such behavior is still considered to be rational, even though it is based on constraints. However, it does not protect from financial instability (Dornbusch *et al.* 2000).

2.1.2.3 Multiple Equilibriums

A broader explanation of contagion is related to changes in investors' expectations and confidence. Calvo & Mendoza (1997) developed a theory related to investors' behavior that focuses on market coordination problems. Investors adjust their behavior based on self–fulfilling expectations that can create multiple equilibriums. Contagion occurs when a crisis in one economy causes another economy to move to a bad equilibrium, meaning depreciation of a currency, a fall in equity prices, capital outflows, or debt defaults. Diamond & Dybvig (1983) developed a model, which has been extensively used to analyze bank runs and its causes. They show that individual investors base their decisions on the actions of other investors, that means withdraw their deposits only if other investors do. This results in either bad equilibrium when bank experiences bank run or in a good equilibrium if investors keep their deposits in the bank. Analogically to bank run, economic crisis can affect the whole economy. Economy could suffer sudden withdrawals of investments if investors' confidence level shift significantly. That is why some economists argue that contagion is a result of sudden shifts in market expectations and confidence. The first multiple equilibriums theories aimed to explain crisis in emerging markets (Gerlach & Smets 1995). However, it is not easy to apply it empirically, because it did not control for some factors, such as fundamental causes so it is hard to distinguish between contagion caused by investors' behavior and fundamentals.

2.2 Empirical Evidence on Contagion

Most empirical work testing for evidence of contagion has relied on co–movements in asset prices. The following is the summary of the most significant researches on financial contagion. We follow Dungey *et al.* (2004) and classify the methods into the following categories: correlation approach, probability–based approach, extreme returns test, and alternative approaches. The latter contains methodologies based on measures of capital flow movements and volatility spillovers.

2.2.1 Correlation Approach

One of the most common ways to empirically test for contagion is to use the asset price tests. Studies compare the correlation coefficients of macroeconomic fundamentals such as interest rates and asset prices across different markets. A significant increase in coefficients is concluded to be the evidence of contagion. Usually, these studies observe large co–movements in the asset returns, however, there has been some disagreements whether these co–movements intensify in the periods of recession. Reinhart & Calvo (1996) state that co–movements on equity returns intensified in emerging markets in Asia and Latin America after the Mexican crisis in 1994. Moreover, Frankel & Schmukler (1996) prove that the co–movements in prices of country funds in Latin America, East Asia, and Mexico increased significantly after the crisis, which confirms that the Mexican crisis was significantly contagious. They also suggest that domestic and international investors may have been differently informed claiming that domestic investors in Mexico lost their confidence before investors in the United States. Moreover, authors propose that shocks do not necessarily spread directly from one emerging market to another and that very often a third market is involved.

Baig & Goldfajn (1998) confirm the evidence of contagion in East Asian crisis in 1997–1998. They tested for evidence of contagion between the financial markets of Thailand, Malaysia, Indonesia, Korea, and the Philippines and found that cross–border correlations among currencies and sovereign spreads increased during the recession period. However, a significant increase in correlations among different economies may not be enough to prove evidence of contagion. If markets are financially interdependent, a significant change in prices in one market will force changes in other markets as well. Forbes & Rigobon (2002) argue that increase in volatility and correlations during the recession could be a result of transmission mechanism that exist in calm periods as well as during the crises periods. Moreover, they show that an increase in correlations of asset prices be a result of correlation between macroeconomic fundamentals, investors' risk perception and preferences, and not an evidence of contagion. If we face endogeneity problem, in order to find evidence of contagion, it is necessary to control for co–movements in these variables as well as in fundamentals during stable periods. Some economists have taken this into consideration. Forbes & Rigobon (2002) checked for contagion during the Mexican crisis in 1994, East Asian crisis in 1997 and U.S stock market recession in 1987 using daily volatilities. The results of the research confirmed that correlation coefficients across countries are not significantly higher during the recessions, if such problems as endogeneity, omitted variable bias and heteroscedasticity are controlled for. Corsetti *et al.* (2005) criticise work of Forbes & Rigobon (2002) and claim that their result of no contagion is achieved by setting unrealistic assumptions on the volatility of country–specific shocks. They focus on the Hong Kong stock market crash in October 1997, which was also the leading case study of Forbes & Rigobon (2002), and find that contagion is present in at least five countries. Favero & Giavazzi (2000) studied Exchange Rate Mechanism crisis by modeling volatility of European interest rates to test for contagion. The results were positive, i.e. they found evidence of contagion in the residuals of interest rates even after controlling for normal interdependencies.

2.2.2 Probability–Based Approach

The second group of studies uses conditional probabilities models, which control for normal interdependencies in fundamentals and help detecting contagion. Eichengreen *et al.* (1996) suggested the methodology that examines whether the probability of crisis in one country is higher if the other countries are facing recession as well. This methodology is a continuation of studies done by Dornbusch *et al.* (1995) where they aimed to estimate model for crisis prediction in a single economy . The research done by Eichengreen *et al.* (1996) aimed to estimate the probability of crisis occurrence in one economy conditional on information of crisis in other economies after controlling for interdependencies in macroeconomic fundamentals. These test can differentiate between different channels of contagion, such as trade and financial linkages, and test for contagion for each of them; however, the main advantage of conditional probabilities model is that it does not require knowing the particular channel of contagion in order to test for its presence. Eichengreen *et al.* (1996) proved that trade links are more likely to assist contagion as a transmission channel than the macroeconomic fundamentals. In their research they employed probit model to show that the likelihood of domestic currency crisis increases if some other currency is being infected by speculative attack. The evidence of contagion is constantly questioned. The common argument is that when several economies are attacked simultaneously this is not the evidence of contagion but rather weak macroeconomic fundamentals. Eichengreen *et al.* (1996) respond to such critics by including the incidence of crises elsewhere to the common domestic factors of currency crises. Finally, they conclude that the presence of a currency crises elsewhere increases the chances of a shock on the home currency.

De Gregorio & Valdes (2001) used similar approach to analyze how external crisis could spread across the borders. They analyzed the co–movements of alternative crisis indicators for 20 countries during the Asian crisis in 1997, Mexican crisis in 1994 and debt crisis in 1982. They concluded that that Mexican crisis was less contagious comparing with Asian and debt crisis. Due to methodology used, however, they could not determine whether spillovers were caused by contagion or by fundamental co–movements between the markets. Furthermore, they found that debt structure and flexible exchange rate regime could reduce the contagion, while capital regulations do not seem to influence it. It is worth mentioning that Caramazza *et al.* (2000) analyzed the same crises using the approach suggested by Eichengreen *et al.* (1996), however, it presented rather different results. They argued that these crises did not differ significantly in terms of contagion. Moreover, the results showed that such fundamentals as common creditors and financial instability are significant in explaining crisis while an exchange rate regime as well as capital controls do not have any significant effect on that.

Bordo & Murshid (2000) took a slightly different perspective and tested the crises over the last century in order to answer the question whether financial crises are becoming more contagious over time. The results showed that the main countries of the prewar and interwar gold standard (the United Kingdom and United States) were responsible for transmitting the shocks to other economies, nonetheless during the crises this pattern seemed to weaken. Furthermore, after 1973, countries that are not interdependent showed significant co–movements in asset prices during the recessions. However, the results also showed high volatility on correlation coefficients, which prevented the authors to interpret the increase in correlations as the evidence of contagion, since Forbes & Rigobon (2002) suggested that such spreads might be common. All factors considered, authors did not find strong evidence that contagion has been intensifying over the years. Glick & Rose (1999) apply a similar methodology to prove that currency crises are more likely to be regional. They use data for five different currency crises and prove that currency crises affect groups of countries that are closely connected by international trade. Moreover, they claim that contagion is more likely to be regional rather than global because trade linkages are stronger between countries in the same region compared to countries from different regions (see also Diwan & Hoekman 1999). Kaminsky

& Reinhart (1998) claim that methodology based on conditional probabilities help predict crises in another country if some countries from the same region face crises. Furthermore, likewise Glick & Rose (1999), they support the idea that contagion is more regional rather than global problem (see also Frankel & Schmukler 1996; Kaminsky & Schmukler 2001). Moreover, trade linkages happen to be more important to Latin America than to East Asia as a transmission channel of contagion. Kaminsky & Reinhart (1998) found evidence that in case of Latin American countries, there is a high probability that crisis could be transmitted through third–party linkages while analogous linkages have no substantial influence on East Asian countries. Baig & Goldfajn (1998) studied East Asian crisis in 1997. They found that East Asian countries did not have strong trade linkages with each other; therefore, such linkages could not be accounted for the expansion of the crisis.

2.2.3 Extreme Returns Test

The methodology built on extreme returns has attracted a lot of attention because extreme contractions in stock markets may have severe implications for the portfolios of institutional investors. Many researchers focus on the events in the negative tail of the distribution of returns, with the aim of getting a better understanding for value-at-risk applications.

Bae *et al.* (2003) suggests a new approach to measure contagion in financial markets. They employ extreme value theory to capture extreme return shocks across analyzed markets. They conclude that contagion is detectable and is influenced by such factors as domestic interest rates, variation in exchange rates, and conditional domestic volatility. However, they fail to conclude that contagion is stronger for extreme negative returns. Gropp *et al.* (2007) build their methodology based on Bae *et al.* (2003) work and analyze contagion among European banks in the period 1994–2004. They apply two–staged methodology to test for contagion. First they calculate distance to default measure for each bank in the chosen sample and in order to calculate how many banks experience shocks conditional on other domestic and European banks experiencing shocks at the same day – "coexceedances". Afterwards, they apply multinomial logit model to test how contagious are banking sectors in selected European countries. They find significant evidence of contagion in some European countries. However, there are also some countries that seem to be resistant to contagion risk. They claim that this is a result of their low cross – border interbank exposures. They also conclude that introduction of euro had enhanced contagion risk across the markets. Finally, they claim that large banks are more likely to be exposed to contagion risk compared to the smaller ones, which is in line with their previous result that banks with low exposures are less precarious. This type of methodology does not precisely measure one particular transmission channel of contagion. The dependent variable used in these researches – distance to default – is derived from equity price data allowing to measure contagion as seen by bank's shareholders. DD measure indicates bank' weaknesses and summarizes all necessary information about a bank. Therefore this type of methodology is considered to be an advantage.

2.2.4 Alternative Approaches

2.2.4.1 Capital Flows

Measuring capital flows co–movements is another approach to test the transmission of contagion. This type of tests could probably offer the best insight, however, not so many economists rely on it. Van Rijckeghem & Weder (1999) studied Mexican, Asian and Russian crisis. They find evidence that spillovers through bank lending were a transmission channel for crisis to emerging markets. Moreover, they conclude that spillovers helped forecast capital flows in third countries after the Mexican and East Asian crisis. Finally, they claim that contagion risk can be mitigated by diversifying their creditors and by preventing borrowing from the creditors that are exposed to crisis countries. Froot *et al.* (2001) explore the daily flows for international portfolios for emerging markets for the period 1994 – 1998. They conclude that increase in prices leads to higher portfolio flows and vice versa. Their results also show that common creditor factor in a region seems to be more and more important over time which suggests that institutional investors' behavior could contribute to transmission of shocks. Kaminsky *et al.* (2000) analyse portfolio and mutual funds trading strategies. They find evidence of positive momentum trading: fund managers systematically buy winners and sell losers. In the crisis period managers follow contemporaneous momentum trading – they sell current losers and buy current winners. Meanwhile, in the normal times managers follow lagged momentum – they sell past losers and buy past winners. They also find evidence that fund managers and investors profit from contagion trading – they sell assets in one market if they see drop in prices in other markets and vice versa. Moreover, authors conclude that the contemporaneous momentum trading reached the highest point during the Mexican crisis in 1994. Kaminsky *et al.* (2000) claim that contagion strategies used by fund managers play a major role in transmission of contagion from one country to another.

2.2.4.2 Volatility Spillovers

Examination of cross–market movements is another way to test for contagion. Edwards (1998) studied the Mexican Peso crisis in 1994 and found strong evidence that this crisis was contagious only towards some countries in Latin America. Park & Song (1998) did similar studies on volatility spillovers among newly industrialized East Asian economies during the recession period. Their conclusion suggested that the Southeast Asian crisis did not directly initiate the crisis in Korea, but instead it had direct negative consequences on Taiwan's economy, which later on played significant role in causing Korean crisis. However, both studies above did not control for global macroeconomic shocks so it was not possible to distinguish whether there was evidence of pure contagion or it resulted from fundamental linkages across countries. The available literature on sovereign credit default swaps contagion is rather limited. Chen *et al.* (2011) studied the Argentinian sovereign crisis and found significant increase in correlation between Argentinian and other Latin American sovereign CDS spreads. Arghyrou & Kontonikas (2012) studied EMU debt crisis and conclude that in the early phase of crisis contagion was mainly originating from Greece, while in the latter period involved more countries as potential contagion initiators and transmitters. Alter & Beyer (2012) used a similar methodology and found significant linkages not only between sovereign credit markets itself but also between sovereign credit markets and European banks. Alter & Schüler (2012) study the dependence between the default risk of chosen Eurozone countries and their domestic banks during the recent crises, employing credit default swap spreads as a risk measure. Their conclusion proposes that before banks received capital injections the contagion was spreading from banks credit spreads into sovereign credit default swaps market. After bailouts, authors observe stronger adverse effects to sovereign CDS in the short run. However, they conclude that these effects become of no consequence in the long run. Moreover, they find strong relations between government CDS and banks' CDS spreads. The dependence of government and bank credit risk is miscellaneous across different countries but homogeneous within the same country. Beirne *et al.* (2009) examine the volatility spillovers from developed to emerging markets. They also test how transmission channels modify during volatile periods in developed markets, and examine the significance of conditional correlations between developed and emerging market returns. First of all, the invoked LR tests suggest that volatility in developed countries influence conditional volatilities in emerging markets. Furthermore, spillover effects change during the volatile episodes – conditional correlations between emerging and developed markets tend to increase during these periods. They also conclude that the conditional volatility increases more in developed economies than emerging ones, which explains the increase in conditional correlations between markets. Diebold & Yilmaz (2009) study the dependencies between asset return spillovers and volatility spillovers. In their analysis they cover 19 global equity markets for the last 20 years, which naturally includes tranquil and volatile episode. They find evidence that the asset return spillovers have tendency of slight increase over the years but display no major outbursts, whereas volatility spillovers present opposite results of no clear tendencies but significant outbursts during crisis episodes.

Chapter 3

Banking Sector in Nordic Countries

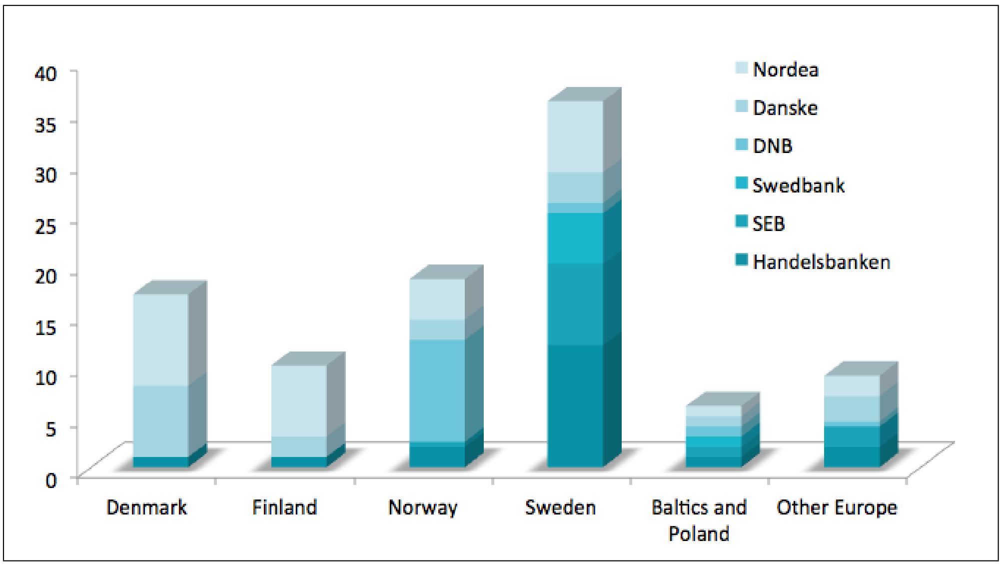
3.1 Introducing the Nordic Banking Sector

Continental Nordic countries are known for their particular strength and stability in the financial sector. Therefore, it was assumed that these countries would be coping with the recent financial crisis more efficiently. In fact, all of the Nordic countries suffered systemic banking crisis in the early 1990s, so it was expected that they have learned a lesson. In the case of Finland, the consequences of systemic crisis were more severe than after Great Recession in 1929 (Mayes 2009). This fact notwithstanding, collective myopia has a critical element of short lasting memory of previous recessions, and it leads economies to a new crisis. Furthermore, it is the unpromising reality that governments fail to prepare for these low–probability occasions that have disastrous outcomes. For these two reasons, it was anticipated that the Nordic region would cope better with the current financial turmoil than most of the leading economies.

However, what we saw in practice let us conclude that Nordic countries did not learn from their mistakes, as Iceland's economy suffered the most severe consequences. In Denmark's case, there was a large number of bank failures. Swedish banking sector also felt quite severe repercussions mostly because it is highly exposed to the Baltic region which was hardly hit by the crisis. Obviously if the countries with the painful experience from the past did not respond adequately we cannot expect or even be surprised that others have been caught short by the recession. However, the picture is not definite since the severity of the crisis varied across countries remarkably and hence no single lesson can be drawn. Still, we observe a more general pattern and can conclude that the countries which were hardest hit by systemic crisis in 1990s, suffered milder aftermaths of economic recession that started in 2007. Iceland sidestepped and Denmark had only mild consequences of the systemic crisis in 1990s but paid back the price two decades later (Mølgaard 2003).

Nordic banking sector is driven by six largest banks which dominate markets in all four Nordic countries and account for approximately 90 percent of all listed Nordic banks. These banks have activities across the region, and their assets constitute to around 230 and 360 percent of gross domestic product in Denmark and Sweden, respectively[1]. If we combine foreign assets and liabilities of the Nordic banks, they constitute around 150 percent of all Nordic region GDP, which points to the large–scale of the cross–border operations within Nordic region. It is worth mentioning that the number presented represent only publicly–listed banks.

Figure 3.1: Total Assets of Publicly–Listed *Nordic–4* Banks



Sources: Annual Reports and IMF staff calculations.

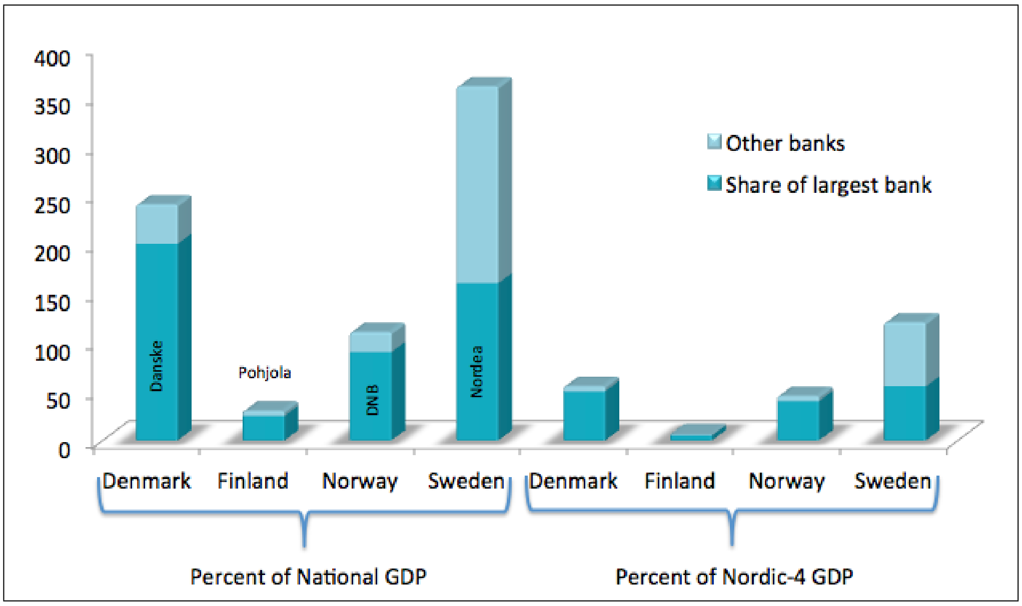
The Nordic banking sector is unique due to its extensive integration within the region. While operations in the Baltic states and other European markets are sizable, the most substantial exposure of the six largest banks is to the Nordic region and constitutes about 85 percent of their credit portfolio.

Similarly, the proportion of large banks sovereign bond exposure to the region is about 75 percent. Leverage ratios of Nordic banks are stable and only slightly higher than in other European banks. However, it provides much better access to international capital markets at often lower rates than major

[1]Inclusion of unlisted Danish mortgage banks such as Realkredit and Totalkredit would enhance the banking sector to around 360 percent of GDP.

European banking systems. The financial crisis that started in 2007 in U.S. had a negative impact on some of the large Nordic banks and resulted in more restricted access to foreign markets, however, when global financial turmoil evolved to the euro area crisis, it had almost no impact on Nordic banks. On the contrary, Nordic banks benefited from a "safe–haven" status and lower credit default swap spreads than the majority of other European banks.

Figure 3.2: Credit Portfolio Exposure of Six Largest Banks by Geography, 2012



Sources: Annual Reports and IMF staff calculations.

The major Nordic banks are strongly dependent on wholesale funding, including covered bonds. It is a result of a shortage of deposits caused by households' preferences for pension schemes and investment products. The main Nordic banks finance half of their assets with customer deposits and the other half they borrow from domestic and international interbank and debt capital markets. Nordic banks benefit from the recycling of retail savings that are driven by tax incentives and culture of financial investment in domestic pension funds and insurance products. Institutional investors are required to invest in domestic currency assets to match their liabilities. In Scandinavia, the government bonds have relatively low rate that leads to very few investment options; bank papers one of those. That is the reason, why covered bonds are an important source of financing in Nordic banking sector. The major Nordic banks have issued the covered bonds for nearly EUR 500 billion by the end of 2012 which amounts to approximately 70 percent of all covered bonds issued in Nordic countries. Altogether, the covered bonds issued in Nordic–4 account for approximately 35 percent of global outstanding covered bonds and approximately 60 percent of all bonds issued in 2011. Denmark together with Germany has the oldest covered bond markets in Europe. Across Nordic–4, Danish and Swedish markets are the largest in terms of a percent of GDP and over 75 percent of all bonds issued are in domestic currencies, and only 20 percent of covered bonds are issued in euro currency.

3.2 The Nordic Banking Crises in the Early 1990s

All four continental countries experienced recession in the late 1980s and early 1990s. Denmark was the first one to be hit by the crises, however the ravage was the least disastrous. Over a hundred financial institutions ceased to exist over eight years period. Most common solution was a merger with bigger and more sound institutions. The remaining institutions preferred government bailout than to go bankrupt, however, the decision was mostly based on potential costs. Roughly out of 100 institutions only eight banks declared bankruptcy. Support from the government did not change form of the ownership of rescued institutions, there was no special organization formed for rescuing the banks, rescued banks were not labeled as "bad" banks, neither any guarantees were issued (Mølgaard 2003). Moreover, according to Statistics Denmark, the economy did not experience any major downturn although there were a number of quarters between 1987 and 1991 in which there was a decline in gross domestic product.

After Denmark, it was Norway's turn. According to Moe *et al.* (2004), in the years 1988–1990 13 small banks declared bankruptcy. However, this was not considered to be part of systemic crises, although the economy experienced some decline in the first half of 1989. The actual systemic crises hit Norway in 1991–1992 when the second and fourth largest banks deprived of all their capital and the largest bank lost roughly 90 percent of it. The government inserted the required amounts of capital into impaired banks after wiping out or writing off the shareholders according to their detriment. The government later sold majority of these stakes and was able to make surplus on these transactions even after allowing for discounting, however, the costs to the society were more destructive.

Jonung (2010) observes that the magnitude of crises in Sweden were similar to that in Norway, although provisioning made by the banks were the greatest and most cautious of all four countries. In the beginning of 1991, the government provided bailouts for third largest bank, Nordbanken, in which it was also a stakeholder, as well as for largest savings bank in Sweden. However, unlike in Denmark or Norway, here the government after bailing out labeled them as ‘bad banks’ for impaired conditions and issued guarantees against creditor losses. According to Statistics Sweden, economy experienced sharp recession in 1991–1992 and as a result was displaced from the exchange rate mechanism (ERM) despite very intense defense (Gordon 2000).

Finland was the last one of four countries to be hit by the crisis, however, the repercussions were the most disastrous. To realize the scale of intensity of the crisis in each country we look at the public sector support as a percentage of GDP in gross terms: in Denmark, it was only about 0.5 percent, Norway – 2.6 percent, Sweden – 6.1 percent, and Finland devoted 17.2 percent (Hsu 2013). The Finnish economy suffered significant decline when the GDP fell by 12.6 percent over the period of 1991–1993. The equally critical was the impact on unemployment when just in three years it raised by 15 percent. Systemic crisis has hit Finland more harshly than Great Depression in 1929 in terms of GDP, however, we have to stress that at that time Finland had very impoverished economy so the repercussions were ever harder (Honkapohja 2009).

A main explanation for the crisis was the reaction of banks to the deregulation of the financial sector. Denmark was the only country that had adapted important capital adequacy requirements, as this was the origin of the introduction of the Basel standards. However, the situation deteriorated due to unbalanced macro–economic policies, mainly trying to maintain exchange rate pegs. Moreover, this was another example of crisis associated and caused by major rises in asset prices. In case of Finland, the collapse of the former Soviet Union also had intense negative impact on the economy.

3.3 Development in Nordic Banking Sector: A Problem of Cross–Border Banks

At the time the Nordic crises hit, all the banks in the region had very little international operations – they were almost completely national. Their operations abroad, even the ones with other Nordic countries, constituted very small part to their revenues compared to their domestic activities. Therefore, the internal supervision institutions and central banks were solely responsible for assuring the financial stability in their economies. However, they also had the ability to handle all financial systems alone since no other countries or foreign institutions were involved. The situation has changed radically since then. At the beginning of the current financial crises, majority of banks ran their operations across national borders. Nordea is Finland's largest bank, however, it is quartered in Sweden. Its second largest bank is Danske bank, which has quarters in Denmark. That helps us to draw clear picture of Finnish banking sector, and we can conclude that at the moment majority of its banking sector and supervision is in foreign hands. Largest Swedish banks have significantly expanded their activities across Nordic countries, as well as Baltic states. Largest Swedish bank Nordea is a leading bank in Sweden and Finland. However, it also has a substantial market share in Denmark and Norway. During the current financial turmoil, the large banks with the significant share of foreign operations were the ones that faced the worst problems, but not necessarily the largest losses (see also Hardie & Howarth 2009). However, this does not necessarily mean that they would have coped with the problems better if they were solely national banks.

When the crisis strike, it's not only the largest banks that suffer devastating consequences. In fact, it is very rare that a large bank would fail on its liabilities or that largest institutions would allow it to fail. The more considerable impact is normally on small banks that are not strong enough to survive the financial turmoil. If the likely impact is that small banks will default on its liabilities and declare bankruptcy, there are commonly two possible scenarios. The most likely way out is that one of the major banks in the country or even region will purchase the defaulting banks at an advantageous price and take over all of its obligations. In such case, there will be no interruption of activities and no problems to the customers. However, shareholders of the defaulting bank will suffer substantial losses. The second option is that the bank will not be saved and will be allowed to default and declare bankruptcy. The deposit insurer will step in to protect insured deposits. However, here the impact will be more severe. First of all, the shareholders lose the entire value of the shares they hold. Also, the junior debt holders experience losses since they are not protected the same way as insured deposit holders. One good example is the case of Roskilde bank in Denmark. This bank ran into financial troubles due to the recession of the Danish property market and in the middle of 2008 was acquired by Danmarks Nationalbank that provided some financial support. The bank was allowed to collapse. However, the authorities have provided a redemption plan that enabled the obligations and branches to be taken over by other financial institutions. Denmark's National Bank has not used such rescue schemes in the Nordic systemic crisis and , in fact, has not helped a bank directly since the Great Depression. Even though Roskilde was a small bank, it was important to support its existence in any way.

Whenever the impact of the crisis is so large that a large bank or a number of smaller banks experience severe problems, there are always doubts about the integrity of the system. Whenever the larger financial intermediaries are not able to acquire the defaulting banks, a more extensive support is needed. In the Nordic countries, considering the previous crises and its consequences, it is expected for the state to step in, in order to prevent the possible failures and to assure help for rescue plans. An important step would be to offer guarantees against losses. Such guarantees would stand together with existing deposit insurance and hopefully would help troubled banks to raise additional funds backed by these guarantees. Bank runs initiated by investors' fears not to get repaid is what leads banks to failure. Even if the bank can meet its obligations, a significant withdraw of funds at once generates the failure that the investors were initially worried about. The largest losses will be incurred by those who are unable to withdraw or by uninformed investors, which are normally depositors.

Cross–border banking undoubtedly complicates the situation in times of turmoil. However, Nordic countries encountered a number of problems in their system solving the question of defaulting banks. The most important issue was the failure to organize a systematic payout to depositors. The problem was not shortage of funds, but the fact that the systems did not know how to deal with such rapid payouts. Important remark is that the EU law indicates that insured depositors are required to be paid in the next three months. Thus, if depositors saw any signs that it would be impossible to find a buyer for defaulting bank, they would run on the banks and withdraw their funds, even though they are insured, as nobody wants to lose access to funds for even short period (Kaufman 2006).

In the aftermath of Nordic systemic crisis, authorities implemented two main solutions. One was to inject the required amount of capital into impaired bank, which was often done by merging it with another sound bank, and then let them work resolve issues on their own, however, with the substantial amount of supervision. Another solution was to ignore impaired assets and label affected bank as 'bad bank'. Sweden and Finland decided to adopt the latter solution while Norway was following the former. These bad banks cease to exist when the last impaired asset matures. In order to help the borrowers, some loans were prolonged for longer periods. When the impaired assets are kept in the existing bank, the incentives to solve the issues faster will be distinctly higher, even if it means discounting bad assets and selling it. During the years, Nordic countries do not seem to have changed their minds over the usefulness and appropriateness of these options.

In order to effectively solve issues related to cross–border bank, countries should have to get together and create an efficient rescue plan. Relatively closed region as Nordic countries would be a good example for implementation of such practice. The dismal reality shows that if the cross–border bank is experiencing some difficulties, it is normally the home country that is burdened with the whole problem. And since the cross–border banks are normally all of sufficient sizes, the home authorities will take all necessary measure to keep the bank from defaulting even if it requires to go to extremes and results in severe consequences for society.

3.4 The Nordic–4 as Safe–Havens

During the recent financial crises, the investors perceived the Nordic countries as safe havens due to its stable economies and a history of strict fiscal disciplines. Nordics proved themselves to deserve this title in various ways, such as appreciating exchange rates and setting interest rates at very low levels.

- Denmark's currency is pegged to the euro which has let some investors perceive it as a hedge against severe euro zone crisis, with international reserves growing by 250 percent since autumn 2008, to over 20 percent of GDP. Price effects have been realized together with a negative policy rate for certificates of deposits and 3–month uncollateralized interbank borrowing;

- Finland shared the crisis experience with other "core" euro area members. Its sovereign yields have reached the same level as in Germany and safe–haven flows contributed to the increase in Target II balances to around 30 percent of GDP on average over 2012. These balances represent internal euro zone deposit changes and current account financing provided by the official sector (e.g., via the Emergency Liquidity Assistance);

- Norway has retained full control over its monetary policy. Its trade–weighted exchange rate appreciate by more than 15 percent since December 2008. Moreover, bank deposits from the rest of the globe have jumped by 25 percent since the summer of 2011;

- Sweden moved to floating exchange rate regime in 1992. Its trade–weighted exchange rate has decreased by just over 20 percent since early 2009 as results of currency appreciation against the value of its main trading partners. Foreign exchange reserves have also expanded, though this is partly a result of an active policy choice to increase liquidity buffers.

Chapter 4

Data and Methodology

4.1 Hypothesis Development

In the following section we develop and formulate the research hypothesis based on the existing literature and previous findings as well as our predictions about the Nordic banking sector.

As discussed in previous chapter, Nordic countries are known for its financial strength and stability as well as high interconnectedness across all four markets. The discussion on the need for banking sector regulation and supervision relies crucially on the issue whether there is cross–border contagion risk in banking, or not. Reviewed studies showed that contagion is economically and statistically significant in many countries around the globe (Reinhart & Calvo 1996; Eichengreen *et al.* 1996; Baig & Goldfajn 1998; Gropp *et al.* 2007). This leads us to our first hypothesis raised in this research:

Hypothesis 1: *Cross–border contagion is present and statistically significant in the Nordic countries: collapse of banks in one Nordic country would have negative effect in another Nordic country.*

Furthermore, many studies have been devoted to test the behavior of crisis and whether the effects of contagion intensify in the aftermath of any major turmoils (Frankel & Schmukler 1996; De Gregorio & Valdes 2001; Corsetti *et al.* 2005). Moreover, Forbes & Rigobon (2002) claim that sometimes what is perceived to be contagion is, in fact, only interdependence between financially connected markets. Therefore, we want to measure if Nordic region is exposed to contagion risk and if this risk intensifies in the times of financial distress. It is important to understand the connection between the crisis and the contagion effects and take actions accordingly. This leads us to our second hypothesis:

Hypothesis 2: *Recent financial crises have intensified the cross–border contagion across all Nordic countries.*

Last but not least, we do not analyze any particular channel of contagion in our research. However, the banks in our sample are very heterogeneous. We expect to conclude that some countries with large foreign active banks are more exposed to contagion risk. That would help us conclude that some contagion transmission channels are more likely than others. This assumption is based on analysis by Minoiu & Reyes (2011), who suggest that contagion could be transmitted through cross–border lending. We know that in cross–border lending, large banks play a dominant role, and, therefore, we finally arrive to our third hypothesis:

Hypothesis 3: *Banking sectors with high share of large internationally active banks have higher exposure to cross–border contagion risk.*

4.2 Data Description

The purpose of our empirical research is to analyze how contagious are the banking sectors in our selected countries. The methodology builds on the existing empirical literature, especially on Bae *et al.* (2003) who propose a new approach to measure financial contagion to emerging markets, and Gropp *et al.* (2007) who analyze contagion within European banks.

Our data sample covers 4 Nordic countries, namely Denmark, Sweden, Norway and Finland. The Nordic countries are a geographical region which also includes Iceland. However, due to our chosen methodology, we had to drop Iceland since it does not have data needed for our research[1]. Selecting our data sample we started with all the banks in Denmark, Sweden, Norway and Finland that are listed at the stock exchange. We analyze banks performance for ten years period – from January 2004 to January 2014. We dropped all the banks whose data was not available for the entire period. The two selection criteria help us to get rid of all banks with questionable data quality and complete our data set [2]. Our final data set contains 16 banks in total (see Table 4.1). We believe that contagion is a short–term phenomenon, therefore, in order to capture it, we have to use high–frequency – daily data. Each bank contains 2,507 daily observations, making the total sample of 40,112 observations (see Table 4.2). The chosen banks are quite large relative to the banks population in Nordic region. Moreover, six of the banks in our sample are listed between 100 largest banks in the world, which reflects the strength of Nordic financial system. On average, total assets of our sample banks amount to EUR 145 billion (median: EUR 39 billion). The relatively high average is not surprising, and it is a result of the requirement of all banks in our sample to be listed at the stock exchange. However, the size of banks differs significantly across the sample. For example, Nordea bank is more than 160 times larger than the smallest bank in the sample. The sample banks have quite a large market share in all markets. It varies from almost 40 percent in Finland to almost 79 percent in Sweden (see Table 4.2).

Our dependent variable is the number of banks experiencing shocks on the same day. In order to obtain it, we calculate daily distance–to–default values for each bank in our sample (see Subchapter 4.3 for a detailed calculation). We follow the methodology suggested by Bae *et al.* (2003) and Gropp *et al.*

[1] There are no publicly listed Icelandic banks, so we could not include it in our research.

[2] This especially applies to the very small banks that have trading volumes below 1,000 shares in more than thirty percent of trading days during the ten years period.

Table 4.1: List of Sample Banks (Sorted by Total Assets in 2013, Millions of Euro)

	Bank Name	Country Code	Total Assets
1	Nordea Bank AB	SE	630.434
2	Danske Bank A/S	DK	432.305
3	DnB ASA	NO	284.964
4	Svenska Handelsbanken	SE	281.042
5	Skandinaviska Enskilda Banken AB	SE	280.481
6	Swedbank AB	SE	205.527
7	Storebrand ASA	NO	53.712
8	Pohjola Bank	FI	43.720
9	Jyske Bank A/S	DK	35.099
10	Sydbank A/S	DK	19.812
11	Sparebanken	NO	18.722
12	Aktia Bank	FI	10.934
13	Spar Nord	DK	9.994
14	Avanza Bank AB	SE	6.393
15	Alm. Brand A/S	DK	5.301
16	Bank of Aland	FI	3.887

Source: author's computations.

(2007) for arbitrarily defining large shocks. They define as large shocks those observations that are falling in the negative 95th percentile of the common distribution of the percentage change in DD (dd_{it}/dd_{it-1}). However, for each bank we chose cut–off point from the bank–specific distribution (dd_t/dd_{t-1}) since we assume that the stochastic processes controlling the distance to default at different banks are different. Selecting the negative 95th percentile allows us to have a sufficiently large sample size for the estimation as well as to meet the need for "large" shocks in the spirit of extreme–value theory (Straetmans 2000). Finally, we count how many banks in a given country are in the negative tail and following Bae *et al.* (2003), we call it "coexceedances". Our dependent variable is a count variable and its values vary from 0 to 5[3].

Gropp & Moerman (2004) use the contingency of large shocks to banks' distance to default to analyze systematically influential banks. They use Monte Carlo simulations to prove that data tails do not correspond to standard distri-

[3]It depends on the number of banks in the sample.

Table 4.2: Description of the Sample by Countries

	Number of Observations	Number of Banks	Percentage of Total Market Share	Number of Observations per Bank	Maximum Number of Coexceed.
Denmark	12,535	5	71.5	2,507	5
Sweden	12,535	5	78.9	2,507	5
Norway	7,521	3	49.0	2,507	3
Finland	7,521	3	38.6	2,507	2
Total	40,112	16	-	-	15

Note: Total market share of the sample banks on the deposit market, although the market shares vary in different niche markets.

Source: author's computations.

butional assumptions (multivariate normal, Student t) and, therefore, no common patterns can be drawn. This suggests that the distribution of distance to default of separate banks exhibits heavy tails and the correlation among banks' distances to default is significantly higher for larger shocks. Bae *et al.* (2003) apply the same methodology for emerging–market stock returns. Both studies manifest the need for examining the tails of the distribution of returns or the distance to default separately from the common distribution.

Table 4.3: Coexceedances by Countries

	Denmark	Sweden	Norway	Finland
Coexceedances = 0	1,981	2,136	2,184	2,165
Coexceedances = 1	417	245	272	326
Coexceedances = 2	74	61	51	16
Coexceedances $\geq$ 3	65	31	-	-
Total	2,507	2,507	2,507	2,507

Source: author's computations.

We are examining how contagious are the banking sectors in the Nordic countries. However, we cannot reject the alternative of contagion non-existence and the fact that common shocks are due to the interdependence between markets since they are closely related with financial linkages. Therefore, to be able to distinguish between the contagion and interdependence, we include common factors to control for common shocks. Choosing the independent variables we rely on the existing literature of financial recessions and contagion

(Forbes & Rigobon 2002). In total, we employ four independent variables as control factors. First of all, we take into account the systemic risk possibly affecting banking sectors. It measures how many stock markets experience shocks at the same time. In order to construct this variable, we use four stock market indexes. We include euro area stock market index EURO STOXX 50, VIX market index to measure U.S. market volatility, MSCI Emerging Markets Index for emerging markets volatility and finally domestic stock market indexes. For domestic markets we chose OMXC20, OMXS30, OBX and OMXH25 for Denmark, Sweden, Norway and Finland accordingly. Defining large shocks we used the same methodology as for banks. We calculate daily returns and then define the bottom 95th percentile. All observations falling in this distribution we define as shocks and set equal to 1. Systemic risk is then the sum of these for market indexes, and it varies from 0 to 4. It measures how many markets are experiencing large shocks at time t. We believe that the systemic risk should be positively correlated to the number of banks experiencing shocks.

Our second independent variable is yield curve in the domestic country, and it measures the impact of interest rate shocks on number of coexceedances. We calculate the difference between ten year government bond and interbank rate for three months yield and then first–difference it. Yield curve slope is commonly used measure in monetary policy helping to measure economic growth. According to changes in these rates, banks modify their balance sheets – transform long–term assets into short term and vice versa. If the yield curve flattens, the banks have to pay more for deposits they are holding without receiving higher yields for long term loans. Therefore, we believe yield curve variable to be positively correlated to the number of coexceedances. The third independent variable is the volatility of the domestic market. Bae *et al.* (2003) find that conditional stock return volatility is particularly important in explaining contagion to emerging markets. For estimating stock market volatility, we use GARCH (1,1) model of the following form using maximum likelihood.

$$\sigma_{tc}^2 = \alpha + \beta_1 \varepsilon_{c,t-1}^2 + \beta_2 \sigma_{c,t-1}^2 \tag{4.1}$$

σ_{tc}^2 represents the conditional stock market volatility in country c at time t, and ε represents stock market returns in the corresponding country. The estimated coefficients are presented in Table 4.4. Our obtained values vary between 0.08 and 0.13 for β_1 and between 0.78 and 0.92 for β_2.

We are interested in contagion across Nordic countries. However, we cannot reject the possibility of volatility spillovers from outside. In order to control for this, we include conditional volatility of U.S. market that was estimated using GARCH (1,1)[4]. We tried to estimate the models with conditional volatility of the euro area and emerging markets. However, correlation between EURO STOXX 50 and domestic stock market indices and U.S. stock market and emerging market indices are above 0.5. Therefore, we chose just U.S. market volatility. The stock markets open one day later in U.S. than Europe so the conditional volatility is lagged by one day.

Table 4.4: Estimated Coefficients of the GARCH (1,1) Model for Daily Stock Market Returns in the Analyzed Countries

	Coefficient	**St. Error**	**Z - Stat**	**Probability**
OMXC20				
Constant	0.00	0.00	6.68	0.00
ε^2_{t-1}	0.10	0.01	10.66	0.00
σ^2_{t-1}	0.88	0.01	79.02	0.00
OMXS30				
Constant	0.00	0.00	4.66	0.00
ε^2_{t-1}	0.08	0.01	10.64	0.00
σ^2_{t-1}	0.91	0.01	108.86	0.00
OBX				
Constant	0.00	0.00	4.14	0.00
ε^2_{t-1}	0.12	0.01	9.71	0.00
σ^2_{t-1}	0.87	0.01	67.79	0.00
OMXH25				
Constant	0.00	0.00	4.17	0.00
ε^2_{t-1}	0.08	0.01	10.28	0.00
σ^2_{t-1}	0.92	0.01	114.70	0.00
VIX				
Constant	0.00	0.00	9.80	0.00
ε^2_{t-1}	0.13	0.01	11.44	0.00
σ^2_{t-1}	0.78	0.02	45.75	0.00

Note: Equation and variable definitions are given in the text.

Source: author's computations.

Furthermore, in order to control for serial autocorrelation we include lagged dependent variable of our model as we suspect that first–differencing did not remove it completely.

Finally, to test for contagion from other markets, we include coexceedances

[4]Domestic volatility, and U.S. volatility was rescaled by multiplying the estimated values by 1,000.

from other countries to our model. Gropp *et al.* (2007) used number of lagged coexceedances. We, on the other hand, believe in efficient market hypothesis. Knowing that Nordic markets are very much interconnected, we assume that shocks in one country do not take one day to spread to other markets and that reaction of other markets is instant and, therefore, we chose not to use lagged values. However, if the markets are not as efficient as we originally assumed, we will miss some cases of contagion.

Table 4.5 presents summary of all variables used in our model. We can see that, on average banks in our sample are four standard deviations away from the default point (mean distance to default of 3.924). SEB bank is the most volatile bank in terms of stock prices and, therefore, distance to default, and is the only bank that experienced negative distance to default. The largest distance to default in our sample is almost twenty standard deviations away from the default point. The largest negative percentage change in distance to default is 75 percent. The negative cut–off point differs for each bank and varies from -3 to -1 percent. Tables 4.2 and 4.3 present more descriptive statistics on the number of banks and number of coexceedances per country. The number of banks per country differs somewhat: in Denmark and Sweden there are five banks in the sample while in Norway and Finland there are only three. Table 4.5 also indicates that there was at least one day in which all or almost all banks underwent large negative shocks simultaneously.

Table 4.3 shows that in Denmark there were 34 days with three or more coexceedances, in Sweden there were 63 such days, while in Norway there were 50 and in Finland 19 days with 2 coexceedances. However, we have to stress out that the number of coexceedances highly depends on the number of banks included in the sample and, therefore, does not necessarily imply that one banking sector is stronger or weaker than the other one. Nevertheless, we can compare countries with the same number of banks in the sample. We can see that Danish banks tend to experience fewer shocks compared to Swedish banks and that banks in Norway tend to be subject to larger shocks more frequently compared with Finnish banks. Of the total of sixteen banks in the sample, a maximum of twelve are simultaneously in the tail (on May 22, 2006; on October 7, 2008; on October 27, 2008).

Table 4.5: Variable Definitions and Descriptive Statistics

Varibale	Definition	n	Mean	Median	Std.Dev.	Min.	Max.
Bank–Specific							
dd_{it}	Distance to default of bank i in day t	40,112	3.924	3.786	1.918	-0.144	19.616
$dd_{it}/\|dd_{it-1}\|$	Percentage change in the distance to default	40,112	0.000	0.000	0.027	-0.748	0.794
Country–Specific							
Coexceedances DK	No. of banks in 95th percentile negative tail of $dd_t/\|dd_{t-1}\|$ in DK	2,507	0.251	0	0.592	0	5
Coexceedances SE	No. of banks in 95th percentile negative tail of $dd_t/\|dd_{t-1}\|$ in SE	2,507	0.251	0	0.717	0	5
Coexceedances NO	No. of banks in 95th percentile negative tail of $dd_t/\|dd_{t-1}\|$ in NO	2,507	0.150	0	0.410	0	3
Coexceedances FI	No. of banks in 95th percentile negative tail of $dd_t/\|dd_{t-1}\|$ in FI	2,507	0.151	0	0.378	0	2
Systemic Risk DK	No. of markets in 95th percentile negative tail among US, emerging, Europe, and DK	2,507	0.201	0.000	0.587	0	4
Systemic Risk SE	No. of markets in 95th percentile negative tail among US, emerging, Europe, and SE	2,507	0.201	0.000	0.599	0	4

Continued on next page

Table 4.5: Variable Definitions and Descriptive Statistics (Continued)

Varibale	Definition	n	Mean	Median	Std.Dev.	Min.	Max.
Systemic Risk NO	No. of markets in 95th percentile negative tail among US, emerging, Europe, and NO	2,507	0.201	0.000	0.593	0	4
Systemic Risk FI	No. of markets in 95th percentile negative tail among US, emerging, Europe, and FI	2,507	0.201	0.000	0.608	0	4
Yield Curve DK	Change in slope of yield curve in DK	2,507	-0.003	0.000	0.160	-3.161	2.458
Yield Curve SE	Change in slope of yield curve in SE	2,507	0.001	0.000	0.103	-1.504	2.992
Yield Curve NO	Change in slope of yield curve in NO	2,507	0.002	0.000	0.487	-6.843	7.182
Yield Curve FI	Change in slope of yield curve in FI	2,507	-0.010	0.000	0.352	-6.839	2.999
*Volatility DK**	Conditional volatility of OMXC20	2,507	0.172	0.105	0.234	0.04	2.470
*Volatility SE**	Conditional volatility of OMXS30	2,507	0.210	0.124	0.239	0.045	1.854
*Volatility NO**	Conditional volatility of OBX	2,507	0.302	0.158	0.492	0.039	4.531
*Volatility FI**	Conditional volatility of OMXH25	2,507	0.226	0.137	0.241	0.035	1.752
*Volatility US**	Conditional volatility of VIX	2,507	0.456	0.352	0.323	0.207	3.715

*This variable has been multipled by 1,000.

Source: author's computations.

4.3 Distance–to–Default

The distance to default is represented as the difference between the present market value of assets of the bank and its predicted default point, divided by the volatility of assets (KMV Corporation 2002). The value of equity can be seen as a call option on the assets of the bank. The bank is said to be at default point when its value of assets is equal to the value of debt. The value and volatility of assets can be computed using Black–Scholes model by inserting observed market value and volatility of assets and book value of debt and solving for two unknowns. Whenever the value of assets increase and/or volatility of assets decreases, the distance to default increases meaning that the bank is receding from the default point and the probability of bankruptcy declines. Gropp *et al.* (2007) contend that the distance to default is particularly applicable for predicting and measuring default risk for banks. Particularly, its capability to measure default risk adequately is not impacted by the possible incentives of the stockholders to prefer higher risk taking (contrary to unadjusted equity returns) or by the existence of explicit and implicit financial safety net (contrary to subordinated debt spreads). Furthermore, distance to default incorporates the information about stock returns with market leverage and asset volatility that are the main determinants of the default risk.

Distance to default is derived by starting with the Black–Scholes model. It is assumed that the market value of the bank's underlying assets follows a stochastic process:

$$lnV^T = lnV + \left(r - \frac{\sigma^2}{2}\right)T + \sigma\sqrt{T}\varepsilon, \tag{4.2}$$

which calculates the asset value at time T, given its current value V. ε is the random error of the firm's return on assets, which the Black–Scholes model assumes to be normally distributed, with zero mean and unit variance, N(0,1). Hence, the current distance d from the default point (where $\ln V$=ln$D$) can be written as

$$\begin{gathered} d = lnV^d - lnD = lnV + \left(r - \frac{\sigma^2}{2}\right)T + \sigma\sqrt{T}\varepsilon - lnD \Leftrightarrow \\ \frac{d}{\sigma\sqrt{T}} = \frac{ln\left(\frac{V}{D}\right) + \left(r - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} + \varepsilon. \end{gathered} \tag{4.3}$$

That is, the distance to default,

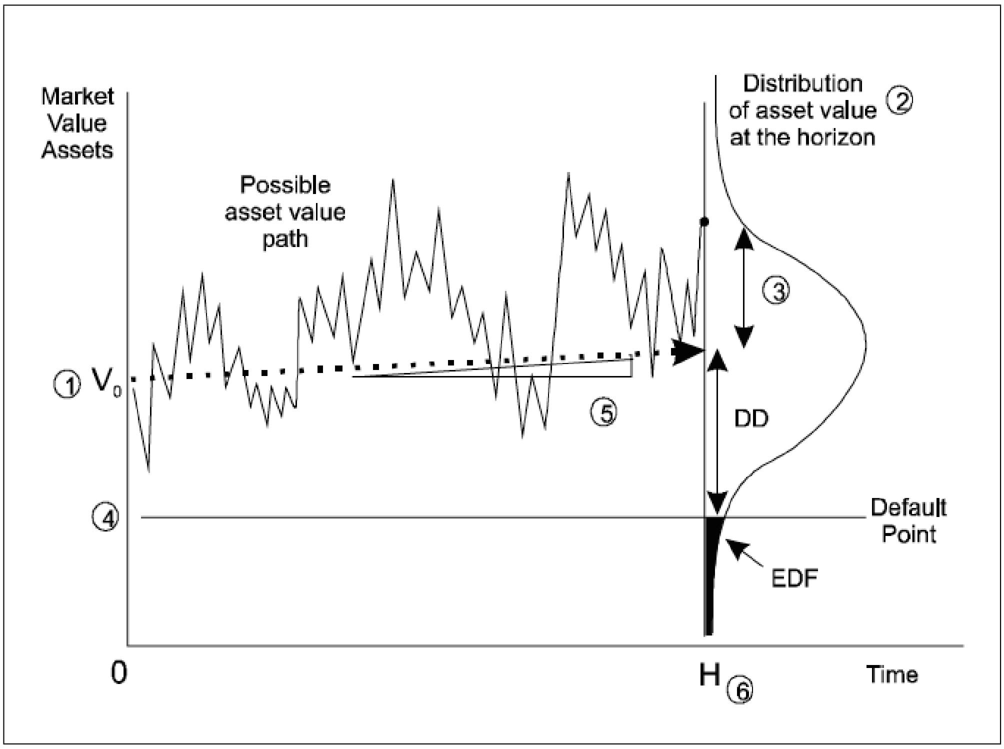
$$dd \equiv \frac{d}{\sigma\sqrt{T} - \varepsilon} = \frac{ln\left(\frac{V}{D}\right) + \left(r - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}, \tag{4.4}$$

is expressed as the number of asset–value standard deviations (σ) that the bank is from the default point. Having observable market value (V_E) and volatility σ_E of equity and book value of debt D as inputs, we can use system of non–linear equations below, in order to solve for value and volatility of assets V and σ.

$$\begin{cases} f(V_E) = VN(d1) - De^{-rT}N(d2) - V_E \\ f(\sigma_E) = \frac{V}{V_E}N(d1)\sigma - \sigma_E \\ d1 \equiv \frac{ln\left(\frac{V}{V_E}\right) + \left(r + \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}} \\ d2 \equiv d1 - \sigma\sqrt{T} \end{cases} \tag{4.5}$$

Figure 4.1 below graphically represents what defines distance to default and how it can be used to determine the default probability of a bank. There are six variables that are important determining the probability of default. Level of the default point, market value and volatility of asset and expected distribution of future asset value are the most critical ones. Length of the horizon depends on the study scope and the expected growth in the asset value does not have significant default predicting power. As mentioned above, if the value of the bank's assets declines below the default point, then the bank defaults on its liabilities. Therefore, the probability of default can also be seen as the probability of bank's assets declining below than the default point. It is called Expected Default Frequency – EDF – and is the grey area under the default point. Figure 4.1 also represents the causative relation and trade–off between the variables. It provides a powerful framework for researchers who need to analyze what–if questions and manipulate various inputs and examine possible outcomes. They can examine effects of potential capital restructurings, examine repercussions of significant stock changes or study the possible options of growth (such as acquisitions and mergers).

Figure 4.1: Distance–to–Default, Crosby & Bohn (2003)



4.3.1 Parameters Estimation

In order to calculate the parameters for Distance–to–Default Model, we use both Excel and R Studio. We implement the underlying parameters to solve the system of nonlinear equations (4.5) and to find the value and volatility of the firm's assets needed to calculate the DD measure.

- The volatility of the equity (σ_E)

The equity volatility, σ_E, is calculated as the standard deviation of absolute daily equity returns. As suggested in Marcus & Shaked (1984), we take six–month moving average to smooth the volatility. They argue that market participants use more smooth volatility instead of using short–term volatile estimates.

- The market value of the equity (V_E)

In order to calculate daily values of market capitalization, we used number of outstanding shares and daily closing stock prices. However, number of outstanding shares is only available on a quarterly basis on published accounts. Therefore, we employed cubic spline interpolation to obtain daily values of outstanding shares, as proposed in Gropp *et al.* (2007). We chose to interpolate only the number of outstanding shares instead of values of market capitalization itself. The reason for this is that we did not observe frequent or dramatic changes in the outstanding number of shares and, therefore, we can conclude that major volatility in market capitalization values is due to volatile stock prices. Interpolating only number of shares and then multiplying by accurate closing stock prices, we have a lower chance of estimation error.

- Risk–free interest rate (r)

We used ten–year government bond rates as risk–free interest.

- Time (T)

T represent time to maturity of the debt. Since it is complicated to obtain the particular information about the maturity structure of firm's liabilities, we chose to set it to one year, which is a commonly used benchmark assumption.

- Liability of the firm (D)

Debt values are available only on a quarterly basis from published accounts so in order to obtain daily values we chose to use spline interpolation again. From KMV model, firm's default point is equal to the short–term plus half of long–term liabilities.

- The value and volatility of the firm's asset (V, σ)

Having all other parameters estimated, we can finally apply the system of non–linear equations and solve for value and volatility of firm's assets. The two non–linear simultaneous equations are complicated. We use R Studio to solve the solutions of the system. The basic steps of the calculation are listed step by step below.

1. The initial volatility of the firm's asset is replaced by the volatility of the equity. Substituting this new value in the first function in equation (4.5), we derive the corresponding value of the firm's asset.

2. Substituting the value of the firm's asset calculated in step 1 into the second function in equation (4.5) to get the corresponding volatility of the equity.

3. If the volatility of the equity calculated in step 2 is equal to the real volatility of the equity, the program stops. Otherwise, we need to readjust the volatility of the firm's asset, and repeat the step 1 and 2 till we obtain the condition in step 3.

4.4 Econometric Model

As defined above, our dependent variable is the number of banks experiencing shocks on the same day – coexceedances. It is a count variable and varies from 0 to 5. There is a number of approaches dealing with count variable as the dependent variable, such as Poisson regressions, negative binomial regressions, and most prevalent – ordered and multinomial logit regressions. The choice of a suitable method depends on the underlying assumptions of each method. For instance, a tobit model assumes the dependent variable to be truncated normal. Gropp & Moerman (2004) rejected this assumption in this type of data. Further, unlike the normal distribution which has a separate parameter for the mean and variance, the Poisson distribution variance is equal to mean. However, this assumption is clearly rejected in our data. The negative binomial model does not rely on the assumption of conditional mean and variance equality. Nevertheless, it assumes the dependent variable to be from the exponential family, which includes the Poisson binomial, gamma, normal and numerous other distributions. Again, given the arguments of Bae *et al.* (2003) and Gropp & Moerman (2004), we do not think this is a suitable model for our data. Finally, we are left with ordered logit and multinomial logit methods models as possible estimation methods. The main difference between these two methods is that the ordered logit model constricts coefficients as well as marginal effects of independent variables to be the same at each outcome, while using multinomial logit model we obtain different parameters for each outcome.

We are interested in different parameters at different outcomes, therefore, as our primary model we chose to employ multinomial logistic regression. However, we will present results of ordered logistic regression in our robustness check section. Below we present our main model, where on the left side is our dependent variable (the number of coexceedances) and on the right side – our independent variables controlling for common shocks and measuring the effects of contagion from other markets.

$$Pr_c\left[Y=j\right]=\frac{e^{\left[\alpha_j' F_c+\beta_j C_{c,t-1}+\sum\limits_{d\neq c}\gamma_{dj}C_{d,t}\right]}}{\sum\limits_{k}^{J}e^{\left[\alpha_k' F_c+\beta_k C_{c,t-1}+\sum\limits_{d\neq k}\gamma_{dj}C_{d,t}\right]}}, \tag{4.6}$$

$j=1,2,3...J$ stands for the number of coexceedances in country c, F_c represents the common shocks in country c, C_{ct-1} represents the lagged number of coexceedances in country c, and C_{dt} represents the coexceedances in period t in country d. Since we control for common shocks, the significant coefficients of C_{dt} would signal cross–border contagion. For simplicity of interpretations and presentation we limit the outcomes to 0, 1, 2 and 3 or more coexceedances, as suggested by Bae *et al.* (2003).

In order to remove the indeterminacy associated with the model, we follow the convention and define $Y = 0$ (zero coexceedances) as the base category. All coefficients are estimated relatively to this base. Still, the interpretation of results from multinomial logit model are not as straightforward as other more conventional regressions, such as OLS, and can be intricate. Therefore, it is useful also to report the marginal effect for the purpose of interpretation. The marginal effects are obtained from the probability for each outcome j:

$$Pr\left[Y = j\right] = \frac{e^{\left[\alpha_j^{'} F_c + \beta_j C_{c,t-1} + \sum\limits_{d \neq c} \gamma_{dj} C_{d,t}\right]}}{1 + \sum\limits_{k}^{J} e^{\left[\alpha_k^{'} F_c + \beta_k C_{c,t-1} + \sum\limits_{d \neq c} \gamma_{dj} C_{d,t}\right]}}. \tag{4.7}$$

Differentiating with respect to $C_{d,t}$ yields

$$\frac{\partial Pr_c\left[Y = j\right]}{\partial C_{d,t}} = Pr\left[Y = j\right] * \left[\gamma_j - \sum_{k=1}^{J} P_k \gamma_k\right], \tag{4.8}$$

which can be computed from the parameter estimates, with the independent variables evaluated at suitable values, along its standard errors. In all tables we will report the estimated coefficients alongside the marginal probabilities obtained from (4.8) as well as standard errors (reported in the brackets).

Chapter 5

Estimation Results

5.1 Base Model

We dedicate the following chapter for results analysis and interpretations. We ran three separate regressions: base model, contagion model and extended contagion model which analyses the impact of financial recession. We start with the analysis of the base model that does not include contagious effects from other Nordic markets. We present the output of the regression in Table 5.1. Recall that our response variable is the number of banks experiencing large shocks on the same day in a given country – coexceedances. Here we are interested what common and systemic factors are influential in explaining simultaneous shocks in the banking sector. Overall, we are able to explain between three (Finland) and eleven (Sweden and Denmark) percent of the variation in our dependent variable using only common and systemic risk factors as the explanatory variables.

We start by analyzing the most significant variables. As expected, conditional domestic volatility appears to be significant in all four markets at at least 5 percent level. The interpretation of multinomial logit model result is not as straightforward as traditional linear models, such as ordinary least squares model. For the purpose of magnitude analysis, we report marginal probabilities alongside the coefficients. We can observe that in case of Denmark, conditional volatility is critical in explaining large shocks when three or more banks are facing difficulties. We can conclude that one percent increase in conditional volatility increases the chance of three or more coexceedances by 0.013 percent all other variables held constant. However, conditional volatility seems to be irrelevant in describing small shocks in Danish banking sector. In the case of

Sweden, we see slightly different results. Conditional volatility seems to be an important factor for causing small shocks, as well as the large ones. We observe that one percent increase in conditional volatility increases the probability of one exceedance by 0.072 percent, and the probability of large shocks, when three or more banks are affected, by 0.015 percent everything else kept constant. In Finnish and Norwegian banking sectors we observe almost identical results. Conditional volatility appears to be significant for small as well as for larger shocks. However, we observe slightly less influential effects. We conclude that one percent increase in conditional volatility would increase the probability of two coexceedances by 0.008 and 0.013 percent for Norway and Finland, accordingly. Our results are in line with Bae *et al.* (2003) research who claim that conditional volatility is critical in explaining financial contagion. High significance of conditional volatility can also be explained by the fact that banks in some countries (e.g., Denmark and Sweden) have a significant weight in domestic stock market indices so it catches the effects that are related to contagion.

We further analyze the importance of global systemic risk on Nordic banking systems. Our results suggest that similar to conditional volatility systemic risk is crucial in explaining disturbances in Nordic banks. It is significant at one percent level for all four markets. In the case of Denmark, Norway and Finland the importance of global systemic risk factor decreases for larger shocks suggesting that these markets observe some negative spillover effects. However, systemic risk has weaker associations with large shocks in these countries. We support such result with the fact that banking activities in Nordic countries are intra–regional. Nonetheless, we see opposite results in Swedish banking sector. For larger shocks, systemic risk factor appears to be more significant. We justify this result with the fact that Sweden is considered to be financial center among Nordic countries. Naturally it has more foreign activities outside the region, therefore, the probability and impact of spillovers from other economies increases. Bengtsson *et al.* (2013) find evidence that importance of systemic risk for Swedish banks increased significantly during the recession in 2008–2009 which supports our findings.

Next, we measure the possibility of volatility spillovers from outside the region by including U.S. market conditional volatility. However, we do not observe any linkages between U.S. stock market volatility and shocks in the Nordic banks, except the case of Denmark. Conditional volatility of U.S. stock market seems to have strong links with shocks in Danish banking sector. For example, one percent increase in conditional volatility increases the probability of three or more coexceedances by 0.013 percent. We believe that increased impact from US on Danish stock market is a result of the Nordic region becoming more connected to the world market as OMX group was acquired by NASDAQ in 2007. Moreover, Danish banking sector was also more involved in acquiring sub–prime assets and other toxic instruments on the international markets.

Our results rejected the assumption that yield curve could be a good predictor for shocks in the banking sector. Economists associate he steepening yield curve with a fall in stock prices. Investors want to benefit from increasing bond yield, which is a safer investment opportunity, so they adjust their portfolios by investing in bonds and withdrawing their investments from stock markets (Rajan 2005). However, yield curve can no longer be used to accurately predict future economic development. It also does not accurately foresee how banks earnings will fluctuate. The conventional view of the banking business is that banks pay short–term interest on deposits and make loans tied to long–term interest rates. However, some researches suggest that bank profits become less responsive to fluctuations in the slope of yield curve. Banks reaction to changes is interest rates depends on their balance sheet size and the heterogeneity of their offered products (Hanweck & Ryu 2005). Moreover, analysis confirms that banks in major advanced countries have learned to insulate from negative changes in the slope of the yield curve over years (English 2002). As a result, yield curve no longer has its ability to correctly predict earnings development and its usefulness as an indicator of the banks soundness and profitability has contracted.

Finally, we can conclude that there is some autocorrelation in our response variable and that it was not entirely removed by first–differencing it. Lagged number of coexceedances is significant for all markets at at least 5 percent level. All in all, our results match our prior assumptions and expectations.

Table 5.1: Multinomial Logistic Regression Output for Base Model, January 2004−January 2014

	Denmark		Sweden		Norway		Finland	
	Coeff.	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***
Coexceedances = 1								
Constant	-2.07***	-	-2.75***	-	-2.46***	-	-2.11***	-
	(0.10)		(0.12)		(0.12)		(0.10)	
Coex. Lagged	0.24***	0.027**	0.55***	0.042***	0.39***	0.033**	0.57***	0.064***
	(0.10)	(0.012)	(0.09)	(0.007)	(0.14)	(0.013)	(0.14)	(0.015)
Systemic Risk	0.26***	0.026**	0.29***	0.016*	0.62***	0.053***	0.27***	0.030***
	(0.10)	(0.012)	(0.11)	(0.009)	(0.09)	(0.008)	(0.09)	(0.010)
Yield Curve	-0.31	-0.044	-0.77	-0.055	0.07	0.007	-0.32	-0.036
	(0.32)	(0.040)	(0.70)	(0.058)	(0.12)	(0.011)	(0.33)	(0.025)
Volatility Own	-0.01	-0.007	0.94***	0.072***	0.58***	0.051***	0.45*	0.049*
	(0.28)	(0.035)	(0.27)	(0.022)	(0.12)	(0.011)	(0.25)	(0.029)
Volatility US	0.57***	0.066***	0.32*	0.025	-0.10	-0.011	-0.03	-0.003
	(0.17)	(0.020)	(0.19)	(0.016)	(0.21)	(0.019)	(0.19)	(0.022)
Coexceedances = 2								
Constant	-4.28***	-	-4.25***	-	-5.22***	-	-5.42***	-
	(0.20)		(0.22)		(0.12)		(0.43)	
Coex. Lagged	0.38**	0.008*	0.60***	0.012***	0.74***	0.010**	1.07***	0.007**
	(0.17)	(0.004)	(0.14)	(0.004)	(0.26)	(0.004)	(0.41)	(0.003)
Systemic Risk	0.74***	0.017***	1.00***	0.023***	1.19***	0.017***	0.41	0.003
	(0.13)	(0.004)	(0.12)	(0.004)	(0.14)	(0.003)	(0.25)	(0.002)
Yield Curve	0.64	0.018	-1.43*	-0.032	-0.08	-0.002	-0.08	0.000
	(0.67)	(0.018)	(0.80)	(0.021)	(0.18)	(0.003)	(0.43)	(0.003)
Volatility Own	0.52	0.012	1.14***	0.024**	0.66***	0.008***	1.79**	0.013**
	(0.35)	(0.009)	(0.40)	(0.010)	(0.19)	(0.003)	(0.72)	(0.006)
Volatility US	0.83***	0.018***	0.01	-0.0023	0.43	0.008	-0.54	-0.004
	(0.25)	(0.007)	(0.34)	(0.009)	(0.32)	(0.005)	(0.81)	(0.006)

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Table 5.1: Multinomial Logistic Regression Output for Base Model, January 2004−January 2014 (Continued)

	Denmark		Sweden		Norway		Finland	
	Coeff.	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***
Coexceedances = 3								
Constant	-5.46***	-	-5.02***	-	-	-	-	-
	(0.32)		(0.25)					
Coex. Lagged	0.37	0.003	0.82***	0.014***	-	-	-	-
	(0.23)	(0.003)	(0.14)	(0.003)				
Systemic Risk	1.00***	0.010***	1.17***	0.021***	-	-	-	-
	(0.16)	(0.002)	(0.13)	(0.003)				
Yield Curve	0.67	0.008	-1.33*	-0.021	-	-	-	-
	(0.94)	(0.011)	(0.69)	(0.014)				
Volatility Own	1.14***	0.013***	1.04***	0.015*	-	-	-	-
	(0.38)	(0.005)	(0.40)	(0.008)				
Volatility US	0.65	0.005	0.48*	0.009	-	-	-	-
	(0.38)	(0.004)	(0.28)	(0.006)				
Pseudo-R^2	0.06		0.11		0.11		0.03	
Log-Likelihood	-1,458		-1,264		-993		-1,075	
N	2,506		2,506		2,506		2,506	
Σ Coex. Lagged	10.41**		60.12***		11.60***		20.71***	
Σ Systemic Risk	51.84***		111.66***		90.23***		10.33***	
Σ Yield Curve	2.15		4.44		0.84		2.78	
Σ Volatility Own	9.63**		17.65***		26.96***		8.12**	
Σ Volatility US	17.52***		4.75		2.07		0.54	

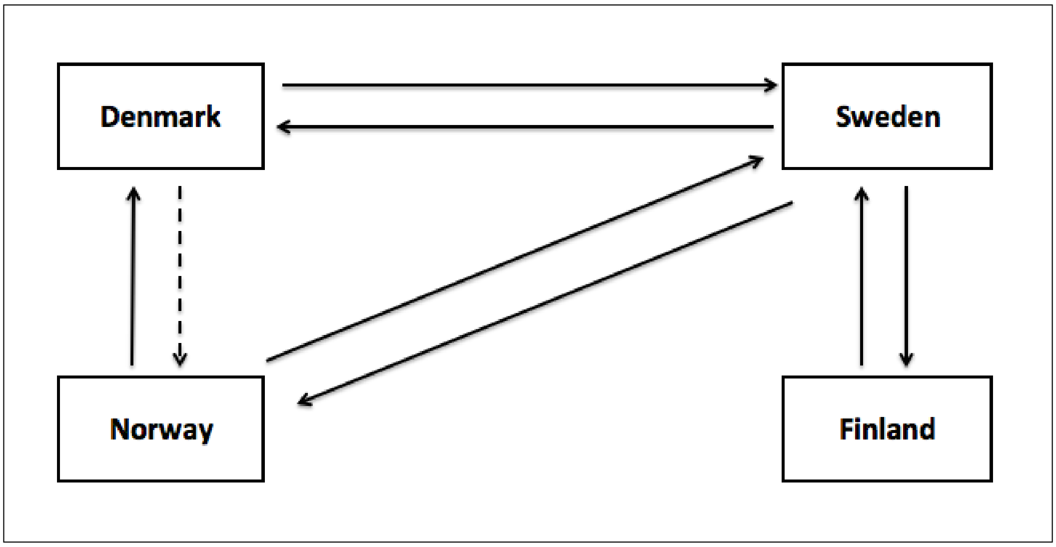
Notes: Response variable: Number of domestic banks simultaneously in the tail ("coexceedances"). Base category is automatically set to zero coexceedances. *, **, and *** indicate significance level at the 10%, 5%, and 1% levels, respectively. Joint significance of the coefficients are reported below and labeled with Σ.

Source: author's computations.

5.2 Contagion Model

Next, we continue with the contagion model, where we include a number of coexceedances from other Nordic countries as variables measuring contagion to the base specification. In the base model, we controlled only for common and systemic shocks. We believe that if coefficients of contagion variables turn out to be positive and significant, we can conclude the existence of contagion across Nordic banking sectors. We report the results in Table 5.2. At the end of each output we report the tests measuring the joint significance of each variable (denoted as, e.g., Σ Contagion DK). We find strong evidence that cross–border contagion is present and statistically significant in all four Nordic markets. As a result, we see an increase in pseudo–R^2 for each country meaning that new variables measuring contagion added information to our specification. Denmark is exposed to contagion risk from Norway and Sweden. Adverse shocks coming from Norway seem to contribute to large shocks causing deterioration in three or more Danish banks simultaneously while it does not appear to affect banks individually. We do not find any exposure to Finish banking sector either for small or large shocks. On the other hand, Sweden seems to be the most crucial for Danish banking sector and responsible for all types of shocks. Norway's highest exposure is to Swedish banking sector as well. We see some links to Danish banks, but they are rather minor. Denmark is partly responsible for both small and large effects adversely influencing Norwegian banking sector. We also spot some minor impact coming from Finish banking sector affecting individual banks. Adding contagion effects from other Nordic countries increased pseudo–R^2 only by 2 percent allowing us to assume that Danish banking sector has some exposure to other parts of the world. This assumption is supported by our previous findings that Denmark is the only Nordic country experiencing spillover effects from U.S. market. We conclude that Finnish banking sector is only exposed to Swedish banks. We do not observe any other influences from other markets. However, adding foreign coexceedances increased pseudo–R^2 by 4 percent which manifests the intensity of exposure. Meanwhile, Sweden, that is considered to be the Nordic financial center, not only transmits shocks to other markets, but also exposes its banking sector to all regional markets. Increase in pseudo–R^2 increasing by 6 percent reflects the high exposure to other markets. Figure 5.1 summarizes the directions of contagion. We present joint significance test results in Figure 5.2. The arrows depict contagion effect from one country to another. Solid arrows represent significance of contagion at 1 percent significance level and dashed arrows at 5 percent level.

Figure 5.1: Contagion Directions



Note: Solid arrows indicate significance of contagion at the 99 percent significance level and dashed arrows at the 95 percent level.

Source: author's composition.

Distance–to–default incorporates the information about stock returns with market leverage and asset volatility that are the main determinants of default risk. The higher the distance to default, the lower the probability of default of the bank and vice versa. The advantage of using this approach is that one does not need to specify a particular channel of contagion, such as cross–border lending. Rather, it reflects interdependencies between banking sectors combining all possible channels of transmission. Nonetheless, based on our results, we believe some contagion channels are more presumable than others.

First, we can reject the possibility of "domino effects" influencing our results. We did not include any banks that defaulted on its liabilities during our analyzed period (Upper & Worms 2004).

Finland has bilateral contagion links only with Sweden. It seems isolated from other three Nordic countries. First of all, the largest bank in Finland is Swedish Nordea, which can explain some part of the large exposure to Swedish banking sector. We can explain the isolation from the rest of the Nordic region in two ways. First of all, Finland is the only Nordic country where official currency is euro. Therefore, we can assume that it is more exposed to Eurozone members than Nordic countries. It is possible that the euro market with centralized monetary policy and the single currency enhances the cross–border interbank links among banks and, therefore, increases cross–border contagion risk (Gropp *et al.* 2007). Another possible explanation is heterogeneity across sample banks. We have three banks representing Finnish banking sector. However, they are rather small in size compared to other banks in the sample. Pohjola bank is Finnish largest domestic bank, however, it has no foreign activities in other Nordic countries whatsoever, and that is not consistent with the rest of the region. All largest national banks have substantial market shares in other Nordic countries as well. Nonetheless, Pohjola bank and Finnish banking sector are relatively small compared to the rest of the region which lets us conclude that this might be another reason for low cross–border contagion linkages. Overall, large banks are considered to be more important in cross–border contagion. That is due to the fact, that international interbank lending among major banks ("money–center banks") may be important. Small domestic banks commonly are not very active across borders in the tiered interbank market structure, in which only large banks have dominant roles (Degryse & Nguyen 2007; Freixas & Holthausen 2005).

Sweden, on the contrary, is exposed to all Nordic countries in terms of cross–border contagion risk. Swedish banking sector is the largest among all Nordic countries, and this is represented by Swedish banks in our sample. Largest Swedish bank Nordea has substantial market shares across all Nordic countries. However, its particularly high exposure to Denmark, who still attempts to recuperate from a burst in the housing market since the global financial recession, and Finland, with drowning high–tech Nokia corporation, is unsettling. The result of mutual contagion linkages is consistent with Freixas *et al.* (2000), who prove that a tiered structure with money–center banks is sensitive to contagion risk.

Similarly to Sweden, Denmark and Norway has high exposures to each other and Sweden, however, not to Sweden. Our sample includes 16 largest banks from all 4 countries, but Finnish banks are significantly smaller than the rest of the sample. ThisSuch results lead us to the conclusion that central contagion channels are related to large banks and above mentioned "money–center banks" and "tired structure" theories. Therefore, our results also support the view of contagion caused by asset sales by one financial intermediary, causing a decrease of stock prices and higher counterparty risks as emphasized in Cifuentes *et al.* (2005). Similarly, Allen & Gale (2000) associate banking sector resistance to shocks with its underlying structure. They find that complete bank networks are more resistant to shocks while incomplete networks are weaker and less resistant to outside adverse shocks since banks with fewer counterparties have difficulty dispelling the shock. However, our results propose quite different picture. Sweden with its strong banking sector appears to be less resilient to shocks from other countries in the region. On the other hand, Finland with smaller banks and less developed banking sector suffers only from shocks from Sweden and is resistant to adverse shocks coming from other two Nordic countries. Minoiu & Reyes (2011) suggest that contagion could be transmitted through cross–border lending. Sweden and Denmark are considered to be a part of the "core" of the global banking network, while Norway and Finland are seen as "periphery". Moreover, they identify significant connections inside Nordic region between Denmark, Sweden and Norway. Finland, on the other hand, is only connected to Swedish banking sector, which supports our findings. Moreover, they prove that a large part of exposure to Nordic countries and especially to Sweden comes from Eastern countries, especially Baltic countries. That is because large share of Baltic banking sector belongs to Nordic banks. Finally, our results could also be an evidence of the problem of asymmetric information. Equity holders seeing deteriorating situation in one bank may take it as a sign of potential problems in other banks. This problem becomes especially relevant if the financial information is unavailable or uninformative (Morgan 2002) or stale (Gropp & Kadareja 2007). Herding behavior of investors results in "bank runs" (Freixas *et al.* 2000).

Table 5.2: Multinomial Logistic Regression Output for Contagion Model, January 2004−January 2014

	Denmark		Sweden		Norway		Finland	
	Coeff.	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***
Coexceedances = 1								
Constant	-2.11***	-	-2.86***	-	-2.57***	-	-2.16***	-
	(0.10)		(0.12)		(0.12)		(0.11)	
Coex. Lagged	0.22**	0.025**	0.54***	0.041***	0.33**	0.027**	0.46***	0.049***
	(0.10)	(0.012)	(0.09)	(0.007)	(0.15)	(0.013)	(0.14)	(0.015)
Systemic Risk	0.18*	0.019	0.20*	0.011	0.51***	0.042***	0.03	0.003
	(0.10)	(0.012)	(0.12)	(0.10)	(0.10)	(0.008)	(0.10)	(0.011)
Yield Curve	-0.32	-0.044	-0.77	-0.056	0.10	0.009	-0.28	-0.031
	(0.32)	(0.040)	(0.66)	(0.055)	(0.12)	(0.10)	(0.23)	(0.024)
Volatility Own	-0.21	-0.030	0.77***	0.062***	0.47***	0.040***	0.07	0.005
	(0.29)	(0.036)	(0.27)	(0.022)	(0.12)	(0.011)	(0.23)	(0.029)
Volatility US	0.57***	0.066***	0.31*	0.026	-0.21	-0.020	-0.13	-0.013
	(0.17)	(0.020)	(0.19)	(0.016)	(0.22)	(0.020)	(0.20)	(0.022)
Contagion DK	-	-	0.18	0.010	0.23**	0.018*	0.03	0.000
			(0.12)	(0.010)	(0.11)	(0.010)	(0.10)	(0.011)
Contagion SE	0.22**	0.022*	-	-	0.42***	0.033***	0.67***	0.073***
	(0.10)	(0.012)			(0.09)	(0.008)	(0.09)	(0.009)
Contagion NO	0.23	0.025	0.46***	0.031**	-	-	0.21	0.023
	(0.14)	(0.018)	(0.16)	(0.013)			(0.14)	(0.016)
Contagion FI	0.07	0.008	0.41**	0.022	0.30*	0.027*	-	-
	(0.15)	(0.019)	(0.17)	(0.014)	(0.16)	(0.015)		

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Table 5.2: Multinomial Logistic Regression Output for Contagion Model, January 2004−January 2014 (Continued)

	Denmark		Sweden		Norway		Finland	
	Coeff.	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***
Coexceedances = 2								
Constant	-4.49***	-	-4.87***	-	-5.67***	-	-5.58***	-
	(0.21)		(0.26)		(0.33)		(0.45)	
Coex. Lagged	0.33**	0.007	0.56***	0.009**	0.63**	0.008**	0.88**	0.006*
	(0.17)	(0.004)	(0.15)	(0.004)	(0.27)	(0.004)	(0.43)	(0.003)
Systemic Risk	0.45***	0.010***	0.75***	0.015***	0.87***	0.010***	0.08	0.001
	(0.15)	(0.004)	(0.14)	(0.003)	(0.15)	(0.002)	(0.27)	(0.002)
Yield Curve	0.48	0.013	-1.40	-0.029	-0.02	-0.001	0.15	0.002
	(0.69)	(0.018)	(1.00)	(0.024)	(0.17)	(0.002)	(0.56)	(0.004)
Volatility Own	0.25	0.006	0.54	0.010	0.57***	0.006**	1.26*	0.009
	(0.36)	(0.009)	(0.44)	(0.011)	(0.20)	(0.003)	(0.76)	(0.006)
Volatility US	0.82***	0.017***	-0.03	-0.004	0.06	0.002	-0.85	-0.006
	(0.26)	(0.007)	(0.37)	(0.009)	(0.38)	(0.006)	(0.85)	(0.006)
Contagion DK	-	-	0.58***	0.010***	0.55**	0.007**	0.26	0.002
			(0.16)	(0.004)	(0.18)	(0.003)	(0.29)	(0.002)
Contagion SE	0.66***	0.014***	-	-	0.95***	0.012***	0.94***	0.006***
	(0.14)	(0.004)			(0.16)	(0.003)	(0.24)	(0.002)
Contagion NO	0.41	0.008	1.00***	0.019***	-	-	0.12	0.000
	(0.24)	(0.006)	(0.22)	(0.006)			(0.45)	(0.003)
Contagion FI	0.12	0.003	1.58***	0.032***	0.04	-0.001	-	-
	(0.29)	(0.007)	(0.23)	(0.006)	(0.35)	(0.005)		

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Table 5.2: Multinomial Logistic Regression Output for Contagion Model, January 2004−January 2014 (Continued)

	Denmark		Sweden		Norway		Finland	
	Coeff.	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***
Coexceedances = 3								
Constant	-6.13***	-	-5.96***	-	-	-	-	-
	(0.40)		(0.33)					
Coex. Lagged	0.32	0.002	0.74***	0.009***	-	-	-	-
	(0.23)	(0.002)	(0.16)	(0.003)				
Systemic Risk	0.45	0.004	0.86***	0.012***	-	-	-	-
	(0.18)	(0.002)	(0.15)	(0.003)				
Yield Curve	0.45	0.005	-1.07	-0.011	-	-	-	-
	(1.00)	(0.011)	(0.98)	(0.017)				
Volatility Own	0.84**	0.009**	0.26	0.000	-	-	-	-
	(0.41)	(0.004)	(0.48)	(0.008)				
Volatility US	0.52	0.003	0.36	0.006	-	-	-	-
	(0.45)	(0.005)	(0.34)	(0.006)				
Contagion DK	-	-	0.96***	0.015***	-	-	-	-
			(0.16)	(0.003)				
Contagion SE	1.04***	0.009***	-	-	-	-	-	-
	(0.19)	(0.002)						
Contagion NO	0.99***	0.009**	1.12**	0.015***	-	-	-	-
	(0.29)	(0.003)	(0.24)	(0.004)				
Contagion FI	-0.05	-0.001	1.76***	0.024***	-	-	-	-
	(0.39)	(0.004)	(0.26)	(0.005)				

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Table 5.2: Multinomial Logistic Regression Output for Contagion Model, January 2004–January 2014 (Continued)

	Denmark	**Sweden**	**Norway**	**Finland**
	Coeff. **Δ*Prob.***	***Coeff.*** **Δ*Prob.***	***Coeff.*** **Δ*Prob.***	***Coeff.*** **Δ*Prob.***
Pseudo-R^2	0.08	0.17	0.14	0.07
Log-Likelihood	-1,416	-1,180	-951	-1,030
N	2,506	2,506	2,506	2,506
Σ Coex. Lagged	8.27**	47.46***	7.85**	12.56***
Σ Systemic Risk	13.06***	45.22***	44.02***	0.13
Σ Yield Curve	1.72	3.31	0.93	4.35
Σ Volatility Own	5.67	7.93**	17.06***	2.56
Σ Volatility US	16.38***	3.45	1.18	1.51
Σ Contagion DK	-	36.08***	10.93**	0.76
Σ Contagion SE	41.77***	-	41.96***	67.69***
Σ Contagion NO	12.88***	32.95***	-	2.11
Σ Contagion FI	0.38	68.18***	3.35	-

Notes: Response variable: Number of domestic banks simultaneously in the tail ("coexceedances"). Contagion effects are captured by the coefficient of coexceedances in country i (labeled Contagion i). Base category is automatically set to zero coexceedances. *, **, and *** indicate significance level at the 10%, 5%, and 1% levels, respectively. Joint significance of the coefficients are reported below and labeled with Σ.

Source: author's computations.

5.3 Contagion Model Extension: The Effect of the Crisis

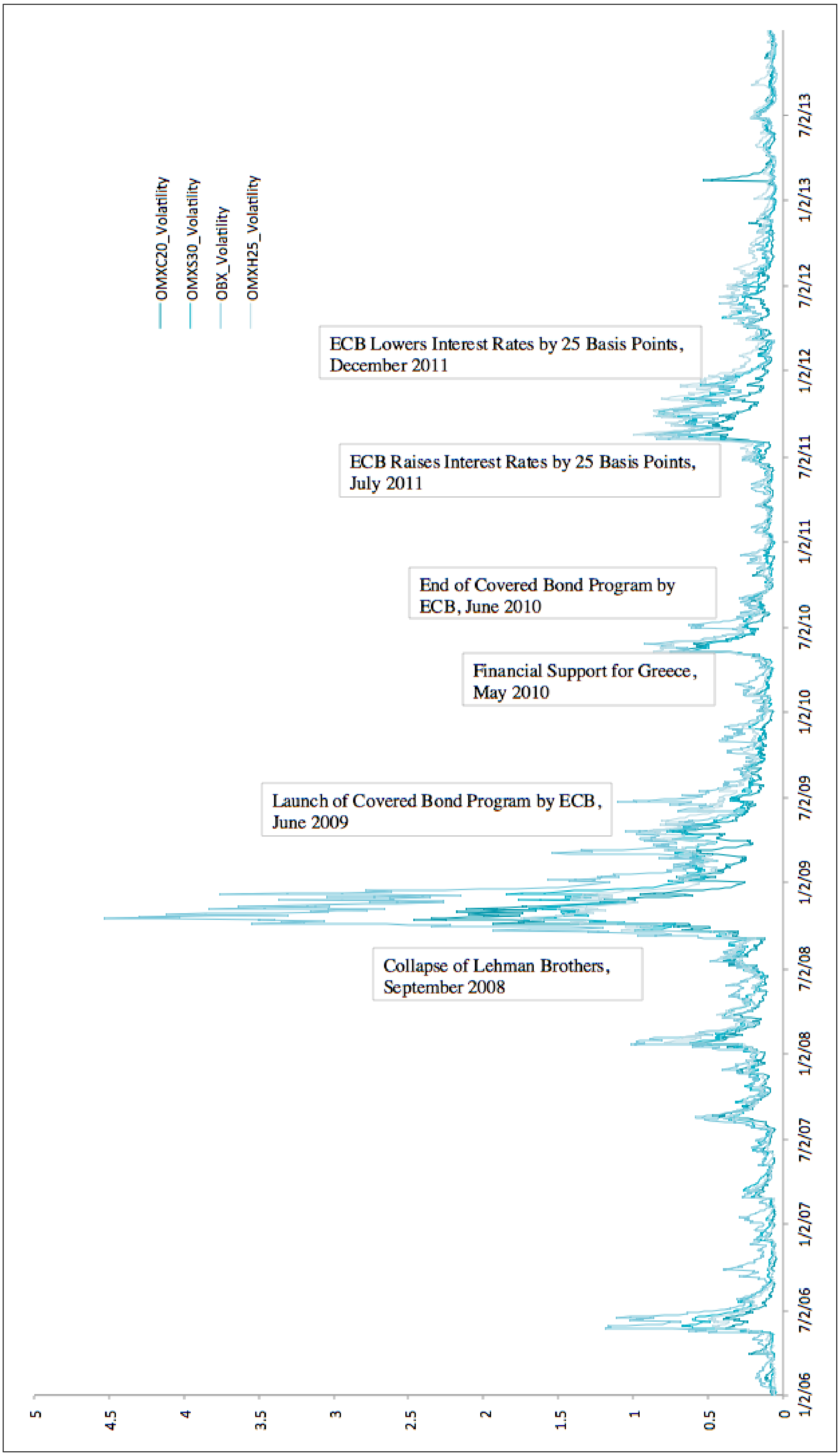
The effect of the recent financial crisis on cross–border contagion risk across Nordic countries is quite vague. One could argue that the 2007 financial crisis may result in an increase of cross–border contagion risk, since the cross–country correlations increase during crisis (Forbes & Rigobon 2002). On the other hand, (Allen & Gale 2000) argue that the right allocation of interbank assets and liabilities across a number of banks should absorb the contagion risk. In order to check if our results from the base model are not entirely driven by coexceedances during the volatile episodes, we split our sample into two subsamples of tranquil and volatile periods. We base our decision on volatile periods definition on domestic stock market volatility combined with key dates of the financial crisis (see Figure 5.2).

- September, 2008 – June, 2009 (Collapse of Lehman Brothers – Launch of covered bond programme by ECB)
- May, 2010 – June, 2010 (Financial support for Greece – End of covered bond programme by ECB)
- July, 2011 – December, 2011 (ECB raises interest rates by 25 basis points – ECB lowers interest rates by 25 basis points)

After dividing our sample into two subsamples of tranquil and volatile times, we have 2,177 and 328 observations in each, accordingly. In order to analyze the effect of cross–border contagion on the Nordic markets, we estimate the model separately for the tranquil and volatile periods. We present the results in Tables 5.3 and 5.4.

Surprisingly, the results for the tranquil and crisis periods are similar. We observe slight changes in the significance levels as well as in marginal effects. We can conclude that contagion did not change its directions across Nordic countries during the crisis, and that is in line with the results of (Gropp *et al.* 2007) who did not observe any stronger links during the crises and, in fact, claimed that contagion links seemed to weaken after exclusion of volatile episodes. Most importantly, we do not observe any increased number of cross–border linkages across the region during the crisis period. As proposed by Forbes & Rigobon (2002), contagion appears because of increased correlation across markets. We do not reject this view.

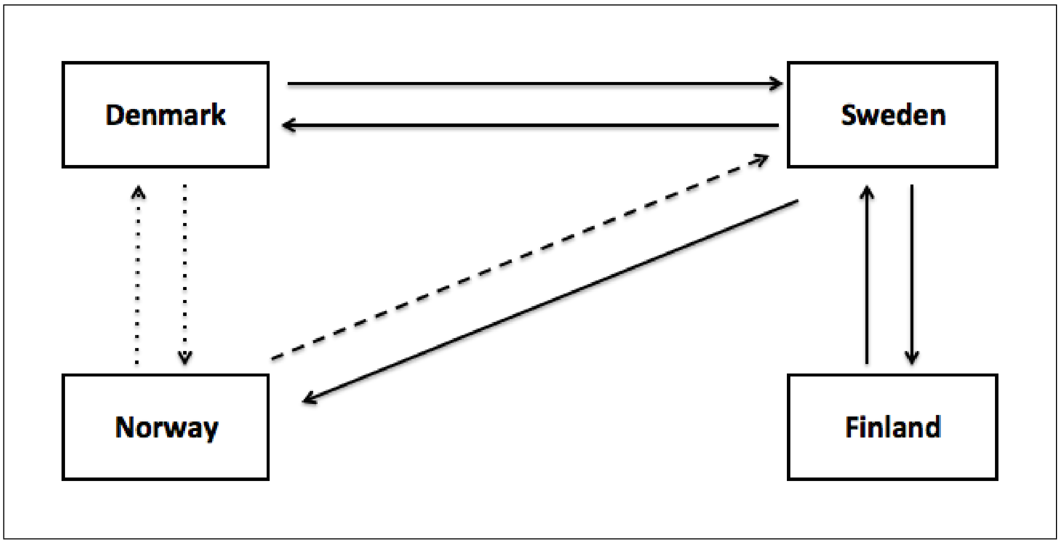
Figure 5.2: Conditional Volatilities of Nordic Market Indices



Source: author's composition.

However, we believe that investor's behavior could have contributed to contagion linkages during the crisis. Before the crisis hit Europe, the Nordic region was seen as financially stable and promising investment opportunity. Investor's did not differentiate across the markets, nor did they check macroeconomic fundamentals thoroughly. It is possible that during a recession they became more careful and more considerate towards their investments and did not see Nordic region as a single market.

Figure 5.3: Contagion Directions for Tranquil Periods



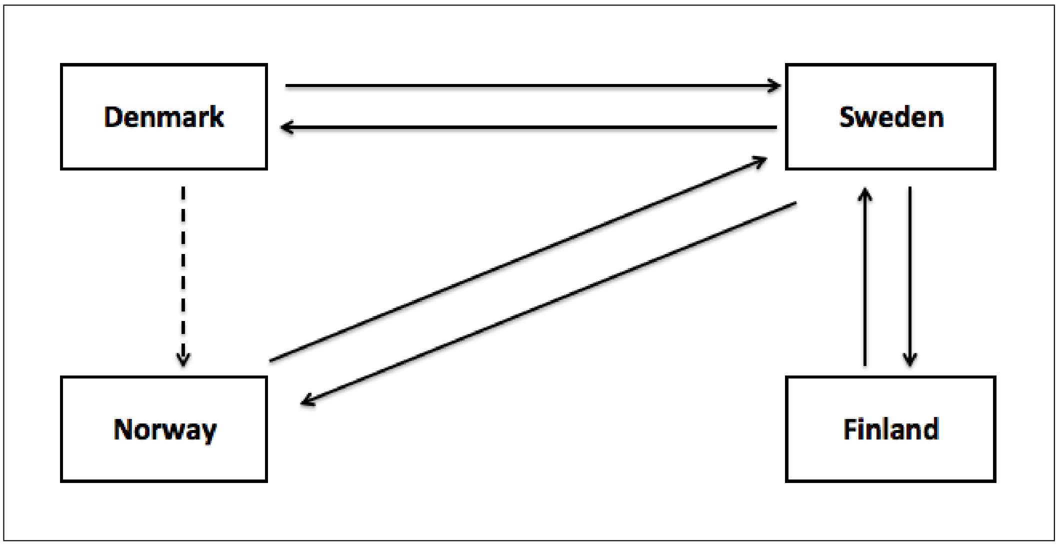
Note: Solid arrows indicate significance of contagion at the 99 percent significance level and dashed arrows at the 95 percent level.

Source: author's composition.

We present joint significance tests of contagion variables at the bottom of Tables 5.3 and 5.4. We conclude that the effect of the recent financial crisis has ambiguous effects on the cross–sectoral banking contagion.

First of all, we should also examine marginal effects for single outcomes and see if there were some changes between tranquil and volatile periods as well. We start with an analysis of Danish banking sector. Before the crisis, Sweden contagion variable was influential for smaller and medium shocks in Danish banking sector (one exceedance and two coexceedances). During the crisis, this effect seems to evaporate as coefficients and marginal probabilities become insignificant. However, for large shocks (three or more coexceedances), we see that marginal probabilities increased from 0.004 to 0.032 manifesting the intensification of adverse shocks. On the other hand, before the crisis we could spot the contagion exposure to Norwegian banks and during the crisis this link seems to disappear. Eventually, looking to joint significance test we

Figure 5.4: Contagion Directions for Volatile Periods



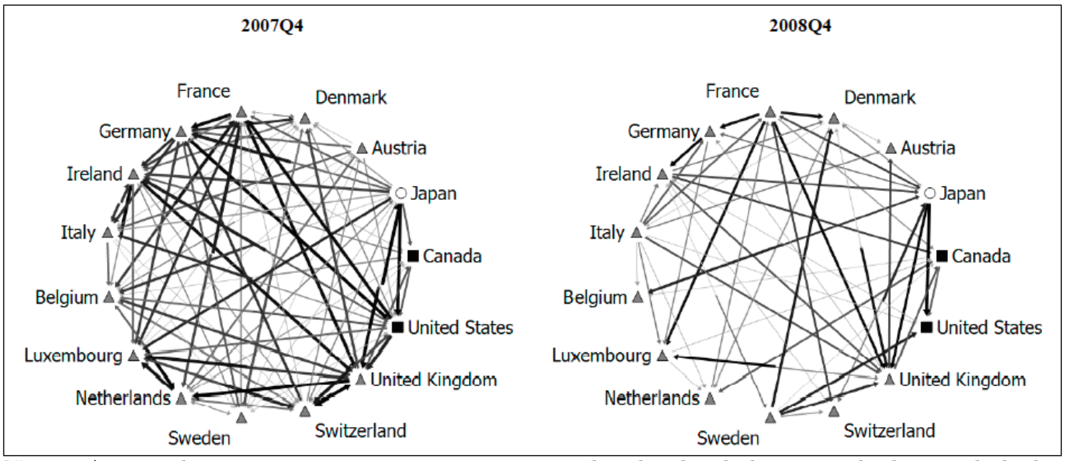
Note: Solid arrows indicate significance of contagion at the 99 percent significance level and dashed arrows at the 95 percent level.

Source: author's composition.

conclude that contagion risk to Danish banking sector declined during the crisis both from Swedish as well as Norwegian markets. In the case of Sweden, we see increased gravity of contagion from Norwegian banking sector as a result of the crisis. On the other hand, our results reveal that contagion from Finland and Denmark decreased and the markets separated somewhat. These results are based on joint significance test. However, if we look to marginal probabilities for large shocks (three and more coexceedances), we can conclude that contagion risk from other Nordic countries increased significantly for large shocks. Marginal probability of Danish contagion variable increased from 0.008 to 0.054, Finnish from 0.013 to 0.086, and Norway contagion variable changed from insignificant to significant implying new contagion exposure during the crisis. In the case of Norway and Finland, we find similar results. We conclude that Norway and Denmark as well as Norway and Sweden became more dependent on each other during the crisis. However, we find evidence that Swedish banking sector became less influential during the financial stress.

The results are, therefore, equivocal. On one hand there are country pairs which experienced a strengthening of the contagion during the crisis (Sweden and Norway), while on the other hand some pairs experienced a weakening (Sweden and Denmark, Sweden and Finland). Two messages stand out in the context. First, the relationship between banking sectors is rather complex - and a crisis occurring in some third country does not necessarily have to activate the contagion process, or at least not for all country pairs, while it can affect other pairs (see (Reinhart & Calvo 1996; Frankel & Schmukler 1996; Corsetti *et al.* 2005; De Gregorio & Valdes 2001)). Second, there seems to be a core banking system in the Nordic region - the Swedish banking system. This latter result, as well as the general message related to the crisis period, is also supported by the findings in Minoiu & Reyes (2011). They analyze global banking network focusing on cross–border flows of financial capital. They find evidence that connectivity tends to weaken during the global financial crises (see Figure 5.5). In their analysis, they divide economies into "core" and "periphery" which stand for advanced, and emerging and developing markets, accordingly. "Core" economies are the dominant players in the global banking network and act as lenders, while "periphery" markets act as borrowers who receive liquidity. They find evidence that links between "intra-core" and "core-periphery" sharply reduced during the crisis as cross–border flows dried up (Hoggarth *et al.* 2010; Milesi-Ferretti & Tille 2011). Similarly, Cetorelli & Goldberg (2012) argue that cross–border lending was key transmission channel of global financial crisis to emerging economies. Domestic loan supply in impaired economies shrank due to collapse of direct cross–border lending by foreign banks and domestic banks caused by shortage of interbank and cross–border lending.

Figure 5.5: Global Banking Network, Minoiu & Reyes (2011)



Note: Arrows between countries represent cross–border bank loans. Thicker and darker arrows represent larger flows. When bilateral flows occur, the connecting arrows split into two, each half–aarow representing the magnitude of one flow.

Table 5.3: Multinomial Logistic Regression: Tranquil and Volatile Periods (Output for Denmark and Sweden)

	Denmark				Sweden			
	Tranquil		***Volatile***		***Tranquil***		***Volatile***	
	Coeff.	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***
Coexceedances = 1								
Constant	-1.89***	-	-2.34***	-	-2.92***	-	-1.45***	-
	(0.15)		(0.32)		(0.18)		(0.37)	
Coex. Lagged	0.22*	0.024*	0.22***	0.030***	0.46***	0.031***	0.52***	0.065***
	(0.12)	(0.014)	(0.09)	(0.003)	(0.13)	(0.009)	(0.14)	(0.020)
Systemic Risk	0.33**	0.038**	0.54***	0.051***	0.25	0.015	0.18	0.005
	(0.13)	(0.016)	(0.22)	(0.022)	(0.17)	(0.012)	(0.17)	(0.024)
Yield Curve	-0.24	-0.031	-1.18	-0.029	-0.47	-0.034	-0.99	-0.046
	(0.33)	(0.040)	(0.90)	(0.017)	(0.52)	(0.098)	(0.79)	(0.09)
Volatility Own	0.66***	0.035***	0.28***	0.029***	0.65***	0.062***	-0.12	0.013
	(0.19)	(0.013)	(0.11)	(0.012)	(0.18)	(0.002)	(0.43)	(0.063)
Volatility US	0.72***	0.084***	0.56**	0.057	0.80***	0.056***	-0.25	-0.011
	(0.22)	(0.027)	(0.27)	(0.034)	(0.26)	(0.019)	(0.29)	(0.045)
Contagion DK	-	-	-	-	0.13	0.006	0.09	-0.002
					(0.16)	(0.011)	(0.20)	(0.029)
Contagion SE	0.25**	0.027*	0.22	0.014	-	-	-	-
	(0.12)	(0.014)	(0.17)	(0.022)				
Contagion NO	0.26	0.030	0.25	0.018	0.51**	0.035**	0.27	-0.002
	(0.18)	(0.021)	(0.26)	(0.034)	(0.20)	(0.015)	(0.27)	(0.038)
Contagion FI	0.09	0.011	0.08	0.027	0.38*	0.022	0.59*	0.023
	(0.17)	(0.020)	(0.35)	(0.018)	(0.21)	(0.015)	(0.37)	(0.047)

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Table 5.3: Multinomial Logistic Regression Output for Denmark and Sweden, Tranquil and Volatile Periods (Continued)

	Denmark				**Sweden**			
	Tranquil		***Volatile***		***Tranquil***		***Volatile***	
	Coeff.	Δ***Prob.***	***Coeff.***	Δ***Prob.***	***Coeff.***	Δ***Prob.***	***Coeff.***	Δ***Prob.***
Coexceedances = 2								
Constant	-4.34***	-	-4.80***	-	-5.27***	-	-2.98***	-
	(0.32)		(0.59)		(0.38)		(0.64)	
Coex. Lagged	0.62***	0.012***	0.53***	0.005***	0.48**	0.006	0.51**	0.018
	(0.21)	(0.005)	(0.18)	(0.002)	(0.22)	(0.004)	(0.22)	(0.014)
Systemic Risk	0.53**	0.009*	0.31*	0.021**	0.71***	0.011***	0.69***	0.035***
	(0.24)	(0.005)	(0.12)	(0.011)	(0.22)	(0.004)	(0.20)	(0.012)
Yield Curve	0.42	0.010	0.34	0.086	0.77	0.017	-1.98	-0.238
	(0.72)	(0.015)	(0.55)	(0.074)	(0.81)	(0.023)	(0.89)	(0.189)
Volatility Own	0.29	0.018	0.69***	0.060***	0.58**	0.091**	-0.24	0.013
	(0.35)	(0.041)	(0.25)	(0.022)	(0.22)	(0.022)	(0.67)	(0.043)
Volatility US	0.78*	0.013	0.97***	0.043**	0.96**	0.016**	-0.63	-0.092
	(0.41)	(0.009)	(0.36)	(0.020)	(0.41)	(0.008)	(0.34)	(0.047)
Contagion DK	-	-	-	-	0.99***	0.016***	0.05	-0.013
					(0.20)	(0.004)	(0.27)	(0.016)
Contagion SE	0.75***	0.014***	0.53**	0.019	-	-	-	-
	(0.19)	(0.004)	(0.24)	(0.013)				
Contagion NO	0.29	0.005	0.57	0.018	0.72**	0.011*	1.20***	0.057***
	(0.37)	(0.008)	(0.36)	(0.034)	(0.33)	(0.006)	(0.34)	(0.021)
Contagion FI	-0.01	0.000	0.40	0.002	1.59***	0.026***	1.79***	0.079***
	(0.37)	(0.008)	(0.46)	(0.047)	(0.28)	(0.006)	(0.43)	(0.025)

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Table 5.3: Multinomial Logistic Regression Output for Denmark and Sweden, Tranquil and Volatile Periods (Continued)

	Denmark				**Sweden**			
	Tranquil		***Volatile***		***Tranquil***		***Volatile***	
	Coeff.	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***	***Coeff.***	**Δ*Prob.***
Coexceedances = 3								
Constant	-7.00***	-	-5.27***	-	-6.40***	-	-3.18***	-
	(0.77)		(0.68)		(0.60)		(0.62)	
Coex. Lagged	0.31	0.001	0.22***	0.005***	0.85***	0.007***	0.40*	0.009
	(0.46)	(0.002)	(0.11)	(0.001)	(0.24)	(0.002)	(0.22)	(0.015)
Systemic Risk	0.95***	0.004**	0.25***	0.004***	1.13***	0.009***	0.50***	0.020*
	(0.33)	(0.002)	(0.11)	(0.002)	(0.23)	(0.002)	(0.19)	(0.012)
Yield Curve	0.07	0.000	0.78	0.036	-0.76	-0.016	-0.54	-0.021
	(0.31)	(0.008)	(0.97)	(0.055)	(0.55)	(0.021)	(0.29)	(0.023)
Volatility Own	0.25	0.013	0.88***	0.078***	1.52***	0.007***	-1.38	-0.095
	(0.21)	(0.013)	(0.34)	(0.032)	(0.46)	(0.003)	(0.68)	(0.046)
Volatility US	0.72	0.002	0.63*	0.014	0.04	-0.002	0.07	0.027
	(0.92)	(0.004)	(0.34)	(0.023)	(0.67)	(0.008)	(0.42)	(0.029)
Contagion DK	-	-	-	-	1.00***	0.008***	0.76***	0.054***
					(0.25)	(0.003)	(0.23)	(0.013)
Contagion SE	1.12***	0.004**	0.82***	0.032***	-	-	-	-
	(0.34)	(0.002)	(0.26)	(0.013)				
Contagion NO	1.18**	0.005*	0.73**	0.022	0.68	0.005	1.12***	0.054***
	(0.53)	(0.002)	(0.37)	(0.020)	(0.42)	(0.004)	(0.31)	(0.020)
Contagion FI	-0.67	-0.003	0.28	0.020	1.67***	0.013***	1.79***	0.086**
	(0.86)	(0.004)	(0.47)	(0.026)	(0.38)	(0.004)	(0.42)	(0.025)

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Table 5.3: Multinomial Logistic Regression Output for Denmark and Sweden, Tranquil and Volatile Periods (Continued)

	Denmark		Sweden	
	Tranquil	***Volatile***	***Tranquil***	***Volatile***
	Coeff. Δ***Prob.***	***Coeff.*** Δ***Prob.***	***Coeff.*** Δ***Prob.***	***Coeff.*** Δ***Prob.***
Pseudo-R^2	0.05	0.15	0.10	0.21
Log-Likelihood	-1,138	-260	-854	-291
N	2,177	328	2,177	328
Σ Coex. Lagged	9.95**	16.55***	20.63***	16.44***
Σ Systemic Risk	14.30***	12.69***	24.41***	14.21***
Σ Yield Curve	0.95	4.92	1.05	5.65
Σ Volatility Own	9.54**	17.05***	15.58***	4.81
Σ Volatility US	11.42***	8.89**	11.30***	5.96
Σ Contagion DK	-	-	28.87***	13.83***
Σ Contagion SE	22.93***	13.12***	-	-
Σ Contagion NO	6.45*	5.24	9.90**	19.72***
Σ Contagion FI	0.98	0.86	39.55***	27.26***

Notes: Response variable: Number of domestic banks simultaneously in the tail ("coexceedances"). Contagion effects are captured by the coefficient of coexceedances in country i (labeled Contagion i). Base category is automatically set to zero coexceedances. *, **, and *** indicate significance level at the 10%, 5%, and 1% levels, respectively. Joint significance of the coefficients are reported below and labeled with Σ.

Source: author's computations.

Table 5.4: Multinomial Logistic Regression: Tranquil and Volatile Periods (Output for Norway and Finland)

	Norway				Finland			
	Tranquil		***Volatile***		***Tranquil***		***Volatile***	
	Coeff.	$\boldsymbol{\Delta Prob.}$	***Coeff.***	$\boldsymbol{\Delta Prob.}$	***Coeff.***	$\boldsymbol{\Delta Prob.}$	***Coeff.***	$\boldsymbol{\Delta Prob.}$
Coexceedances = 1								
Constant	-2.75***	-	-1.88***	-	-2.09***	-	-2.10***	-
	(0.16)		(0.33)		(0.16)		(0.42)	
Coex. Lagged	0.59***	0.048***	0.89***	0.076***	0.38**	0.039**	0.79***	0.108***
	(0.18)	(0.015)	(0.32)	(0.023)	(0.16)	(0.017)	(0.30)	(0.041)
Systemic Risk	0.41***	0.032***	0.61***	0.069***	-0.11	-0.012	0.14	0.022
	(0.14)	(0.011)	(0.15)	(0.019)	(0.15)	(0.016)	(0.14)	(0.020)
Yield Curve	-0.02	-0.002	0.16	0.025	-0.25	-0.027	0.32*	0.046*
	(0.21)	(0.018)	(0.15)	(0.021)	(0.21)	(0.022)	(0.17)	(0.024)
Volatility Own	0.22	0.014	0.52***	0.067***	-0.03	-0.003	-0.23	-0.052
	(0.53)	(0.043)	(0.16)	(0.023)	(0.68)	(0.071)	(0.51)	(0.072)
Volatility US	0.29	0.023	1.06***	0.064***	-0.23	-0.022	-0.06	-0.002
	(0.27)	(0.022)	(0.39)	(0.027)	(0.29)	(0.031)	(0.30)	(0.043)
Contagion DK	0.20	0.016	0.29	0.026	0.04	0.005	-0.06	-0.013
	(0.14)	(0.011)	(0.19)	(0.026)	(0.13)	(0.014)	(0.18)	(0.025)
Contagion SE	0.38**	0.030***	0.38**	0.027	0.66***	0.068***	0.71***	0.096***
	(0.13)	(0.010)	(0.16)	(0.021)	(0.11)	(0.011)	(0.15)	(0.020)
Contagion NO	-	-	-	-	0.26	0.027	0.12	0.019
					(0.18)	(0.019)	(0.24)	(0.034)
Contagion FI	0.23	0.018	0.45	0.075*	-	-	-	-
	(0.19)	(0.016)	(0.32)	(0.044)				

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Table 5.4: Multinomial Logistic Regression Output for Norway and Finland, Tranquil and Volatile Periods (Continued)

	Norway				Finland			
	Tranquil		***Volatile***		***Tranquil***		***Volatile***	
	Coeff.	$\boldsymbol{\Delta Prob.}$	***Coeff.***	$\boldsymbol{\Delta Prob.}$	***Coeff.***	$\boldsymbol{\Delta Prob.}$	***Coeff.***	$\boldsymbol{\Delta Prob.}$
Coexceedances = 2								
Constant	-6.75***	-	-4.36***	-	-5.30***	-	-7.43***	-
	(0.58)		(0.59)		(0.77)		(0.59)	
Coex. Lagged	-0.07	-0.001	0.41***	0.039***	0.78	0.004	0.92	0.010
	(0.63)	(0.004)	(0.12)	(0.015)	(0.56)	(0.003)	(0.73)	(0.011)
Systemic Risk	0.99***	0.006***	0.79***	0.034***	0.45	0.003	-0.21	-0.004
	(0.28)	(0.002)	(0.19)	(0.011)	(0.37)	(0.002)	(0.50)	(0.008)
Yield Curve	0.23	0.002	-0.02	-0.007	1.03	0.001	-0.03	0.001
	(0.51)	(0.003)	(0.18)	(0.011)	(0.88)	(0.016)	(0.60)	(0.009)
Volatility Own	1.82**	0.018**	0.38	0.009	0.18	0.001	1.27**	0.050*
	(0.67)	(0.009)	(0.23)	(0.015)	(0.35)	(0.015)	(0.45)	(0.027)
Volatility US	0.80	0.005	-0.48	0.002	-0.20	-0.006	-1.19	-0.018
	(0.66)	(0.004)	(0.45)	(0.029)	(0.48)	(0.010)	(0.67)	(0.021)
Contagion DK	0.63**	0.004*	0.57**	0.030**	-0.20	-0.001	0.76	0.012
	(0.32)	(0.002)	(0.23)	(0.014)	(0.48)	(0.003)	(0.47)	(0.008)
Contagion SE	0.53	0.003	0.95***	0.053***	1.06	0.005	0.91***	0.010
	(0.33)	(0.002)	(0.22)	(0.013)	(0.31)	(0.002)	(0.42)	(0.007)
Contagion NO	-	-	-	-	0.44	0.002	-0.29	-0.005
					(0.62)	(0.004)	(0.82)	(0.013)
Contagion FI	0.68	0.018	-0.17	-0.027	-	-	-	-
	(0.54)	(0.016)	(0.46)	(0.029)				

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Table 5.4: Multinomial Logistic Regression Output for Norway and Finland, Tranquil and Volatile Periods (Continued)

	Norway		**Finland**	
	Tranquil	***Volatile***	***Tranquil***	***Volatile***
	Coeff. $\boldsymbol{\Delta Prob.}$	***Coeff.*** $\boldsymbol{\Delta Prob.}$	***Coeff.*** $\boldsymbol{\Delta Prob.}$	***Coeff.*** $\boldsymbol{\Delta Prob.}$
Pseudo-R^2	0.06	0.22	0.04	0.09
Log-Likelihood	-721	-215	-856	-168
N	2,177	328	2,177	328
Σ Coex. Lagged	9.72**	12.22***	6.25**	7.67**
Σ Systemic Risk	15.60***	26.35***	2.06	1.42
Σ Yield Curve	0.16	1.65	1.95	3.48
Σ Volatility Own	4.84*	10.44***	0.01	5.52*
Σ Volatility US	2.12	9.45***	1.05	1.01
Σ Contagion DK	4.99*	6.38**	0.33	2.90
Σ Contagion SE	9.96***	20.92***	29.82***	24.85***
Σ Contagion NO	-	-	2.26	0.42
Σ Contagion FI	2.59	3.01	-	-

Notes: Response variable: Number of domestic banks simultaneously in the tail ("coexceedances"). Contagion effects are captured by the coefficient of coexceedances in country i (labeled Contagion i). Base category is automatically set to zero coexceedances. *, **, and *** indicate significance level at the 10%, 5%, and 1% levels, respectively. Joint significance of the coefficients are reported below and labeled with Σ.

Source: author's computations.

5.4 Robustness Check

In order to check for robustness of the results, we estimate alternative models. It is important to check if our results are not spurious to be able to draw reliable conclusions. Hence, we apply the following robustness checks to prove the validity of our results: redefining threshold for defining adverse shocks, adding conditional volatilities of countries with significant contagion effects, reestimating model using ordered logit regression. Instead of reporting results for each specification, we summarized the robustness checks in convenient matrix tables[1]. The summarized results of contagion model estimated using multinomial logit model are presented in Table 5.5.

Table 5.5: Results of the Basic Contagion Model

To ↓ From →	Denmark	Sweden	Norway	Finland
Denmark	X	***	***	-
Sweden	***	X	***	***
Norway	**	***	X	-
Finland	-	***	-	X

Source: author's composition.

In the previous section, we divided our data sample into tranquil, and volatile periods in order to measure the contagion effects during the crisis and during tranquil periods. At the same time we were able to prove that our results are not driven or distorted by crisis since they were not significantly different from our central contagion model, which was our first robustness check.

Table 5.6: Results of the Basic Contagion Model for the Tranquil Periods

To ↓ From →	Denmark	Sweden	Norway	Finland
Denmark	X	***	*	-
Sweden	***	X	**	***
Norway	*	***	X	-
Finland	-	***	-	X

Source: author's composition.

[1]Full regression outputs are available from the author upon request.

Table 5.7: Results of the Basic Contagion Model for the Volatile Periods

To ↓ From →	Denmark	Sweden	Norway	Finland
Denmark	X	***	-	-
Sweden	***	X	***	***
Norway	**	***	X	-
Finland	-	***	-	X

Source: author's composition.

Next, we changed our threshold for defining adverse shocks. In the basic specification, we used bank–specific distribution because we wanted to have the same number of shocks for each bank. However, now we put an assumption that stochastic processes controlling the distance to default at different banks are identical and use a common distribution to define adverse shocks. Our results suggest that stochastic processes are, in fact, the same for all the banks in our sample since the results do not differentiate from the basic specification.

Table 5.8: Results Using Common Distribution of $dd_{it}/|dd_{it-1}|$

To ↓ From →	Denmark	Sweden	Norway	Finland
Denmark	X	***	***	-
Sweden	***	X	***	***
Norway	***	***	X	-
Finland	-	***	-	X

Source: author's composition.

Then, as suggested in Gropp *et al.* (2007), we suspect that our results are somewhat influenced by volatility spillovers from other Nordic markets rather than contagion. Therefore, we reformulate our contagion model by including conditional volatilities of those markets where we found significant contagion effects. We report the results of the reestimated model in Table 5.9 and conclude that they are identical to our contagion model results.

Finally, we reestimated our contagion model using ordered logit regression. Almost identical contagion direction indicate that estimation method does not influence our results. We present results of ordered logit model in Table 5.10.

Table 5.9: Results after Adding the Conditional Volatilities of the Countries with Significant Contagion Coefficients

To ↓ From →	Denmark	Sweden	Norway	Finland
Denmark	X	***	***	-
Sweden	***	X	***	***
Norway	***	***	X	-
Finland	-	***	-	X

Source: author's composition.

Table 5.10: Results using an Ordered Logit Model

To ↓ From →	Denmark	Sweden	Norway	Finland
Denmark	X	***	***	-
Sweden	***	X	***	***
Norway	***	***	X	-
Finland	-	***	-	X

Source: author's composition.

5.5 Postestimation

There are a couple of postestimation tests that are often applied regarding the multinomial logit model estimation. First, it is common to compute the joint significance test and check that all of the coefficients of our response variables are simultaneously equal to zero, i.e., the independent variable does not influence our dependent variable. We report the results of joint significance tests in the bottom of our regression output tables. Multinomial logit model is often considered to be theoretically and empirically superior to the more commonly used analysis because it does not have strict assumptions such as normality, linearity, or homoscedasticity. However, it does assume the collinearity to be relatively low as it gets more complicated to discern the effects of different variables is they are highly correlated.

Nevertheless, the multinomial logistic regression has a fundamental assumption of the independence of irrelevant alternatives (IIA). It means that different response variable outcomes must be independent, or a choice of one category is not related to another category existence or absence. We assess this assumption using Hausman–McFadden test. We present the results in Table 5.11. Hausman test for IIA assumption confirms the suitability of our data. We cannot reject H_0 hypothesis and, therefore, confirm that outcomes are independent of each other. In the case of Norway, we can observe negative *Chi-square*. However, Hausman & McFadden (1984) note this possibility and conclude that negative result is evidence that IIA has not been violated. The Hausman test of IIA is defined as:

$$H_{IIA} = (\widehat{\beta}_R - \widehat{\beta}^*_F)'[\widehat{Var}(\widehat{\beta}_R) - \widehat{Var}(\widehat{\beta}^*_F)]^{-1}(\widehat{\beta}_R - \widehat{\beta}^*_F) \quad (5.1)$$

Hausman & McFadden (1984) emphasize that H_{IIA} can be negative when $(\widehat{\beta}_R - \widehat{\beta}^*_F)$ is not positive semidefinite and suggest that a negative H_{IIA} is evidence that IIA holds[2].

Table 5.11: Hausman Test for IIA Assumption

H_0: Odds (Outcome–J vs. Outcome–K) are independent of other alternatives

Denmark

Omitted	chi2	df	p >chi2	evidence
1	14.109	18	0.722	for H_0
2	24.516	18	0.139	for H_0
3	22.788	18	0.199	for H_0

Sweden

Omitted	chi2	df	p >chi2	evidence
1	17.709	18	0.475	for H_0
2	12.785	18	0.804	for H_0
3	8.981	18	0.960	for H_0

Norway

Omitted	chi2	df	p >chi2	evidence
1	16.067	9	0.065	for H_0
2	-3.095	9	–	–

Finland

Omitted	chi2	df	p >chi2	evidence
1	2.119	9	0.989	for H_0
2	5.895	9	0.750	for H_0

Note: If chi2 <0, the estimated model does not meet asymptotic assumptions of the test

Source: author's computations.

[2] $\widehat{\beta}_F$ – estimates of full model, $\widehat{\beta}_R$ – estimates of restricted model, $\widehat{\beta}^*_F$ – estimates of full model after eliminating coefficients not estimated in the restricted model.

Chapter 6

Conclusion

The globalization of financial markets during the past few decades has made it much easier to transmit financial crisis from one economy to another. In order to suppress or at least be able to forecast the contagion, it is important to analyze the times of financial distress and focus on the transmission mechanisms and factors which make a crisis spread across borders.

The main focus of this thesis is the analysis of the contagion in the banking sectors of four continental Nordic countries over the 2004 – 2014 period. Using a multinomial logit model we test whether there is any degree of contagion among the four banking sectors, whether it is more pronounced for larger banks and whether the recent financial crisis has exacerbated it. Moreover, we also estimate which common and systemic factors contribute to shocks in the banking sectors in Nordic countries.

We estimated three empirical models to test our hypotheses. First model analyzed what common factors contribute to shocks in the banking sector. We find strong evidence that conditional volatility is crucial in explaining distress in banks. Moreover, we find evidence that Nordics are not an exception and experience adverse effects from systemic risks arising across the globe. We tested if spillovers from U.S. market effects Nordic banks, and found evidence that only Danish banking sector is exposed to such risks. Finally, our assumption that yield curve could be used to predict and explain shocks in the banking sector was rejected. Our result contributed to the predominant view that changes in slope of yield curve can no longer be efficiently used to predict future economic development or accurately foresee how banks earning will fluctuate.

The second empirical model included contagion effects from other Nordic countries. Our results strongly confirm the significant existence of cross–border contagion among Nordic banking sectors. We find evidence that all four markets have some exposure to contagion risk coming from the other country in the Nordic region. However, some countries are more exposed than others. For example, Sweden has bilateral contagion links with all other Nordic countries, while Finland is only connected to Sweden. The role of the banking sector in the global banking network seems to be particularly important here. Sweden, for instance, is part of the international "core" banking centers - connected well both within the region as well as with other important international banking centers. This also reflects on the size of the banks in the system. Finland, on the contrary is a peripheral or at most just a regional banking hub, with relatively small banking institutions. That leads us to the conclusion that contagion is more likely to be transmitted through large banks and/or through internationally important banking centers. In the same vein, we believe that tiered interbank market structure where large banks play a dominant role is more exposed to contagion risk.

Last but not least, we estimated the model measuring what effect did current financial crisis have on contagion risk in Nordic countries. After careful analysis of the results, we come to the conclusion that the effect of recent financial turmoil is equivocal. On one hand, there are country pairs which experienced a strengthening of contagion during the crisis (Norway and Sweden). On the other hand, we find evidence that contagion links between Danish and Swedish, and Swedish and Finnish markets weakened during volatile episodes. Moreover, it is interesting to notice that the strength of contagion risk increased from Danish to Norwegian banking sector but decreased from Norwegian to Danish. That is in line with the fact, that Denmark and Sweden are a part of the core global banking network while Norway and Finland are perceived to be secondary markets. During the financial stress, capital flows dry up. The secondary markets that are heavily dependent on international financing become more susceptible to contagion risk.

The discussion on the need for banking sector regulation and supervision relies crucially on the issue whether there is cross–border contagion risk in banking, or not. At international level, awareness of the causes and understanding of transmission mechanisms of cross–border contagion can help authorities improve international financial regulation system and, thus, make it more resistant to shocks and contagion risk. At domestic level, improved financial supervision policies can help improve the economy and restrict exposure to contagion. Better understanding how contagion spreads within financial intermediaries would be advantageous in making financial reforms, for example, how to regulate capital ratio to balance between maximizing bank's revenues and protecting them from shocks and contagion risk. Once the existence of contagion risk is confirmed, it is important to perform deeper analysis on the possible contagion transmission channels. This issue may be subject for the future research.

References

Agénor, P.-R. & J. Aizenman (1997): "Contagion and Volatility with Imperfect Credit Markets." *Technical report*, National Bureau of Economic Research.

Allen, F. & D. Gale (1999): "The Asian Crisis and the Process of Financial Contagion." *Journal of Financial Regulation and Compliance* **7(3)**: pp. 243–249.

Allen, F. & D. Gale (2000): "Financial Contagion." *Journal of political economy* **108(1)**: pp. 1–33.

Alter, A. & A. Beyer (2012): "The Dynamics of Spillover Effects During the European Sovereign Debt Turmoil." *Technical report*, CFS Working Paper.

Alter, A. & Y. S. Schüler (2012): "Credit Spread Interdependencies of European States and Banks During the Financial Crisis." *Journal of Banking & Finance* **36(12)**: pp. 3444–3468.

Arghyrou, M. G. & A. Kontonikas (2012): "The EMU Sovereign–debt Crisis: Fundamentals, Expectations and Contagion." *Journal of International Financial Markets, Institutions and Money* **22(4)**: pp. 658–677.

Bae, K.-H., G. A. Karolyi, & R. M. Stulz (2003): "A New Approach to Measuring Financial Contagion." *Review of Financial studies* **16(3)**: pp. 717–763.

Baig, T. & I. Goldfajn (1998): "Financial Market Contagion in the Asian Crisis." .

Beirne, J., G. M. Caporale, M. Schulze-Ghattas, & N. Spagnolo (2009): "Volatility Spillovers and Contagion from Mature to Emerging Stock Markets." .

Bengtsson, E., U. Holmberg, & K. Jönsson (2013): “Identifying Systemically Important Banks in Sweden–What Do Quantitative Indicators Tell Us?” *Sveriges Riksbank Economic Review 2013: 2* p. 2.

Bordo, M. & A. P. Murshid (2000): “The International Transmission of Financial Crises Before World War II: Was There Contagion?” In “The Contagion Conference,” .

Calvo, G. A. & E. G. Mendoza (1997): *Rational Herd Behavior and the Globalization of Securities Markets*. Institute for Empirical Macroeconomics, Federal Reserve Bank of Minneapolis.

Calvo, G. A. & E. G. Mendoza (2000): “Rational Contagion and the Globalization of Securities Markets.” *Journal of International Economics* **51(1)**: pp. 79–113.

Caramazza, F., L. A. Ricci, & R. Salgado (2000): *Trade and Financial Contagion in Currency Crises*. International Monetary Fund.

Cetorelli, N. & L. S. Goldberg (2008): “Banking Globalization, Monetary Transmission, and the Lending Channel.” *Technical report*, National Bureau of Economic Research.

Cetorelli, N. & L. S. Goldberg (2012): “Banking Globalization and Monetary Transmission.” *The Journal of Finance* **67(5)**: pp. 1811–1843.

Chen, Y.-H., K. Wang, & A. H. Tu (2011): “Default Correlation at the Sovereign Level: Evidence from Latin American Markets.” .

Cifuentes, R., G. Ferrucci, & H. S. Shin (2005): “Liquidity Risk and Contagion.” *Journal of the European Economic Association* **3(2-3)**: pp. 556–566.

Claessens, S. & K. Forbes (2004): “International Financial Contagion: The Theory.” In “Evidence and Policy Implications/Conference ‘The IMFs Role in Emerging Market Economies: Reassessing the Adequacy of its Resources’ organized by RBWC, DNB and WEF in Amsterdam on November,” pp. 18–19.

Corsetti, G., M. Pericoli, & M. Sbracia (2005): “Some Contagion, Some Interdependence: More Pitfalls in Tests of Financial Contagion.” *Journal of International Money and Finance* **24(8)**: pp. 1177–1199.

CORSETTI, G., P. PESENTI, & N. ROUBINI (1998): "What Caused the Asian Currency and Financial Crisis? Part I: A Macroeconomic Overview." *Technical report*, National Bureau of Economic Research.

CORSETTI, G., P. PESENTI, & N. ROUBINI (1999): "What Caused the Asian Currency and Financial Crisis?" *Japan and the world economy* **11(3)**: pp. 305–373.

CROSBY, P. & J. BOHN (2003): "Modeling Default Risk." *KMV Corporation* .

DE GREGORIO, J. & R. O. VALDES (2001): "Crisis Transmission: Evidence from the Debt, Tequila, and Asian Flu Crises." In "International financial contagion," pp. 99–127. Springer.

DEGRYSE, H. & G. NGUYEN (2007): "Interbank Exposures: An Empirical Xxamination of Contagion Risk in the Belgian Banking System." *International Journal of Central Banking* **3(2)**: pp. 123–171.

DIAMOND, D. W. & P. H. DYBVIG (1983): "Bank Runs, Deposit Insurance, and Liquidity." *The journal of political economy* pp. 401–419.

DIEBOLD, F. X. & K. YILMAZ (2009): "Measuring Financial Asset Return and Volatility Spillovers, with Application to Global Equity Markets." *The Economic Journal* **119(534)**: pp. 158–171.

DIWAN, I. & B. HOEKMAN (1999): "Competition, Complementarity and Contagion in East Asia." *The Asian financial crisis: causes, contagion and consequences* **2**: p. 312.

DORNBUSCH, R., I. GOLDFAJN, R. O. VALDÉS, S. EDWARDS, & M. BRUNO (1995): "Currency Crises and Collapses." *Brookings Papers on Economic Activity* pp. 219–293.

DORNBUSCH, R., Y. C. PARK, & S. CLAESSENS (2000): "Contagion: Understanding How It Spreads." *The World Bank Research Observer* **15(2)**: pp. 177–197.

DRAZEN, A. (2000): "Political Contagion in Currency Crises." In "Currency crises," pp. 47–70. University of Chicago Press.

DREES, B. & C. PAZARBASIOGLU (1998): *The Nordic Banking Crises: Pitfalls in Financial Liberalization?* 161. International monetary fund.

DUNGEY, M., R. FRY, & V. MARTIN (2004): *Empirical Modeling of Contagion: A Review of Methodologies.* 4-78. International Monetary Fund.

EDWARDS, S. (1998): "Interest Rate Volatility, Capital Controls, and Contagion." *Technical report*, National bureau of economic research.

EICHENGREEN, B., A. K. , & C. WYPLOSZ (1996): "Contagious Currency Crises." *Technical report*, National bureau of economic research.

ENGLISH, W. B. (2002): "Interest Rate Risk and Bank Net Interest Margins." *BIS Quarterly Review* **10**: pp. 67–82.

FAVERO, C. A. & F. GIAVAZZI (2000): "Looking for Contagion: Evidence from the ERM." *Technical report*, National bureau of economic research.

FERNALD, J., H. EDISON, & P. LOUNGANI (1999): "Was China the First Domino? Assessing Links Between China and other Asian Economies." *Journal of International Money and Finance* **18(4)**: pp. 515–535.

FORBES, K. & R. RIGOBON (2001): "Measuring Contagion: Conceptual and Empirical Issues." In "International financial contagion," pp. 43–66. Springer.

FORBES, K. J. & R. RIGOBON (2002): "No Contagion, Only Interdependence: Measuring Stock Market Comovements." *The journal of finance* **57(5)**: pp. 2223–2261.

FRANKEL, J. A. & S. L. SCHMUKLER (1996): "Crisis, Contagion, and Country Funds: Effects on East Asia and Latin America." .

FREIXAS, X. & C. HOLTHAUSEN (2005): "Interbank Market Integration under Asymmetric Information." *Review of Financial Studies* **18(2)**: pp. 459–490.

FREIXAS, X., B. M. PARIGI, & J.-C. ROCHET (2000): "Systemic Risk, Interbank Relations, and Liquidity Provision by the Central Bank." *Journal of money, credit and banking* pp. 611–638.

FROOT, K. A., P. G. O'CONNELL, & M. S. SEASHOLES (2001): "The Portfolio Flows of International Investors." *Journal of Financial Economics* **59(2)**: pp. 151–193.

GERLACH, S. & F. SMETS (1995): "Contagious Speculative Attacks." *European Journal of Political Economy* **11(1)**: pp. 45–63.

GLICK, R. & A. K. ROSE (1999): "Contagion and Trade: Why Are Currency Crises Regional?" *Journal of international Money and Finance* **18(4)**: pp. 603–617.

GORDON, R. J. (2000): "The Aftermath of the 1992 ERM Breakup: Was there a Macroeconomic Free Lunch?" In "Currency crises," pp. 241–282. University of Chicago Press.

GROPP, R. & A. KADAREJA (2007): "Stale Information, Shocks and Volatility." *ZEW-Centre for European Economic Research Discussion Paper* **(07-012)**.

GROPP, R., M. LO DUCA, & J. VESALA (2007): "Cross–Border Bank Contagion in Europe." *Technical report*, Working paper series/Johann-Wolfgang-Goethe-Universität Frankfurt am Main, Fachbereich Wirtschaftswissenschaften: Finance & Accounting.

GROPP, R. & G. MOERMAN (2004): "Measurement of Contagion in Banks' Equity Prices." *Journal of International Money and Finance* **23(3)**: pp. 405–459.

HAILE, F. & S. POZO (2008): "Currency Crisis Contagion and the Identification of Transmission Channels." *International Review of Economics & Finance* **17(4)**: pp. 572–588.

HANWECK, G. A. & L. RYU (2005): *The Sensitivity of Bank Net Interest Margins and Profitability to Credit, Interest–Rate, and Term-Structure Shocks across Bank Product Specializations.* Federal Deposit Insurance Corporation.

HARDIE, I. & D. HOWARTH (2009): "Die Krise but not La Crise? The Financial Crisis and the Transformation of German and French Banking Systems." *JCMS: Journal of Common Market Studies* **47(5)**: pp. 1017–1039.

HAUSMAN, J. & D. MCFADDEN (1984): "Specification Tests for the mMltinomial Logit Model." *Econometrica: Journal of the Econometric Society* pp. 1219–1240.

HOGGARTH, G., L. MAHADEVA, & J. H. MARTIN (2010): "Understanding International Bank Capital Flows during the Recent Financial Crisis." *Bank of England Financial Stability Paper* **(8)**.

HONKAPOHJA, S. (2009): *The 1990's Financial Crises in Nordic Countries.* Suomen Pankki.

HSU, S. (2013): *Financial Crises, 1929 to the Present.* Edward Elgar Publishing.

JOKIPII, T. & B. LUCEY (2007): "Contagion and Interdependence: Measuring CEE Banking Sector Co-movements." *Economic systems* **31(1)**: pp. 71–96.

JONUNG, L. (2010): "Lessons from the nordic financial crisis." In "AEA meeting in Denver," Citeseer.

KAMINSKY, G., R. LYONS, & S. SCHMUKLER (2000): "Economic Fragility, Liquidity, and Risk: The Behavior of Mutual Funds During Crises." *unpublished paper, World Bank* .

KAMINSKY, G. & S. SCHMUKLER (2001): "On Booms and Crashes: Financial Liberalization and Stock Market Cycles." *Washington DC. The World Bank. Policy Working Paper No* **2565**.

KAMINSKY, G. L. & C. M. REINHART (1998): "Financial Crises in Asia and Latin America: Then and Now." *American Economic Review* pp. 444–448.

KAMINSKY, G. L. & C. M. REINHART (2000): "On Crises, Contagion, and Confusion." *Journal of international Economics* **51(1)**: pp. 145–168.

KASHYAP, A. K. & J. C. STEIN (2000): "What Do a Million Observations on Banks Say about the Transmission of Monetary Policy?" *American Economic Review* pp. 407–428.

KAUFMAN, G. G. (2006): "Using Efficient Bank Insolvency Resolution to Solve the Deposit Insurance Problem." *Journal of Banking Regulation* **8(1)**: pp. 40–50.

KIM, W. & S.-J. WEI (2002): "Foreign Portfolio Investors Before and During a Crisis." *Journal of international economics* **56(1)**: pp. 77–96.

Koskenkylä, H. (2000): "The Nordic Countriesâ€™ Banking Crises and the Lessons Learned." *Bank of Finland, Financial Markets Department, Working Paper* **6(00)**.

Lowenstein, R. (2000): *When gGenius Failed: The Rise and Fall of Long-Term Capital Management.* Random House LLC.

Marcus, A. J. & I. Shaked (1984): "The Valuation of FDIC Deposit Insurance Using Option–Pricing Estimates." *Journal of Money, Credit and Banking* **16(4)**: pp. 446–60.

Masson, P. R. (1998): *Contagion–Monsoonal Effects, Spillovers, and Jumps Between Multiple Equilibria.* International Monetary Fund.

Mayes, D. G. (2009): "Did Recent Experience of a Financial Crisis Help in Coping with the Current Financial Turmoil? The Case of the Nordic Countries." *JCMS: Journal of Common Market Studies* **47(5)**: pp. 997–1015.

Milesi-Ferretti, G.-M. & C. Tille (2011): "The great Retrenchment: International Capital Flows during the Global Financial Crisis." *Economic Policy* **26(66)**: pp. 289–346.

Minoiu, C. & J. A. Reyes (2011): *Network Analysis of Global Banking: 1978-2009.* International Monetary Fund.

Mishra, P., K. Moriyama, P. N'Diaye, & L. Nguyen (2014): "The Impact of Fed Tapering Announcements on Emerging Markets." *Technical report*, IMF working paper.

Moe, T. G., J. A. Solheim, & B. Vale (2004): *The Norwegian Banking Crisis.* Norges Bank.

Mølgaard, E. (2003): "Avoiding a Crisis: Lessons from the Danish Experience." *Who Pays for Bank Insolvency* .

Moreno, R. & B. Trehan (2000): "Common Shocks and Currency Crises." .

Morgan, D. P. (2002): "Rating Banks: Risk and Ancertainty in an Opaque Industry." *American Economic Review* pp. 874–888.

PADOA-SCHIOPPA, T. (2004): "Regulating Finance: Balancing Finance and Risk."

PARK, Y. C. & C.-Y. SONG (1998): "The East Asian Financial Crisis: A Year Later." In "ponencia presentada a la Conference on the East Asian crisis. Institute of Development Studies, University of Sussex, Brighton," pp. 13–14. Citeseer.

PEEK, J. & E. S. ROSENGREN (2000): "Collateral Damage: Effects of the Japanese Bank Crisis on Real Activity in the United States." *American Economic Review* pp. 30–45.

PRITSKER, M. (2001): "The Channels for Financial Contagion." In "International financial contagion," pp. 67–95. Springer.

RAJAN, R. G. (2005): "Has Financial Development Made the World Riskier?" .

REINHART, C. & S. CALVO (1996): "Capital Flows to Latin America: Is There Evidence of Contagion Effects?" .

SANDAL, K. (2004): "The Nordic Banking Crises in the Early 1990s – Resolution Methods and Fiscal Costs." *The Norwegian banking crisis* **33**: pp. 77–111.

STRAETMANS, S. (2000): "Extremal Spill–overs in Equity Markets." *Extremes and Integrated Risk Management (London: Risk Books)* **187**: p. 204.

UPPER, C. & A. WORMS (2004): "Estimating Bilateral Exposures in the German Interbank Market: Is There a Danger of Contagion?" *European Economic Review* **48(4)**: pp. 827–849.

VAN RIJCKEGHEM, C. & B. WEDER (1999): "Financial Contagion: Spillovers Through Banking Centers." *Technical report*, CFS Working paper.

VAN RIJCKEGHEM, C. & B. WEDER (2001): "Sources of Contagion: Finance or Trade?" *Journal of International Economics* **54(2)**: pp. 293–308.

WHITT, J. (1999): "The Role of External Shocks in the Asian Financial Crisis." *Economic Review* **(Q2)**: pp. 18–31.

YANG, T. & J. J. LIM (2004): "Competitive Devaluations – Bitter Pill or Bad Medicine? The Case of Thailand." *ASEAN Economic Bulletin* pp. 213–233.