The Dynamics of Bank and Sovereign Credit Risk

Kallestrup, René

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René Kallestrup

The PhD School of Economics and Management

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"The Doctoral School of Economics and Management is an active national and international research environment at CBS for research degree students who deal with economics and management at business, industry and country level in a theoretical and empirical manner".

1 Table of Contents

Preface

This thesis marks the end of my Ph.D studies at the Copenhagen Business School and the Central Bank of Denmark. The thesis contains three empirical articles on bank and sovereign credit risk. Each article is self-contained and can be read independently.

Structure of the thesis

The first article deals with the importance of bank fundamentals for the dynamics of sovereign credit risk. The second article (co-authored with David Lando and Agatha Murgoci) takes a closer look at financial sector linkages and the dynamics of bank and sovereign credit spreads. Finally, the third article (co-authored with David Lando) is a case study on the collapse of the Icelandic banking system.

Acknowledgements

I would like to acknowledge the financial support from Danmarks Nationalbank, the Danish Social Science Research Council and PIMCO. A special thank to David Lando and Mads Stenbo Nielsen at the Copenhagen Business School for the excellent feedback on my ongoing work. Further acknowledgements are found in each article.

René Kallestrup
Copenhagen, January 2012.

Introduction

The Global Financial Crisis which started in 2007 is a defining economic event of our lifetime. Recessions and public bailouts of banking systems have resulted in concerns about the solvency of sovereigns in recent years as many Eurozone countries face substantial fiscal pressures. The exact causes of the Global Financial Crisis are still debated but it is unlikely to be the outcome of one single event. In a review of the Global Financial Crisis based on 21 books on the topic, Lo (2011) summarises the underlying causes and policy prescriptions: *"there is still significant disagreement as to what the underlying causes of the crisis were, and even less agreement as to what to do about it ... Like World War II, no single account of this vast and complicated calamity is sufficient to describe it."* The listed causes range from global capital flows, poor regulation, regulatory capture, inequality, high leverage, skewed economic incentives of borrowers and lenders, etc. Gorton and Metrick (2012) also contain an interesting summary of the literature written in recent years and in "Lessons from the Financial Crisis" edited by Berd (2010) several chapters from academic researchers analyse the ongoing crisis. Article III is a chapter from this book.

Reinhart and Rogoff (2009), Reinhart and Rogoff (2011), and Schularick and Taylor (2012) provide comprehensive historical data which can be used for understanding the context of the Global Financial Crisis. It is evident that the ongoing crisis is wide-ranging in scale but most of the banking crises witnessed in recent years are neither unprecedented nor extraordinary to historical patterns. The authors find macro-financial variables that contain valuable information about the likelihood of future financial crises. For example they find a large increase in debt in advance of financial crises. Reinhart and Rogoff analyse public and private debt whereas Schularick and Taylor focus on aggregate bank loans and the total balance sheet size of the banking sector. In order to respond to the current crisis, Reinhart and Rogoff (2009) suggest further research into "early warning" indicators and detailed monitoring of national macro-financial data. This thesis takes a closer at the importance of some of these indicators for the dynamics of bank and sovereign credit risk. In fact, the Global Financial Crisis was not entirely unexpected. In the words of Rajan (2010): *"It is incorrect to say that no one saw this crisis coming. Some hedge fund managers and traders in investment banks put their money instead of their mouths to work. A few government and Federal Reserve officials expressed deep concern. A number of economists, such as Kenneth Rogoff, Nouriel Roubini, Robert Shiller, and William White, repeatedly sounded warnings about the levels of U.S. house prices and household indebtedness. Niall Ferguson, a historian, drew parallels to past booms that ended poorly. The problem was not that no one warned about the dangers; it was that those who benefited from an overheated economy - which included a lot of people - had little incentive to listen. Critics were often written off as Cassandras or "permabears": predict a downturn long enough, the thinking went, and you would eventually be proved*

right, much as a broken clock is correct twice a day. I know, because I was one of those Cassandras".

Johnson and Kwak (2010) and Stiglitz (2010) find that the largest misaligned incentives were found among "too big to fail" U.S. financial institutions - like the six megabanks Bank of America, JPMorgan Chase, Citigroup, Wells Fargo, Goldman Sachs, and Morgan Stanley - which are large and essential to the functioning of the financial system and the economy. In fact, "too big to fail" appears to have been a global phenomenon. The managements of these financial institutions took excessive risk with implicit government guarantees, knowing that if the worst were to happen they would be rescued by governments.[1] Especially in countries where the banking system is large relative to the size of the economy, bank and sovereign credit risk are tightly related.

Article I addresses the importance of bank fundamentals for sovereign credit risk. Market participants tend to use credit default swaps (CDS) - which are similar to insurance contracts that compensates the buyer for losses in the event of a default - to express opinions on the credit risk of specific reference entities. We argue that the dynamics of sovereign CDS spreads in advanced economies is difficult to understand without modelling fragility in the banking and corporate sector. Fragility in the banking sector has been an important driver of sovereign credit risk in recent years through at least two different channels. First, governments injected capital into or guaranteed liabilities of the banking systems because some individual banks are too-important-to-fail or too-interconnected-to-fail. Second, systemic banking crises often result in recessions which in turn cause lower government revenues, large fiscal deficits and potentially sovereign defaults. In order to separate these factors we need to undertake an econometric analysis of fundamental data such as balance sheet and economic variables since sovereign and bank CDS spreads are likely to be simultaneously determined.

The paper contributes to the extensive empirical literature on the relationship between sovereign credit spreads and macroeconomic variables, fiscal indicators as well as risk indicators in international financial markets by using a comprehensive dataset. For example, Longstaff, Pan, Pedersen, and Singleton (2011) find that sovereign risk is primarily driven by global risk premium factors but their econometric analysis excludes bank fundamentals which we argue are important factors in understanding the dynamics of sovereign credit risk. The article is also related to the extensive literature on systemic banking and sovereign debt crises. Reinhart and Rogoff (2009) show that banking crises most often either precede or coincide with sovereign debt crises as massive private debt is transferred to the public balance sheet and undermine the country's fiscal solvency. The authors focus on both the direct costs of rescuing the financial sector as well as the higher

[1]Lately, commisions in the United Kingdom (the Independent Commission on Banking) and in Switzerland (the Commission of Experts) have made recommendations to address the "too big to fail" issue with banks in their countries.

public deficits due to the economic slowdown following banking crises. In recent years several papers have analysed the interaction of credit spreads on banks and sovereigns as a result of fragility in the financial sector. For example, Acharya, Drechsler, and Schnabl (2011) show that financial sector bailouts and sovereign credit risk are intimately linked. Most existing papers base their conclusions on analyses of financial variables over specific time periods. We complement these studies by focusing on the interactions of CDS spreads on banks and sovereigns with balance sheet variables of national banking systems and the public sector. By modelling credit risk as a result of changes in balance sheet variables we are able to more precisely decompose the dynamics of sovereign CDS spreads into bank and public sector contributions.

Our econometric results have implications for regulating systemic risk and analysing financial stability. First, if the banking system is large relative to GDP as in Switzerland, Ireland, United Kingdom, Sweden, and Denmark it is beneficial to demand extra capital buffers of the financial sector to protect the public balance sheet against contingent liabilities. It is also in line with the recommendations of the Financial Stabilty Board (2011) on additional loss absorbency requirements for systemically important financial banks. In these countries, a rise in bank credit risk can easily cause a 'jump' in sovereign credit risk. Second, if the banking sector's holding of sovereign bonds in the home country is high relative to their capital as in Japan, Italy and Greece it is beneficial to demand limits on their sovereign exposures. In these countries, fiscal problems can easily cause a 'jump' in credit risk for banks headquartered in that country. The importance of bank credit risk is varying across countries and our econometric model performs well for countries where credit risk originates domestically.

Article II shows that financial linkages across borders are priced in the CDS markets beyond what can be explained by exposure to both global and country-specific factors. Financial linkages are measured using Bank for International Settlements (BIS) consolidated banking statistics and these statistics are combined with CDS spreads to construct a risk-weighted foreign exposure measure for banking systems in 17 countries. We also construct another measure which takes into account the entire asset side of banking systems by combining the information on foreign exposures with information on the relative size and riskiness of exposures to domestic government bonds and to other domestic residents. This measure also helps explaining bank CDS premia. While the first measure is relevant for proving that banks' foreign financial exposures are reflected in CDS spreads, the second measure is a better candidate for detecting riskiness of a banking system when the risk arises both from exposure to foreign and to domestic factors.

This paper also supplements Acharya, Drechsler, and Schnabl (2011) in several aspects. They focus on the two-way feedback effect between sovereign and bank credit risk which we strongly confirm but with several important differences in the empirical analysis. While we also consider sovereign risk factors in our explanation of bank CDS

spreads, we in addition include private exposures - both foreign and domestic - in our bank fundamentals. This is important since the bulk of banks' foreign exposures are to the private sector and not sovereigns. The decomposition of bank exposures to which we have access to gives a clear picture of the role of financial linkages in the determination of bank credit risk and the Expected Default Frequency (EDF) measures also add information on the risk of bank assets. In this sense our explanatory variables are closer to true bank fundamentals than bank equity returns used in Acharya, Drechsler, and Schnabl (2011). Furthermore, for the purpose of analysing the role of banking risk for sovereign credit risk, we extend the modelling of government guarantees.

The fact that interlinkages are priced in CDS markets throughout the entire sample may have several explanations. A common practice among hedge funds and risk managers is to hedge exposures through 'proxy hedging'. For example, a bank may wish to hedge emerging market credit risk in Eastern Europe, either because it has exposure to sovereigns itself (as a direct exposure or as counterparty risk in large derivatives contracts) or because it wishes to hedge a large loan exposure in such countries using a 'macro' hedge. A cheaper solution may be to buy protection on Austrian banks which are known to have large exposures in these countries. This would explain the co-movement of bank CDS spreads across countries and why market participants seem to follow these interlinkages carefully.

The De Larosiere Report (2009) advocates the establishment of a common data base containing relevant information on risk exposures of financial institutions and markets, both at the national and international level. The analysis here shows that markets seem to have taken such exposures into account in the pricing of CDS contracts and to the extent that CDS premia do reflect default risk, this is evidence in support of the idea, that such information could help building early warning systems. The insights from the two above articles should be combined to get a better understanding of the dynamics of bank and sovereign CDS spreads. The work was inspired by the systemic banking crisis in Iceland.

Article III is a detailed case study of which culminated in a systemic banking crisis, currency crisis and public debt crisis in late 2008. Strangely, a month before the crisis the IMF (2008) issued a Financial Sector Assessment Program Update claiming that: "[T]he banking system's reported financial indicators are above minimum regulatory requirements and stress tests suggest that the system is resilient." We examine the collapse of the Icelandic banking system as an almost perfect example of how a dysfunctional and overstretched financial system can sink a country into a deep systemic crisis. We follow step by step the growth of the bubble of banking in Iceland, analyse the flawed policies and procedures that misled the international creditors, rating agencies and regulators into believing that these banks were indeed worthy of an investment grade (and even triple A) ratings, and sort through the aftermath of their collapse to gather lessons for

others on how to avoid the fate of the Icelandic banking system. Our analysis is based on a wide range of publicly available statistics and information.

There are many features of the Icelandic banking system leading up to the collapse that are very similar to previous banking crises. The warning signals that have preceded banking crises in the past - as seen in Reinhart and Rogoff (2009) and Schularick and Taylor (2012) - were present in Iceland as well. Some were more extreme than in any other previous banking crises when measured against the size of the Icelandic economy. It is, however, astonishing that the build-up of the banking system could reach such proportions given the fact that in 2006 the system was already under heavy pressure from markets. Some investors had already then questioned both the business models of Icelandic banks and the huge imbalances in the Icelandic economy. There were several factors that made the continued build-up possible. First, sovereign support, in terms of both promised government support and central bank liquidity provision against dubious collateral, played a key role. Second, the supervision of banks in Iceland was extremely weak and did not react to questionable business practices that authorities could have detected at the time. These practices, for example, meant that real leverage was much higher than reported. Third, credit ratings were too high, in part because the agencies overestimated the value of the sovereign support and because they relied on accounting reports, in which assets and profitability were inflated because of inadequate loan loss provisioning.

Briefly summing up, the overall purpose of this thesis is to gain further understanding of bank and sovereign credit risk. The first article is about the importance of domestic bank fundamentals for the dynamics of sovereign credit risk. The second article takes a closer look at financial sector linkages and the dynamics of bank and sovereign credit spreads. Finally, the third article is a case study on the collapse of the Icelandic banking system. The three articles provide new insights into understanding interesting bank and sovereign aspects of the Global Financial Crisis.

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Summary

This section contains English and Danish summaries of the three articles that comprise the thesis.

ENGLISH SUMMARY

Article I: The Importance of Bank Fundamentals for Sovereign Credit Risk
The first article challenges the general view on sovereign credit risk which traditionally has been analysed through the lens of macroeconomic and public debt variables. We argue that the dynamics of sovereign credit risk depends critically on fragility in the banking sector. This paper decomposes sovereign and bank credit risk into bank and public sector contributions based on an econometric analysis of balance sheet variables. In recent years, we find that fragility in the banking sector has been an important driver of sovereign risk. Furthermore, bank credit risk has been influenced by sovereign risk. The paper also discusses implications for detecting systemic risk across countries and over time.

Article II: Financial Sector Linkages and the Dynamics of Bank and Sovereign Credit Spreads
(co-authored with David Lando and Agatha Murgoci)
The second article shows that financial linkages across borders are priced in the CDS markets beyond what can be explained by exposure to common factors. Information on the relative size and riskiness of aggregate exposures of banks in one country to countries abroad is used to construct a dynamic measure of the risk arising from banks' foreign exposures. We also construct a new measure which in addition takes into account the relative size and riskiness of bank exposures to domestic government bonds and other domestic residents. The two measures help explaining the dynamics of bank CDS premia after controlling for country specific and global risk factors. Finally, a dynamic measure of the size of the implicit guarantee, that the sovereign may be assumed to extend for the domestic banking system, strongly impacts sovereign CDS premia.

Article III: The Collapse of the Icelandic Banking System
(co-authored with David Lando)
The third article analyses the collapse of Iceland's three largest banks in the Autumn 2008 which is the biggest banking failure relative to the size of an economy in modern history. We show that commonly used early warning indicators of banking crises were very strong in the case of Iceland and document how the Icelandic banks managed to continue their aggressive growth despite a funding crisis in early 2006. Strong reported financial key figures masked the true riskiness of the Icelandic business model and the

extreme concentration risk in the financial system. In addition, investors and rating agencies overestimated the value of potential sovereign support from a country whose fiscal capacity was limited compared to the size of the banks' assets. Helped by strong credit ratings and an implicit sovereign guarantee, the banks were able to fund their risky business model through foreign deposits and by accessing bond markets outside of Europe. While central bank liquidity facilities have been critical in saving the global banking system, the Icelandic case study also reveals how such facilities may prolong a crisis, make it deeper and ultimately contribute to a crash of a floating exchange rate.

DANSK RESUMÉ

Artikel I: Vigtigheden af Fundamentale Bank Variable for Kreditrisikoen på Stater

Den første artikel udfordrer det traditionelle syn på staters kreditrisiko, som typisk er blevet analyseret ved hjælp af makro og gældsrelaterede variable for den offentlige sektor. Vi viser, at dynamikken i staters kreditrisiko afhænger af banksektorens finansielle sårbarhed. Dette papir dekomponerer kreditrisikoen for stater og banker i en del fra banksektoren og den offentlige sektor baseret på en økonometrisk analyse af balancevariable. I de senere år har banksektorens sårbarhed været en vigtig drivkraft bag kreditrisikoen for stater. Endvidere har kreditrisikoen for banker været påvirket af gældsrelaterede variable i den offentlige sektor. Papiret diskuterer også implikationer for at opfange systemisk risiko på tværs af lande og over tid.

Artikel II: Bankers Eksponeringer og den Dynamiske Kreditrisiko for Banker og Stater

(medforfattere: David Lando and Agatha Murgoci)

Den anden artikel viser, at bankers eksponeringer på tværs af grænserne er indpriset i CDS markedet udover hvad kan forklares af fælles faktorer. Oplysninger om den relative størrelse og risikoen på den samlede eksponering af banker i et land mod andre lande kan bruges til at konstruere et dynamisk mål for den risiko, som opstår som følge af bankers udenlandske engagementer. Vi konstruerer også et mål, der ydermere tager hensyn til den relative størrelse og risiko på bankers eksponeringer mod indenlandske statsobligationer samt indenlandske private kunder. Begge mål hjælper med at forklare dynamikken i bankernes CDS præmier efter der er kontrolleret for landespecifikke og globale risikofaktorer. Ydermere viser vi at et dynamisk mål for størrelsen af den implicitte garanti, som staten må antages at give til det indenlandske banksystem, påvirker CDS præmien for stater.

Artikel III: Den Systemiske Bankkrise i Island

(medforfatter: David Lando)

Den sidste artikel analyserer sammenbruddet af Islands tre største banker i efteråret 2008, som er det største bankkollaps i forhold til størrelsen af en økonomi i nyere tid. Vi viser, at almindeligt anvendte tidlig "varslingsindikatorer" for bankkriser var meget tydelige i Island, og vi dokumenterer, hvordan de islandske banker formåede at fortsætte deres aggressive vækst på trods af en mindre finansieringskrise i begyndelsen af 2006. Stærke økonomiske nøgletal tilslørede den sande risiko ved den islandske forretningsmodel og den ekstreme koncentration af risiko i det finansielle system. Ydermere overvurderede investorer og kreditvurderingsbureauer værdien af eventuel støtte fra en stat, hvis skattemæssige kapacitet var begrænset i forhold til størrelsen af bankernes aktiver. Hjulpet af gode kreditvurderinger og en implicit statsgaranti, så var bankerne i stand til at finansiere deres risikable forretningsmodel via udenlandske indskud og adgang til obligationsmarkeder uden for Europa. Mens centralbankers likviditetsfaciliteter har været kritiske for at redde det globale banksystem, så viser det islandske "case study" også hvordan sådanne faciliteter kan forlænge en krise, gøre den dybere og i sidste ende bidrage til et sammenbrud af en flydende valutakurs.

The Importance of Bank Fundamentals for Sovereign Credit Risk

René Kallestrup *

January 2012

Abstract

Traditionally, sovereign credit risk has been analysed through the lens of macroeconomic and public debt variables. We argue that the dynamics of sovereign credit risk depends critically on fragility in the banking sector. This paper decomposes sovereign and bank credit risk into bank and public sector contributions based on a statistical analysis of balance sheet variables. In recent years, fragility in the banking sector has been an important driver of sovereign risk. Furthermore, bank credit risk has been influenced by sovereign risk. This paper also discusses implications for detecting systemic risk across countries and over time.

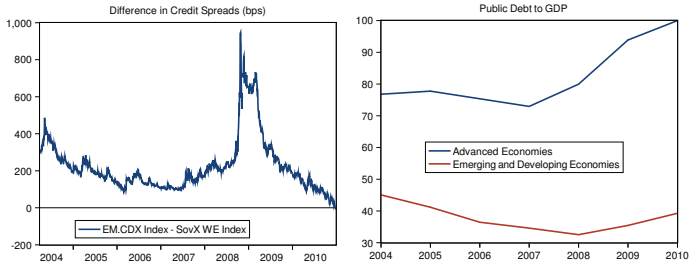
Credit risk, banks, sovereign risk; **JEL:** G01; G15; G21

* The author is at the Department of Finance, Copenhagen Business School, Solbjerg Plads 3, DK-2000 Frederiksberg, Denmark (e-mail: rk.fi@cbs.dk). I am grateful for helpful discussions with Mads Stenbo Nielsen, David Lando, Lasse Heje Pedersen, Allan Timmermann, Jesper Lund, Malene Kallestrup Lamb, Jesper Rangvid, Patrick Augustin, and Rune Mølgaard.

1 Introduction

Sovereign credit risk has typically been associated with emerging markets. In the aftermath of the Global Financial Crisis, however, credit spreads on sovereign indices have been similar in advanced and emerging market economies as seen in Figure 1. It has happened as public debt to GDP in advanced economies has risen substantially whereas it has remained fairly stable in emerging markets.[1]

Figure 1: **Sovereign Credit Risk in Emerging Market vs Advanced Economies**



The difference between the CDX Emerging Market Index and SovX Western Europe Index has narrowed in 2010 (left-hand panel). A negative number implies sovereign CDS spreads in advanced economies are higher than in emerging markets. It partly reflects diverging trends in public debt to GDP in emerging markets and advanced economies (right-hand panel). Source: JP Morgan DataQuery and IMF World Economic Outlook. Before the launch of the SovX in Q3 2009 we use a theoretical index reported by JP Morgan.

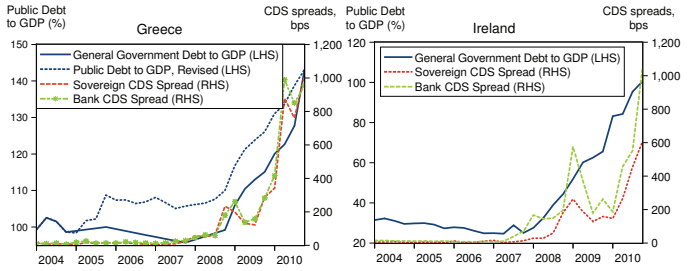
The literature on sovereign credit risk is extensive but there have been few studies on the determinants of the dynamics of sovereign credit risk in advanced economies. Traditionally, sovereign credit risk has been analysed through the lens of fiscal and macroeconomic variables. The story fits well in the case of Greece as seen in Figure 2 where credit spreads and public debt to GDP seem to be positively related. Figure 3, however, indicates that in order to find determinants of the dynamics of sovereign credit default swap (CDS) spreads it it is not sufficient to focus on debt to GDP ratios of the public sector. For example, public debt to GDP barely rises in Austria and Denmark whereas sovereign CDS spreads in these countries widen sharply. Furthermore, the figure shows how sovereign credit risk in advanced economies is correlated with the health of the banking sector. This paper analyses bank fundamentals and argue that the dynamics of sovereign credit risk depends critically on fragility in the banking sector. We add additional insights to the conclusions in Longstaff, Pan, Pedersen, and Singleton (2011) who argue that sovereign risk is primarily driven by global risk premium factors.[2]

[1] World public debt market has increased from USD 25.6 trillion in 2006 to USD 41.4 trillion in 2010 and it is an important asset class that accounts for 66 percent of world GDP as shown in Appendix A. The public sector refers to the 'general government' and the private sector to 'non-financial corporations' and 'households'.

[2] The authors find that the majority of the variation in sovereign credit spreads is linked to global

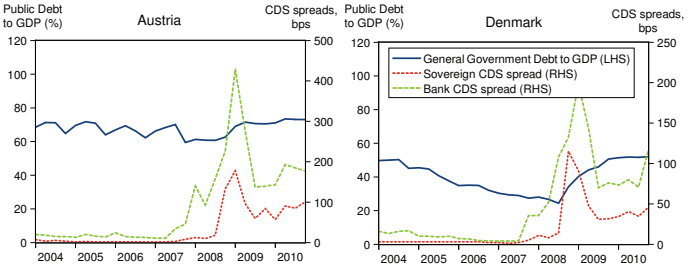
Their econometric analysis excludes bank fundamentals which are important factors in understanding the dynamics of sovereign credit risk.

Figure 2: **Sovereign Debt and Credit Spreads in Greece and Ireland**



The Greek general government debt to GDP as well as CDS spreads for the Greek government and the average of two largest banks. In April and October 2010, Greek authorities made substantial revisions to the historical government deficit and debt figures as shown by the European Commission (2010). See Figure 4 for a comment on Ireland.

Figure 3: **Sovereign Debt and Credit Spreads in Advanced Economies**



Data is shown for two advanced economies: Austria and Denmark. We see that sovereign and bank CDS spreads are co-moving. Furthermore, in order to find determinants of the dynamics of sovereign CDS spreads it is not sufficient to focus on debt to GDP ratios of the public sector.

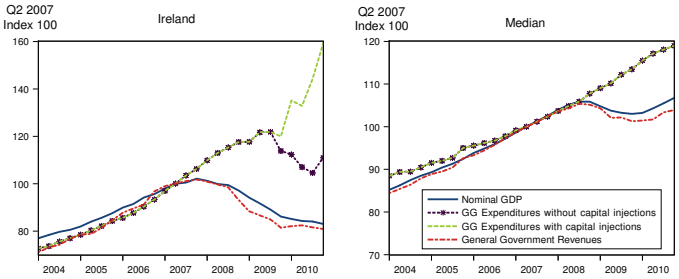
Fragility in the banking sector has been an important driver of sovereign credit risk in recent years through at least two different channels. First, governments injected capital or guaranteed liabilities on the banking systems because some individual banks are too-important-to-fail or too-interconnected-to-fail. For example, the governments in Ireland and Iceland ran substantial fiscal deficits and witnessed a sharp rise in public debt on the back of assistance to help their banking systems. The deficit-increasing (and debt-increasing) impact of banking sector capital injections in Ireland is seen on the left hand side in Figure 4.[3] In addition, it is important to focus on the public sector's off-balance

factors such as the return on the US stock market and a US high-yield index.

[3]Capital injections into the financial sector are considered government expenditures and not acqui-

sheet liabilities. In public accounts, government guarantees of the banking system are treated as contingent liabilities and are not recorded on the balance sheets unless they are absolutely certain to be called upon. For example, the Irish public sector's contingent liabilities relative to GDP peaked at almost 196% of GDP in 2008 as the government guaranteed the liabilities of the domestic banks.[4]

Figure 4: **The Health of the Banking System influences the Public Sector**



In Ireland, massive capital injections into the financial sector were deficit-increasing for the general government. It indicates that the health of the banking system has influenced the public sector (left-hand panel). Public revenues decreased during the Global Financial Crisis in all advanced economies and expenditures were difficult to cut back in the economic downturn (right-hand panel). The median is based on a sample of 19 advanced economies as explained in section 3.

Second, in a comprehensive historical study Reinhart and Rogoff (2009) present evidence that systemic banking crises often result in recessions which in turn result in lower government revenues, large fiscal deficits and potentially sovereign defaults. In fact, they find that the slower growth after a financial crisis is a more important driver of the rise in public debt than the rescuing of the financial sector. Furthermore, Cecchetti, Kohler, and Upper (2009) find that banking crises coincide with a sharp contraction in economic activity on the back of lower credit availability and a fall in confidence indicators. Both studies point to compelling evidence of a causal link between the banking crises starting in 2007 and the associated economic crises. In Figure 4 on the right, we show that a fall in nominal GDP in advanced economies is co-moving with lower public revenues whereas public expenditures are difficult to cut back to balance the public budget in a recession (as they act as fiscal stabilisers).[5]

The paper is also related to an important paper by Acharya, Drechsler, and Schnabl

sition of equity by Eurostat accounting rules if they do not yield a sufficient rate of return according to EU 'state aid rules'. In 2009 to 2010, Irish public capital injections amounted to 29.8% of GDP, the impact on debt was 25.8% of GDP and on the deficit 22.5% of GDP according to the Central Bank of Ireland (2011).

[4]Guarantees on bank deposits are not included in the 196%. Other types of financial support schemes include purchases of bank assets, liquidity provisions, etc.

[5]From 2008 to 2009, the decline is government revenues is sharper than the fall in nominal GDP. Eurostat (2011b) suggests that the sharper fall in government revenues compared to GDP is not necessarily the result of a change in fiscal policy but can be due to 'automatic stabilisers' in the taxing system.

(2011) who provide empirical evidence of a two-way feedback between bank and sovereign credit risk using data on CDS spreads before and after the explicit bailouts of the banking sectors across countries around Q4 2008. For example, the authors find that sovereign CDS spreads after public bailouts of banking systems can be explained by pre-bailout public debt to GDP as well as pre-bailout CDS spreads on domestic banks. Our paper adds additional insights into their analysis as we show a dynamic decomposition of sovereign CDS spreads into bank and public sector contributions. In order to separate these effects we need to undertake an econometric analysis of fundamental data such as balance sheet and economic variables since sovereign and bank CDS spreads are likely to be simultaneously determined. We argue that a banking system's assets pledged as collateral in short-term repo transactions with central banks can be seen as a time-varying measure of public bailouts.[6] If commercial banks obtain most of their short-term funding from central banks - for instance using domestic bonds as collateral - it tends to signal that banks have funding liquidity difficulties.

Likewise CDS spreads are decomposed into bank and public sector contributions based on a panel econometric analysis of balance sheet variables. These results are broadly similar to Acharya, Drechsler, and Schnabl (2011) who base their econometric analysis on market-based indicators. There are several reasons why a rise in sovereign credit risk may spill-over into bank credit risk in the country where the bank is headquartered. First, banks can experience a direct loss on their holdings of government bonds. Second, banks may see a reduction in systemic support uplifts from existing explicit or implicit government guarantees. Third, few banks have a credit rating above the home government and they thus benefit from systemic support from the government in the case of problems. Hence, a rise in sovereign credit risk can directly be transferred to the banking system. Nevertheless, a strong link is often the result of banks' poor credit risk assessments of the domestic government. Domestic banks can relatively easily protect themselves against sovereign credit risk by reducing their reliance on the public sector in the first place (or buy credit protection on the domestic government). Furthermore, systemic support uplifts of the banking systems by the rating agencies are often related to problems in the banking sector in the first place.

Our econometric results have implications for regulating systemic risk and analysing financial stability. First, if the banking system is large relative to GDP as in Switzerland, Ireland, United Kingdom, Sweden, and Denmark it is beneficial to demand extra capital buffers of the financial sector to protect the public balance sheet against contingent liabilities. In these countries, a rise in bank credit risk can easily cause a 'jump' in sovereign credit risk. The Basel II or Basel III accords on minimum bank capital do not act as an effective defense against systemic banking crises. Second, if the banking sector's holding of sovereign bonds in the home country is high relative to their capital as in Japan,

[6]Central bank seigniorage revenue is transferred to the general government through profits and the government normally recapitalises the central bank in the case of losses.

Italy and Greece it is beneficial to demand limits on their sovereign exposures. In these countries, fiscal problems can easily cause a 'jump' in credit risk for banks headquartered in the that country.

The remainder of the paper is organised as follows. Section 2 comments on the related literature. Section 3 presents the data and explains why our dataset is important for finding determinants bank and sovereign CDS spreads. Section 4 analyses the empirical relationship between balance sheet variables and bank as well as sovereign CDS spreads. Section 5 finds that the significant variables identified in section 4 also explain distressed sovereign events. Section 6 concludes.

2 Related literature

This paper is related to several strands of the existing literature: (i) the empirical literature on the determinants of sovereign credit risk and (ii) recent empirical studies of the interaction of systemic banking and sovereign debt crises. First, the paper contributes to the extensive empirical literature on the relationship between sovereign credit spreads and macroeconomic variables, fiscal indicators as well as risk indicators in international financial markets. The dataset in this paper, however, is more comprehensive than in recent papers on the determinants of sovereign credit spreads such as Alexopoulou, Bunda, and Ferrando (2009), Bellas, Papaioannou, and Petrova (2010), Baldacci, Gupta, and Mati (2008), Barbosa and Costa (2010), and Haugh, Ollivaud, and Turner (2009). These studies find important determinants of credit spreads in specific countries and for certain time horizons - either in emerging markets or a few Euro Area countries - but they do not agree on stable and significant determinants of sovereign credit spreads. Longstaff, Pan, Pedersen, and Singleton (2011) find that sovereign risk is primarily driven by global risk premium factors but their econometric analysis exclude bank fundamentals which we argue are important factors for understanding the dynamics of sovereign credit risk in most countries.[7]

Second, the article is related to the extensive literature on systemic banking and sovereign debt crises. Reinhart and Rogoff (2009) as well as Reinhart and Rogoff (2011) show that banking crises most often either precede or coincide with sovereign debt crises as massive private debt is transferred to the public balance sheet and undermine the country's fiscal solvency. The authors focus on both the direct costs of rescuing the financial sector as well as the higher public deficits due to the economic slowdown following banking crises. In recent years several papers have analysed the interaction of

[7]Panizza, Sturzenegger, and Zettelmeyer (2009) survey the sovereign debt literature and focus on how sovereign debt can exist in spite of the lack of a straightforward legal enforcement. Interestingly, Acharya and Rajan (2011) show in theoretical model that the direct cost of sovereign default is large, and default is only an option when the country simply does not have the political and economic ability to raise the revenues needed to repay debt. For example, governments issuing debt in own currency face 'collateral damage' to their banks if they default on their debt.

credit spreads on banks and sovereigns as a result of fragility in the financial sector.[8] Dieckmann and Plank (2010) show that global and domestic equity markets have high explanatory power for the behaviour of sovereign CDS spreads. Mody (2009) and Sgherri and Zoli (2009) argue that the differentiation in sovereign credit spreads across countries was caused mainly by differences in the health of the domestic financial sector following the rescue of Bear Stearns and the failure of Lehman Brothers in 2008. Attinasi, Checherita, and Nickel (2009) link wider sovereign spreads to the announcements of bank rescue packages. Ejsing and Lemke (2011) find that sovereign and bank CDS spreads have become increasingly integrated since the rescue packages in 2008. Acharya, Drechsler, and Schnabl (2011) show that financial sector bailouts and sovereign credit risk are intimately linked. Our paper complements and extends the econometric results in these studies which primarily base their conclusions on analyses of financial variables over specific time periods. We differ from these studies by focusing on the interactions of CDS spreads on banks and sovereigns with balance sheet variables of national banking systems and the public sector since 2004. By focusing on credit risk as a result of changes in balance sheet variables we are able to more precisely decompose the dynamics of sovereign CDS spreads into bank and public sector contributions. Finally, Kallestrup, Lando, and Murgoci (2011) address the co-movement of credit default swaps on banks and sovereigns across countries based on banks' financial exposures using CDS spreads and Moody's expected default frequencies (EDFs) as measures of credit risk. This paper models bank credit risk directly as a function of balance sheet variables and supplements the latter analysis.[9]

3 Data Description

Our sample covers 19 advanced economies over the period Q1 2004 to Q4 2010 where we have both bank and sovereign CDS spreads as well as quarterly bank and sovereign balance sheet data. The data is quarterly since balance sheet variables are scarcely available on a monthly frequency. The countries included are Austria, Australia, Belgium, Switzerland, Germany, Denmark, Spain, France, United Kingdom, Greece, Ireland, Iceland, Italy, Japan, South Korea, Netherlands, Portugal, Sweden, and United States.[10]

[8] Gray, Merton, and Bodie (2007a), Gray, Merton, and Bodie (2007b), and Gray and Malone (2008) provide a structural framework for analysing risk transfers from the corporate sector via the banking sector and to the government.

[9] This paper has not attempted to predict credit risk ahead of time as done in the literature on early warning indicators of financial fragility. Frankel and Saravelos (2010) find that crisis incidence indicators have performed well in predicting vulnerabilities in 2008-09 based on macro-financial variables identified as successful in the past. A classical article worth mentioning that focuses on generating early-warning signals before changes in credit risk include Kaminsky, Lizondo, and Reinhart (1998) who propose monitoring several indicators that tend to exhibit unusual behaviour prior to crises. Goldstein, Kaminsky, and Reinhart (2000) also conduct a lot of empirical tests of early warning indicators and conclude that many in-sample leading indicators are effective out-of-sample.

[10] For Iceland, we include the CDS for the sovereign after the domestic operations of the banks were taken by the Icelandic government in Q3 2008. Norway is not included since bank balance sheet data is

The extended sample includes 38 countries where we have balance sheet data but not necessarily bank and sovereign CDS data.[11] Initially, we take a look at the credit spreads for the banking and sovereign sector.

3.1 Credit Spreads

A CDS contract is similar to an insurance contract that compensates the buyer for losses in the event that a bank or sovereign for example does not repay its debt.[12] The contract is explained in more details in Duffie (1999) and Longstaff, Mithal, and Neis (2005). If the 5-year CDS spread on Greece is 1000 basis points the party buying credit protection pays the seller a fixed spread of 1000 basis points per year until either a credit event occurs on the reference entity or for a term of five years. In the case Greece pays back its debt, the protection seller does not make a payment to the protection buyer. If Greece does not pay back its debt, the protection seller pays the buyer the difference between the par value of the bond and post-default value of a specific bond (determined in an auction specified by the International Swaps and Derivatives Association, ISDA). Hence, the protection buyer is sure to get the par value back on the bond (in absence of a basis risk).

In this paper, the CDS spread is the object of study, a premium that may reflect both fundamental credit risk, traders risk aversions and liquidity conditions in the CDS market.[13] Counterparty value adjustment (CVA) desks of investment banks are main players in the CDS markets since they are natural buyers of credit protection on sovereign and banks across countries in order to hedge exposures from mark-to-market fluctuations.[14] We prefer CDS spreads rather than country-specific bond spreads since it is difficult to find a risk-free interest rate to subtract from the sovereign yield. In addition, bond yields may be substantially influenced by liquidity factors. One can also analyse credit ratings as an alternative to credit spreads. However, CDS spreads incorporate information significantly faster than credit ratings as for example documented in Flannery, Houston, and Partnoy (2010).[15] Since CDS spreads may be driven by other factors than direct default protection, we also analyse the initiation of IMF-supported programs as a binary indicator of distressed sovereign risk in section 5 in order to make sure that our econometric

not updated in the IMF International Financial Statistics database.

[11]The additional 19 countries are Bulgaria, Brazil, Canada, Chile, Czech Republic, Estonia, Finland, Hungary, Israel, Lithuania, Latvia, Mexico, Poland, Romania, Russia, Slovenia, Slovakia, Turkey and South Africa.

[12]Credit events for Western European sovereign CDS are restructuring, failure to pay and repudiation/moratorium. See Morgan Stanley (2011) for further details.

[13]See Longstaff, Mithal, and Neis (2005) for arguments that the contractual nature of credit default swaps makes them far less sensitive to liquidity. Fitch Solutions (2011) provides a liquidity score for individual CDS spreads. Gandhi, Longstaff, and Arora (2011) show that counterparty credit risk is a very small component of the CDS spread due to collateralisation of swap liabilities.

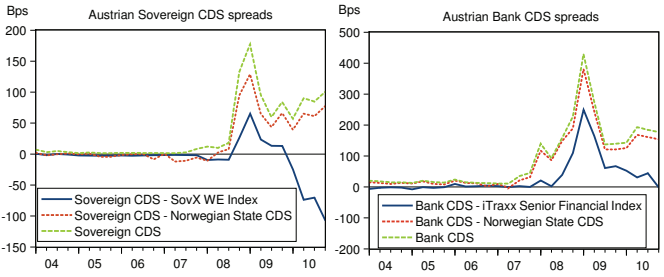
[14]See also the Bank of England (2010) and the Treasury Borrowing Advisory Committee (2010).

[15]Credit ratings are designed to be more stable over time based on an assessment of default risk over long time horizons. IMF (2010) and Jaramillo (2010) survey the literature on the determinants of credit ratings.

results primarily are driven by expected loss considerations and not risk premia.

The pricing data for credit default swaps are obtained from CMA which sources their information on executable and indicative prices directly from the largest and most active credit investors in the OTC market. There are some holes in the data sample in the early period and they are filled with the Fitch CDS Pricing source. Table 2 and table 3 in Appendix B contain summary statistics of sovereign and bank CDS spreads for the core sample. The measure of sovereign risk is quarter-end midmarket 5-year sovereign credit spread. Our paper investigates determinants of the sovereign credit spread beyond what can be explained by global factors or risk premia.[16] We focus on explaining observed values of sovereign CDS spreads against a benchmark inspired by traditional tests of capital asset pricing models. Initially, we considered the 5-year iTraxx SovX Western Europe index - which comprises 15 equally weighted midmarket sovereign constituents from the Eurozone region plus Denmark, Norway, Sweden and the United Kingdom - as a benchmark. However, sovereign spreads in a low risk country will be distorted by looking at this measure as seen in Figure 5. For example, the excess spread is tightening in Austria even though sovereign fundamentals are not improving. Hence, our preferred benchmark is the sovereign CDS spread on Norway where the public debt is more than minus 150 percent of GDP in 2010 (that is public assets are much higher than the outstanding gross debt of 55 percent of GDP). As a robustness check in section 5 we include time fixed effects in the estimation instead of measuring the CDS spreads against a benchmark. It turns out that the chosen benchmark is highly correlated with time fixed effects.

Figure 5: **The Explanatory Variable**



This paper focuses on finding determinants of the excess credit spreads which are not driven by global risk premia. For Austria we plot the 5-year CDS spreads of the sovereign against the 5-year iTraxx SovX Western Europe index and against the sovereign CDS on the large creditor nation Norway (left-hand panel). Furthermore, for Austria we plot the average 5-year CDS spreads of the two largest banks against the 5-year iTraxx Senior Financial Index and against the Norwegian government (right-hand panel).

The measure of credit risk in the banking sector is the average 5-year CDS spreads for

[16]Longstaff, Pan, Pedersen, and Singleton (2011) argue that sovereign risk is primarily driven by global risk premium factors.

two largest banking groups measured by the book value of assets in the country.[17] Again, we also want to find determinants of bank credit spreads minus a benchmark. A reasonable benchmark is the iTraxx Senior Financial Index which comprises 25 equally-weighted financial entities in Europe and includes banking groups in Switzerland, Germany, Spain, France, United Kingdom, Italy and Portugal. Time fixed effects turn out to be highly correlated with the chosen benchmark as seen in section 5 on robustness checks.

Table 4 contains a list with the banks included and Table 5 reports net notional of CDS contracts outstanding on the respective governments and banking groups headquartered in the given country. It is noteworthy that the CDS notional on a sovereign tends to be substantially larger than on the banks in the country. It is the case even for countries with low amount of public debt to GDP (gross and net) and where the banking sector is much larger than the size of the economy (for example in Denmark, Sweden and the Netherlands, public debt is low but the largest bank headquartered in the country accounts for close to 200% of GDP). In countries where the sovereign CDS spread is lower than bank CDS spread, data for the notional CDS outstanding suggests that proxy hedging of credit risk - i.e. hedging through correlated but 'cheaper' hedging vehicles - via the sovereign CDS spread is a common practice as argued in Kallestrup, Lando, and Murgoci (2011).[18] The next sections focus on finding determinants of changes in excess credit spreads which are not driven by global risk premia.

3.2 Bank Credit Risk Explanatory Variables

The dynamics of bank credit risk can be difficult to model since banks tend to have a complex capital structure. Fundamental credit risk in the banking sector is often linked to various modifications of the so-called CAMELS variables based on banks' balance sheets and income statements: Capital adequacy, Asset quality, Management, Earnings, Liquidity, and Sensitivity to market risk (see e.g. FRBSF Economic Letter (1999)). There is no consensus on how to combine the CAMELS variables into an overall credit assessment, though. Furthermore, the variables have severe limitations in predicting bank failures as documented by King, Nuxoll, and Yeager (2006) and Davis and Karim (2008). The rating agencies have developed their own rating methodologies based on related quantitative and qualitative indicators to assess bank stand-alone ratings and various uplift to the ratings based on for instance systemic support from the government

[17] The results are robust to including more banks CDS spreads in the study but there are problems about availability of time series going back to 2004. For Denmark we use the CDS on Danske Bank only.

[18] A part of the rise in sovereign CDS contracts is likely to reflect hedging of credit risk of sovereign counterparties who are not posting collateral in, for example, large interest rate and currency swap transactions with banks. Association for Financial Markets in Europe (2011) documents that expected potential exposure (EPE) of dealers to European sovereigns may total as much as USD 70bn or around 50 percent of net notional CDS contracts outstanding on these reference entities. However, other factors must also be at work since the net notional CDS amount on the Swedish government is still higher than on the domestic banks despite the fact that the Swedish Debt Office uses bilateral Credit Support Annex (CSA) agreements.

(see Moody's (2007) and Standard & Poor's (2011)).

In this paper we focus on relating banks' credit risk to macro-financial variables such as aggregated national bank balance sheet variables. An analysis of the components of national banking systems' balance sheets is likely to reveal more information than just measuring the total size of banking systems.[19] In particular, national balance sheet variables of banks are reported by Allen, Rosenberg, Keller, Setser, and Roubini (2002) and Rosenberg, Halikias, House, Keller, Nystedt, Pitt, and Setser (2005) to contain important information before systemic crises in emerging markets. Below we go through our data and how the macro-financial variables are expected to be related to the dynamics of credit spreads. The bank balance sheet variables are based on cross-country comparable data from the IMF International Financial Statistics (IFS) and most of the balance sheet variables are deflated by domestic gross domestic product at current prices.[20]

Assets

Domestic banking assets are split into claims on the private sector in the country, claims on the domestic general government and the domestic central bank, as well as claims on non-residents.

- Private sector credit includes banks' domestic lending to households and non-financial corporations and holding of other debt instruments. High credit growth may deteriorate the asset quality as this is an indicator of lower marginal asset quality of the banks' loan portfolios. The asset quality of the domestic banking sector's private claims is likely to be influenced by the evolvement of macroeconomic variables and financial variables. As macro-financial variables we include real GDP, the unemployment rate, real house prices and measures of the health of the real estate sector. The latter is measured as the median expected default frequency (EDF) of firms associated with real estate or construction in the country.[21] A main part of banks' assets are collateralised with some kind of residential or commercial property.[22] We do not use EDFs for the banking sector as Moody's (2010) shows

[19] Gerlach, Schulz, and Wolff (2010) analyse the effect of banking systems on credit spreads. The authors conclude that in normal times countries with large financial sectors show lower credit spreads than countries with small financial sectors whereas sovereign risk of countries with large financial sectors increases at a higher pace when the risk of a banking crisis becomes imminent.

[20] We refer to banks corresponding to where the IMF International Financial Statistics Database use the term "other depository corporations" that consists of all resident financial corporations (except the central bank) that issue liabilities included in the national definition of broad money. Other financial corporations are not included in our dataset due to the lack of cross-sectional comparable data. The IMF data is consolidated by the banking sector and net out domestic interbank financial claims and liabilities. It should not be confused by the consolidation principles based on the ownership of the individual banking institutions underlying the supervisory process.

[21] The EDF data is borrowed from Kallestrup, Lando, and Murgoci (2011).

[22] IMF Financial Soundness Indicators provide data on residential and commercial real estate loans (including collateralised by commercial real estate) to total loans for certain countries. IMF's Financial Soundness Indicators provide data on residential and commercial real estate loans (including collateralised by commercial real estate) to total loans for certain countries. In advanced economies they account for

that the level of the EDF severely underestimate the true riskiness of the banking sector.

- Banks are for example exposed to the domestic sovereign through holdings of government bonds. In case the value of the government bonds falls in the secondary market, there is a fall in mark-to-market value of the bank's assets as shown. Banks' claims on the government and claims on non-nationals - banks, non-banks and governments - are examined in Kallestrup, Lando, and Murgoci (2011).

Liabilities

It is also interesting to analyse the composition of the banking system's aggregated liabilities. Liabilities are split into liabilities to the domestic central bank[23], liabilities to the domestic general government, short-term and long-term external liabilities, deposits as well as the book value of shares and other equity.

- If commercial banks obtain most of their short-term funding from central banks - for instance using domestic bonds as collateral - it tends to signal that banks have funding liquidity difficulties. Central bank funding is also interesting since central banks book collateral at market value and banks are subject to margin calls if there is a fall in market value. Short-term collateralised funding by central banks reduce the risk of bank default because of funding liquidity but it often does little to reduce the long-run probability of default considerably against the higher loss given default. Assets pledged as collateral matters for the pricing of CDS spreads on unsecured debt as credit spreads should reflect the lower recovery in the case the bank defaults. Hence, the magnitude of short-term collateralised loans with central banks is expected to be positively related to the dynamics of banks' credit spreads. These loans are usually the symptom of deterioration in asset quality rather than the cause of the rise in credit risk. Along the same lines, Diamond and Rajan (2001) and Benmelech and Dvir (2011) argue that short-term borrowing may be optimal response to weak fundamentals when banks find it hard to secure long-term funding.

  The central bank funding data is published for aggregated banking systems and the individual banks are often not willing to disclose the amount. In our data period central bank lending has been short-term (less than one-year) whereas three-year refinancing operations for example were introduced by the Eurosystem and national central banks in late 2011. Outside our data period it is probable that the introduction longer-term repo transactions with central banks may have contributed

around 40% of total loans on average.

[23]In United Kingdom we use reserve repos from the Bank of England's assets and in Australia we use total central repo assets from the Reserve Bank of Australia.

to a fall in the probability of default more than raising the severity of loss as it alleviates long-term funding liquidity risks.

- In countries with more total short-term external debt (in the banking, sovereign and private sector), empirical studies tend to find a greater likelihood of a crisis. External debt is liabilities to non-residents, where residency is defined in relation to a geography. According to this definition it does not matter whether the debt is denominated in foreign or domestic currency. Short-term external debt is defined as debt having an original maturity of less than one year.[24] Much of the earlier sovereign empirical research has primarily focused on total short-term external debt and crisis incidence in emerging countries (see for example Rodrik and Velasco (1999), Bussiere and Mulder (1999) and Kaminsky, Lizondo, and Reinhart (1998)). In this paper we distinguish between bank and sovereign external debt instead of lumping them together as done in existing studies.

- As a related funding liquidity variable we include total syndicated loans provided to a country where the nationality of at least one of the syndicate banks differs from that of the borrower. Syndicated loans are credits granted by a group of banks to a borrower and typically act as a backstop facility to commercial paper programs for banks and corporates. A large fall in syndicated loans may signal severe funding problems for banks and corporates in a country.

- Total deposits are found by summing demand deposits, time and savings deposits and foreign currency deposits. The change in outstanding amount of total deposits is likely to be negatively related to bank credit risk. A rise in deposits may signal fewer funding liquidity problems as most deposits are protected by insurance schemes, reflecting a stable source of bank funding. Likewise, a substantial withdrawal of private deposits e.g. on the back of limited deposit insurance, expectations of capital controls or imposition of a tax on deposits may signal severe funding liquidity problems. As banks move closer to insolvency, however, a rise in deposits may also be positively correlated with bank credit risk as seen in Iceland in 2008. In domestic bankruptcy laws, depositors can be super senior to those of any other creditors which should raise senior bank credit risk along with a rise in depositors (since the loss given default is higher for ordinary senior bond creditors).

- The book value of equity may be positively or negatively related to bank credit risk depending on the banking system's risk profile. We use data for unweighted capital to total assets. The banking system's equity market capitalisation is most likely jointly determined with the CDS spreads (at least on a quarterly frequency) and hence we did not include this measure as an explanatory variable.

[24] We do not expect changes in banks' long-term external liabilities to be significantly related to the change in bank credit spreads. The data source for external debt is Quarterly External Debt Statistics jointly developed by the World Bank and the International Monetary Fund.

A description of bank variables, macro variables, and financial variables is found in Table 6 and Table 7 shows outlier statistics of quarterly changes. It reveals that Iceland is an extreme observation due to build-up of a large banking system relative to GDP and subsequent collapse. It suggests that our econometric results should be tested without including Iceland and see whether they are robust to including the country. Kallestrup and Lando (2010) provide a case study of the banking crisis in Iceland. A correlation table of changes in the variables is found in Appendix C. We now turn to a description of the sovereign explanatory variables.

3.3 Sovereign Credit Risk Explanatory Variables

In order to understand the dynamics of sovereign credit risk it is important to analyse the public sector's balance sheet. We analyse the sovereign's balance sheet through the general government sector which consists of central government, state government, local government and social security funds but formally excludes the central bank. Below we assess the importance of 'traditional' fiscal variables, foreign currency debt, other debt composition indicators and short-term versus long-term external debt for the dynamics of sovereign credit spreads. The data sources for traditional fiscal variables are Eurostat, OECD and IMF International Financial Statistics (IFS). Other data is collected from various statistical sources such as the BIS, IMF, World Bank and credit rating agencies.

Traditional Fiscal Variables

The dataset includes 'traditional' quarterly fiscal variables such as gross or net general government debt scaled against the domestic GDP.[25] In addition, we include the primary balance relative to GDP, i.e., total revenue less expenditure excluding gross interest payments. Higher public debt burdens or deficits relative to GDP are expected to widen sovereign credit spreads. We have also included quarterly projected future public deficits as reported in the OECD Economic Outlook and the IMF World Economic Outlook as the expected future debt burden may be more important than the current debt outstanding. Higher public expenditures and debt may be the direct result of bank bailouts, though. In our data sample, however, the only case where bailouts have caused the government debt to increase much more than government assets is in Ireland and Iceland. In these two countries we have adjusted public debt for bank bail-outs as a robustness check.[26]

Debt in Foreign Currency

It is likely that the change in foreign currency debt is positively correlated with the dynamics of sovereign credit risk (if the debt has not been hedged). If the central government has a high share of foreign currency debt relative to total debt and the country

[25]The assets of the general government include financial assets and non-financial assets.

[26]Interestingly, Eurostat (2011a) and IMF (2009) have collected yearly data on the impact of direct financial institutions support schemes on the public sector's net and gross debt across countries.

faces a fall in the domestic exchange rate, the debt measured in domestic currency rises and may thus contribute to rise in sovereign credit risk. Hence, we agree with Standard & Poor's (2010) who views it as beneficial for the sovereign's refinancing risk if debt primarily is denominated in local currency.

Fixed and Floating Debt

In our estimation, we include the share of domestic government bonds with fixed interest rate and the average maturity of domestic central government debt outstanding. We believe that it is prudent that Standard & Poor's (2010) assesses it as beneficial for the sovereign's refinancing risk if government debt is predominantly fixed rate and long term.

External Debt

Short-term debt combined with floating interest rates can quickly raise interest rate expenditures which in turn may result in a higher probability of default and interest rates (see also Calvo (1988)). Much of the earlier sovereign empirical research has primarily focused on short-term external debt and crisis incidences in emerging countries. The argument is that countries with a large amount of short-term debt are more vulnerable to debt roll-over crises. Hence, a higher amount of external short-term debt should be associated with wider sovereign credit spreads. However, short-term debt is likely to be a symptom and not the cause of an impending crisis. When the perception of riskiness is high, investors prefer to hold short-term debt and issuers find it difficult or too expensive to borrow at longer maturities.[27] In addition to short-term external debt we also test the importance of long-term external debt. A rising share of long-term general government debt held by non-residents may be associated with tighter sovereign credit spreads, reflecting a stable amount of funding by the government.

Debt Affordibility

We also relate the dynamics of sovereign credit risk spreads to debt affordability. Debt affordability is measured as the contemporaneous general government gross or net interest rate payments to revenue. It is widely used by the three large credit rating agencies; Moody's, Standard & Poor's and Fitch. Non-linear effects in explanatory variables are likely to be present as the sovereign can be solvent as long as credit spreads are low but close to insolvent when credit spreads rise substantially (see also Haugh, Ollivaud, and Turner (2009)).[28] External debt affordability is tightly linked to the international

[27] See also Diamond and Rajan (2001).

[28] Escolano (2010) provides technical notes on deriving public primary balances compatible with a constant debt ratio or that hit a given debt ratio in finite time depending on expected future variables. The European Commission (2009) and Ostry, Ghosh, Kim, and Qureshi (2010) derive long-term sustainability indicators in specific countries. Explicit ex-post sustainability calculations are rather straightforward given the initial debt to GDP when you make assumptions on the difference between the nominal interest rates and the nominal growth rate. Ex-ante sustainability computations, however, are difficult to relate to the dynamic of credit spreads since the variables are endogenous and depending on expectations.

investment position (NIIP) and the current account balance. The NIIP is the balance sheet of the stock of external financial assets and liabilities and a country with a current account deficit is running down its net foreign asset position.

Recession Indicators
Public revenues are dependent on tax collection from the private sector and the state of the economy. As a proxy for future public revenues we include the median expected default frequency (EDF) of the non-financial sector in the country. Alternatively, a lender that grants credit to corporations located in a particular country may use sovereign CDS spreads to proxy hedge the associated counterparty credit exposures. Hence, one might expect that indicators of corporate credit risk would be significantly related to sovereign CDS spreads.

A description of the sovereign variables, macro variables, and financial variables is found in Table 8. Outlier statistics in Table 9 of quarterly changes do not suggest extreme outliers for the main variables in any specific countries. A correlation matrix of quarterly changes in the variables is found in Appendix C. We now turn to the regression analysis.

4 Regression Analysis

4.1 Data Analysis

Most of the variables in the dataset are deflated by nominal GDP in order to remove time trends as explained in section 3. Nevertheless, this rescaling is not sufficient as graphical inspections of the panel data show that most of the time series are still not stationary but integrated of order one (difference stationary). It suggests that unit root and cointegration tests to panel data are the way forward.[29] Breitung and Pesaran (2008) summarise four popular types of panel unit root tests: Levin, Lin, and Chu (2002), Im, Pesaran, and Shin (2003), and two Fisher-type tests. The null hypothesis is the presence of a unit root whereas the alternative hypothesis is that at least one of the cross-section units in the panel is stationary. The first test assumes a "common root" whereas the latter three allow for individual unit root processes so that the AR coefficients may vary across countries.[30] Table 12 presents the results of the panel unit root tests for some selected explained and explanatory variables. The results indicate the presence of a unit

[29]By using panel data techniques one gains statistical power and improves on the poor power of their univariate counterparts. The traditional augmented Dickey-Fuller test of unit root has a low power in rejecting the null hypotheses of no stationary (particularly for short time series). We also analyse partial autocorrelations functions and Ljung-Box Q-statistic as suggested in Johnston and DiNardo (1997). The variables in first differences do not show problems with negative autocorrelation which typically is a sign of overdifferencing.

[30]The Schwarz information criteria are used to determine the appropriate length of the distributed lag.

root as most of tests fail to reject the null of a unit root in levels. The Hadri (2000) test with a null hypothesis of no unit root gives the same conclusions.

It may be argued that it is not a unit root but simply a structural break. Perron (1989) showed that in the presence of a structural break the standard unit root test lead to a bias towards the nonrejection of the null hypothesis of a unit root. Hence, Perron suggests modified unit root tests that account for one known structural break. Our dataset suggests that the Global Financial Crisis in the summer of 2007 was the culprit of several structural breaks in CDS spreads due to idiosyncratic credit risk across countries. In the data we do not achieve difference stationarity if we just allow for one structural break in a specific quarter.[31] Consequently, we carry on with regressions in first differences as well as regressions in levels (using co-integration techniques).

4.2 Bank Credit Risk

First Difference Estimation

Table 13 reports the results of the ordinary least squares (OLS) panel regression where we regress the change in bank credit default swap spreads minus the iTraxx Senior Financial Index against the changes in macro-financial variables listed in Table 6.[32] We focus on the excess spread since it is much less likely to be driven by global factors such as the US stock market. The estimation is also done with the same coefficients for each country but it can easily be re-estimated as they are country specific. Below i is the index for countries and t is the index for time (1 stands for equation number one). The estimated model is as follows:

$$\Delta(\text{B\_CDS-B\_FINSNR})_{it} = c_{i1} + \beta_1' \times \Delta(\text{LOCAL BANK VARIABLES})_{it} + \epsilon_{it1}$$

The explanatory power of the equation is moderate with an adjusted R-squared around 0.30. The sample covers 18 countries without the outlier Iceland over the period Q1 2004 to Q4 2010. Focus is on detecting 'stable' linear effects even though CDS spreads are likely to be influenced by non-linear effects in explanatory variables.[33] The signs on the significant coefficients in Table 13 are as expected in section 3 and below we go through the significant explanatory variables. In equation IV and V we exclude all the variables which are not significant at the 10 percent confidence level (after general-to-specific modelling). The standard errors are robust in the presence of heteroskedasticity and serial correlation in the residuals.

[31] For example, the government bailouts after the collapse of Lehman Brothers in 2008 can be seen as a structural break. Acharya, Drechsler, and Schnabl (2011) argue for a positive relationship between sovereign CDS spreads and measures of public debt to GDP ratios after bank bailout even if it does not exist beforehand.

[32] Banks' liabilities to the general government is excluded in the regression due to missing values for two countries. The variable is insignificant in sub-samples.

[33] Borio and Drehmann (2009) focus on finding thresholds and the risk of banking crises.

- The change in short-term collateralised loans with central banks has a high explanatory power in explaining the dynamics of bank credit spreads. A rise in short-term central bank funding by one percentage point of GDP co-moves with a rise in excess bank credit risk by around 6 basis points. It is intuitive that CDS spreads on the banks are related to short-term collateralised loans at the central bank. One can argue that a banking system's assets pledged as collateral in short-term repo transactions with central banks make existing unsecured creditors worse off and does little to reduce the long-run probability of default. Assets pledged as collateral matters for the pricing of CDS spreads on unsecured debt as credit spreads should reflect the lower recovery in the case the bank defaults.

- Furthermore, the health of the real estate sector - measured as the change in the median expected default frequency of the real estate or construction sector - is tightly linked to bank credit risk. A rise in the median real estate EDF by 1 percentage point increase bank credit risk by around 9 basis points. The change in the unemployment rate, real house prices, and the growth in real GDP are insignificant in our regression analysis.

- A rise in deposits relative to GDP tightens excess bank credit spreads. Deposits may be seen as a stable source of funding for banks in order to avoid funding liquidity problems. However, deposits are only significant at the 10% confidence level.[34] Hahm, Shin, and Shin (2011) document that non-retail deposits (non-core liabilities) serve as a indicator of vulnerability to a crisis. Contrary to this study, we use CDS spreads as measures of systemic crises and thus we do not need to define a financial crisis with a threshold fall in output, stock or currency markets.

- The percentage change in the domestic stock market and the change in banks' gross short-term external debt are not significant in explaining excess bank credit spreads. The change in domestic private-sector credit to GDP is only a significant determinant of bank credit risk if we include Iceland in the data sample.[35] A high credit growth is likely to indicate a lower marginal asset quality as argued in Kallestrup and Lando (2010) in a case study of Iceland. Syndicated loans are significantly related to bank CDS spreads if we include Iceland in the sample. Signed syndicated loans to the Icelandic entities fell sharply in the year before the banking sector collapsed.

The variables in Table 13 which are significant at the 1% significance level and robust if we exclude Iceland are put in bold. Central bank funding and the riskiness of the real estate sector are two robust variables. Interestingly, the coefficients in bold do not change

[34] When Iceland is included in the sample the coefficient is not significant (see the discussion in section 3).

[35] Similarly, Hahm, Shin, and Shin (2011) find that credit to GDP is not significantly related to country vulnerabilities when liability variables are introduced.

much if the explained variable is the change in the bank CDS spread (rather than the excess spread) as documented in section 5.

Level Estimation

Since the variables are integrated we can use cointegration analysis to find out whether there exists a long-run equilibrium relationship between bank CDS spreads and our macro-financial variables.[36] Pedroni (1999) and Pedroni (2004) extend the Engle and Granger (1987) two-step (residual-based) cointegration tests to involve panel data. Pedroni suggests two classes of test statistics for the null hypothesis of no cointegration that allow for country fixed effects and coefficients to vary across cross-sections. The tests are based on an examination of the residuals of a spurious regression performed using I(1) variables. Under the null hypothesis of no cointegration, the residuals will be I(1).[37] Table 14 reports eleven panel cointegration statistics with varying properties. The tests reject the null hypothesis of no cointegration (often at the 1% significance level) except for one statistic.

In Table 15 we regress bank CDS spreads in levels on the variables reported in section 3 with OLS and use standard errors that are robust in the presence of heteroskedasticity and serial correlation in the residuals. For simplicity we impose homogenous regression coefficients across countries. According to the Granger representation theorem, the variables cointegrate if and only if there exists an error correction. Error-correction equations are not reported in this paper since we believe realistic models should be estimated with country-specific parameters.

$$(\text{B\_CDS-B\_FINSNR})_{it} = c_{i2} + \beta_2' \times (\text{LOCAL BANK VARIABLES})_{it} + \epsilon_{it2}$$

In the bank equation we find that short-term central bank funding is significant at the 1% significance level. Determinants of sovereign credit risk is the focus of the subsequent section. Later we analyse the interaction of bank and sovereign credit risk.

4.3 Sovereign Credit Risk

First Difference Estimation

Table 16 reports the results of OLS panel regressions where we regress the change in sovereign credit default swap spreads relative to the Norwegian sovereign CDS spread against the change in sovereign variables. Norway is the government with the best fiscal fundamentals among advanced economies. We test all the domestic sovereign variables listed in Table 8 but exclude variables which are similar or highly correlated in order

[36] This paper does not focus on cointegration between bank and sovereign CDS spreads. Alter and Schler (2011) find cointegration between bank and sovereign credit default swaps in a sample of seven Eurozone member states.

[37] Pedroni suggests panel unit root tests against the homogeneous alternatives (common AR coefficients) for all countries and the panel unit roots test against the heterogeneous alternatives (individual AR coefficients) for all countries.

to avoid problems with multicollinearity. Below i is the index for countries and t is the index for time. The estimated model is as follows:

$$\Delta(\text{S\_CDS-S\_NO})_{it} = c_{i3} + \beta_3' \times \Delta(\text{LOCAL SOVEREIGN VARIABLES})_{it} + \epsilon_{it3}$$

We use the sample that covers 19 countries including Iceland over the period Q1 2004 to Q4 2010. The explanatory power of equation I in Table 16 is moderate with an adjusted R-squared around 0.40. In equation III and IV we exclude all the variables which are not significant at the 10 percent confidence level (after general-to-specific modeling). Furthermore, we are reluctant to include domestic market prices like the nominal exchange rate as explanatory variables since it is likely to be jointly determined together with credit spreads (or subject to reverse causality).

- We split the general government's debt into three parts. First, we find that a rise in the general government debt in domestic currency by one percentage of GDP widens excess sovereign spreads by around 4 basis points. Second, a change in foreign currency debt is significantly positively correlated with the change in sovereign credit risk. A one percentage point increase in the share of foreign currency debt relative to GDP contributes to a rise in the excess sovereign credit risk spread by around 12 basis points. The foreign currency debt variable is significant even when controlling for a change in the effective nominal exchange rate index separately. However, the coefficient is not stable across various specifications. Third, we find that the change in the general government's long-term external debt is statistically significant determinant of the excess sovereign credit risk. A rise in long-term external debt by one percentage of GDP tightens excess sovereign spreads by around 8 basis points.

- We find an insignificant coefficient on the general government's short-term external debt. It is broadly in line with an IMF (2010) survey of the sovereign literature noticing that most empirical studies find that short-term (external) debt does not appear to be a significant factor in determining the level of the credit rating. In addition, the ratio of fixed debt to total debt is insignificant in the given econometric specification. Likewise, the maturity structure of debt is not significant. We have treated the maturity of debt as exogenous but the variable is likely to be partly endogenous. Arellano and Ramanarayanan (2010) find that emerging market sovereigns' endogenously choose a time-varying maturity structure of debt. When credit spreads are low, governments issue long-term debt more heavily and when credit spreads rise, the maturity of bond issuances shortens.[38]

- The current account level and the net international investment position (NIIP) are measures of external debt sustainability. The variables are both significant but

[38]Entering a sovereign debt crisis, Greece government debt had a long average maturity; much longer than the average maturity of advanced economies (e.g. the United States).

similar in nature. We decided to include the current account in the regressions since the NIIP is often interpolated from yearly data. A rise in current account surplus lowers sovereign credit spreads. The coefficient is still significant if we insert the level of the current account.

- A rise in the median corporate EDF by 1 percentage point widens sovereign CDS spread by around 40 basis points. In our interpretation, higher credit risk in the corporate sector translates into lower public revenues and potentially higher public debt. Interestingly, using the median corporate EDF instead of the local stock market return adds explanatory power to the equation.[39] We have included the contemporaneous value of the corporate EDF in the regression but if it is exchanged with the quarterly lagged value of the median corporate EDF is remains significant. The significance of the corporate EDF for sovereign credit risk is likely to partly reflect proxy hedging in cases where corporate CDS spreads are not available or illiquid.

The regression results above add further insights into the results by Longstaff, Pan, Pedersen, and Singleton (2011) who only include three domestic variables in country-by-country regressions: local stock market return, percentage changes in the exchange rate, and percentage changes of the sovereign's holdings of foreign reserves. We find significance of several other variables as documented above. In our richer panel econometric specification the foreign reserves are insignificantly related to the dynamics of sovereign credit risk. The exchange rate index remains significant but the causality may also be the reverse with a rise in sovereign risk contributing to depreciation of the domestic currency as the risk-adjusted return by investing in the country is decreasing in the sovereign risk premium.[40] In Equation III and Equation IV reported in Table 16 we exclude the domestic exchange rate index since we are interested in finding determinants of the dynamics of sovereign credit risk based on fundamental balance sheet and macro-economic variables.

Level Estimation

Again we can use cointegration analysis to find out whether there exists a long-run equilibrium relationship between sovereign CDS spreads and our macro-financial variables. Table 17 reports Pedroni's eleven panel cointegration statistics. The tests of the sovereign residuals reject the null hypothesis of no cointegration (often at the 1% significance level) except for three statistics.[41] In Table 18 we regress in levels sovereign CDS spreads against a benchmark on the variables reported in section 3 with OLS (ordinary least squares). We use standard errors that are robust in the presence of heteroskedasticity and serial

[39] The variable, %Δ(F_STOCK), is not included in the sovereign equation since the corporate EDF has a more natural interpretation.

[40] We leave this open for future research.

[41] Panel unit root test suggest stationarity in first difference except for current account which seems to be stationary in levels.

correlation in the residuals. Furthermore, we impose homogenous regression coefficients across countries.

$$(\text{S\_CDS-S\_NO})_{it} = c_{i4} + \beta_4' \times (\text{LOCAL SOVEREIGN VARIABLES})_{it} + \epsilon_{it4}$$

In the sovereign equation we find significance of public debt to GDP, the median corporate EDF as well as the current account balance. We now turn to the interaction of bank and sovereign credit risk. Again, we do not report error-correction equations since we believe realistic models should be estimated with country-specific parameters.

4.4 The Importance of Bank Fundamentals for Sovereign Credit Risk

In the previous section we analysed bank and sovereign credit risk separately. Now we want to combine the analyses. In particular, we want to decompose sovereign CDS spreads into a bank and sovereign contribution based on an econometric analysis of balance sheet variables. We focus on sovereign credit risk since Acharya, Drechsler, and Schnabl (2011) has separated bank CDS spreads into a bank and sovereign component based on an analysis of CDS spreads. In Table 20 and Table 21 we combine the significant bank and sovereign variables found in the previous sections (in changes and levels). Cointegration tests reject the null hypothesis of no cointegration. In the bottom of Table 21 the results after general-to-specific modelling of CDS spreads in levels are reported. Aggregated balance sheet variables of a national banking system like collateralised loans can be used to measure bank credit risk and contingent liabilities of the government. A rise in banks' short-term collateralised loans by one percentage point of GDP give rise to 6 basis points wider bank CDS spreads and 3 basis points wider sovereign CDS spreads.

Below we will argue that the banking system's short-term collateralised funding at the domestic central bank is not an endogenous variable in the sovereign regression equation. We defend the results by arguments relying on economic theory and a number of tests. Wooldridge (2002) as well as Roberts and Whited (2011) review the sources of endogeneity - omitted variables, simultaneity and measurement error - and their implications for inference.[42]

First, if any omitted sovereign variables are correlated with our included explanatory variables there is an endogeneity problem which causes problem for inference. For example one might conclude bank credit risk is important for sovereign credit when it is not the case if the sovereign equation is missing important sovereign variables. We do not believe it is a cause for concern as we have included practically all sovereign variables reported in previous studies and used by the rating agencies. Furthermore, we include two sovereign

[42] A key assumption needed for OLS to produce consistent estimates is that the error term is uncorrelated with each explanatory variable. It is impossible to test directly whether a variable is uncorrelated with the error term because the error term is unobservable.

variables which are not directly related to sovereign credit risk such as the EDF for the corporate sector and the current account balance.

Second, we need to exclude a simultaneity bias which occurs when the sovereign CDS spread and bank collateralised loans are determined in equilibrium so it can plausibly be argued either that bank collateralised loans cause sovereign CDS spreads or vice versa. In any case, bank and sovereign CDS spreads are mostly likely to be jointly determined (due to common risk premia, etc.). In Table 19 granger causality tests in first differences indicate that bank fundamentals are important for sovereign credit risk but sovereign CDS spreads do not cause banks to increase their funding at the domestic central bank. In econometric terms we reject that banks' collateralised loans do not granger cause sovereign CDS spreads but we cannot reject that sovereign credit spreads do not granger cause central bank funding.[43] P-values are adjusted for autocorrelation (and heteroskedasticity) as one might suspect persistence in central bank funding.

It is also worthwhile taking a look at a few further tests. Statistically, banks' collateralised loans are not significantly related to 'pure' contemporaneous or lagged public debt variables such as debt to GDP. The same is the case for quarterly forecast of the future public budget as reported by the IMF or the OECD.[44] It is also interesting to take a look at a few practical examples. In countries with low amount of public gross debt outstanding or actually negative net debt like Denmark and Sweden, banks have been reliant on short-term collateralised loans at the central bank (accounting for around 15% of GDP in 2008). In addition, in countries with a low amount of gross debt before the crisis and without contemporaneous expectations of higher debt in the future - like in Iceland and Ireland - central bank collateralised loans have also been substantial.[45]

Third, we do not have major problems with measurement errors. The data on collateralised loans with the central bank is hardly ever revised as is often the case with other macroeconomic data. Furthermore, there are only few problems with monthly time lag due to the publication schedule since our macro-financial dataset is quarterly. For example, data for banks' central bank funding is often reported with one or two month time lag.

In order to illustrate the contribution of the riskiness of national banking systems to sovereign credit risk we can use the estimated panel coefficients to find the fitted value explained by bank and sovereign factors for a particular country. In Figure 6 we see

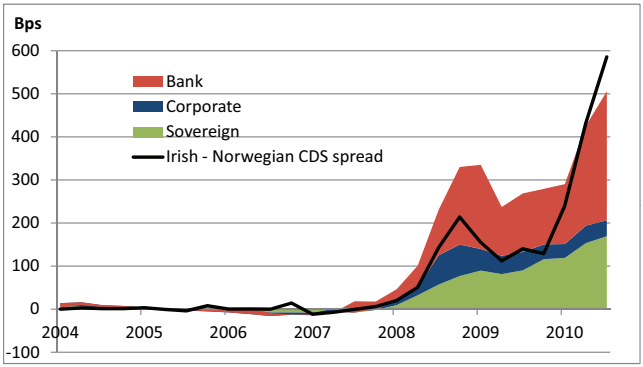
[43]The tests in levels give same conclusions. However, two-way causality in levels between bank CDS spreads and banks' collateralised loans is a possibility.

[44]The results are available upon request.

[45]We acknowledge that when sovereign credit risk rises substantially banks headquartered in the country may switch to become dependent on central bank funding. See for example the Committee on the Global Financial System (2011). We suggest that banks' central bank funding should not be treated as an exogenous variable when sovereign CDS spreads are consistently above a threshold and higher than the average of the CDS spreads on the banks. It means caution is warranted in the so-called GIPS countries (Greece, Italy, Portugal and Spain) in 2010 and 2011. Interestingly, the main clearing house of European bonds, LCH Clearnet, implement substantial haircuts on the sovereign bonds when sovereign credit spreads remain consistently over 500 basis points (see also LCH Clearnet (2011)).

that for Ireland the majority of the change in sovereign credit risk is explained by bank credit risk. The results appear intuitive. On contrary to the results in Sgherri and Zoli (2009) we find a time-varying measure of the importance of Irish bank fundamentals on sovereign credit risk and show statistical and economical significance after 2008. It is important to note, however, that the importance of bank credit risk is varying across countries. The fit of our model is good for countries where credit risk originates domestically. The model fit is worse for banking systems with large foreign exposures and relatively low domestic credit risk (for example Austria, Denmark, Switzerland, Sweden and the Netherlands). Our analysis has to be augmented with data for national banking systems' exposures vis-à-vis individual countries as shown in Kallestrup, Lando, and Murgoci (2011). Kallestrup, Lando, and Murgoci (2011) show that credit risk in the banking system is better understood if we model financial linkages explicitly. Furthermore, we should model banks' exposures on other domestic banks which are important for understanding systemic credit risk.

Figure 6: **Ireland: Decomposing the Sovereign Credit Default Swap**



The figure reports the difference between Irish and Norwegian 5-year CDS spread (Norway has the best fiscal fundamentals in our sample). Norway is the country with the best fiscal fundamentals among advanced economies. We use the estimated panel coefficients to calculate the the fitted value explained by bank and sovereign factors in Ireland.

5 Robustness Checks

IMF-Supported Programs

Fluctuations in CDS spreads may represent both actual changes in default risk and changes in risk aversion. If the variables which explain fluctuations in CDS spreads also help explain the initiation of IMF-supported programs then it shows that at least part of the fluctuation is due to higher default risk. We treat the initiation of IMF-supported programs as distress events for the panel of 19 countries since there are no

explicit sovereign credit events in our data period. Furthermore, we analyse an extended data sample with 38 countries. An IMF-supported program is not classified as a credit event in standard CDS agreements but IMF conditional funds tend to be seen as the last available funding option for a government. In addition, the IMF traditionally enjoys preferred credit status - based on convention and historical precedent - and the loans the organisation provides are super senior to those of any other creditors. It lowers the recovery for the remaining senior debt holders in case of debt restructuring and hence it should widen senior credit spreads. Table 22 shows six countries with access to IMF Stand-By Arrangements (SBA) or Extended Fund Facility (EFF) where GDP per capita is higher than USD 5,000 in our extended sample from 2004 to 2010: Hungary (Q4 2008), Iceland (Q4 2008), Latvia (Q4 2008), Romania (Q2 2009), Greece (Q2 2010) and Ireland (Q4 2010).

Table 23 reports the results of a logit regression where we regress the initiation of an IMF-supported program against the change in a few local bank and sovereign variables. The dependent variable is SBAs or EFFs and the parameters are obtained by maximising the log likelihood function. We want to see whether a few of the significant variables mentioned in section 4 are important in explaining the 6 IMF-supported programs.

$$\Pr(\text{IMF}_{it} = 1 | (\text{Local Variables})_{it}) = \frac{\exp((\text{Local Variables})_{it} \times \beta)}{1 + \exp((\text{Local Variables})_{it} \times \beta)}$$

In Table 23 we see that large increases in collateralised loans or general government debt relative to the two-year moving average increases the likelihood of an IMF-supported program. It supports the case that the local variables capture real probabilities of sovereign default and not just risk premia. That said, other local or global variables may also be important in explaining the initiation of IMF-supported programs. The results are broadly the same if we use probit or extreme value binary estimation methods.

Time Fixed Effects

As a robustness check it is useful to include time fixed effect to capture global risk premia instead of measuring CDS spreads against a benchmark. Table 24 and Table 25 are similar to Table 13 and Table 15 except for a change in the explained variable. The magnitude of estimated bank coefficients are broadly similar to the results reported in section 4. That said, the explanatory power is naturally higher with time fixed effects. Furthermore, Table 26 and Table 27 are similar to Table 16 and Table 18 except for a change in the explained variable. Again the magnitude of estimated bank coefficients appear fairly similar to the tables reported in section 4. It indicates that our econometric results are fairly robust.

6 Conclusion

We show that sovereign credit risk depends critically on fragility in the banking sector in advanced economies. This has been noted previously but little empirical research has been done on the importance of bank fundamentals on sovereign credit risk in a dynamic setting. In our paper, sovereign CDS spreads are decomposed into bank and public sector contributions based on a panel econometric analysis of balance sheet variables. We find that fragility in the banking sector has been an important driver of sovereign credit risk especially since 2008 and add additional insights into Acharya, Drechsler, and Schnabl (2011).

Longstaff, Pan, Pedersen, and Singleton (2011) find that sovereign risk is primarily driven by global risk premium factors but their econometric analysis exclude bank fundamentals which we argue are important factors for understanding the dynamics of sovereign credit risk in most countries. Traditional public debt variables - such as debt-to-GDP - also influence the dynamics of sovereign credit risk but less so than commonly thought in the literature. There exists aggregated balance sheet variables of a national banking system which represent determinants of bank credit risk and contingent liabilities of the government. Interestingly, the size of short-term collateralised loans at the central bank is reflected in CDS spreads on unsecured bank debt since assets pledged as collateral in short-term repo transactions often do little to reduce the long-run probability of default but contribute to a lower recovery in the case of default.

Our empirical results show that it is important to augment the standard structural sovereign credit risk model with a banking sector. Initial work has been done by Gray, Merton and Bodie (2007) but an important challenge for future research will be to develop theoretical models that can account for the strong empirical relationship between macro-financial variables and the dynamics of sovereign credit risk.

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A World Capital Markets

Table 1: **The Size of Capital Markets in Trillios of U.S. Dollars.**

	Stock Market Capitalization	Public Debt Securities	Private Debt Securities	Bank Assets	Gross Domestic Product
World 2010	55.1	41.4	53.5	100.1	62.9
Europe (advanced economies)*	10.7	10.4	20.8	41.7	15.2
Canada	2.17	1.14	0.97	3.06	1.58
United States	17.3	11.2	21.4	14.3	14.5
Japan	4.10	11.6	2.52	11.3	5.46
Asia	11.7	3.60	2.98	15.9	11.4
Latin America and the Caribbean	2.67	1.56	0.99	3.52	4.83
Middle East and Africa	1.58	0.36	0.23	1.95	3.44
Emerging Europe	1.61	0.79	0.23	1.72	3.73
World 2006	50.8	25.6	43.1	70.9	48.2
Europe (advanced economies)*	13.1	7.70	15.5	36.6	13.6
Canada	1.70	0.70	0.63	1.92	1.28
United States	19.6	6.23	20.5	10.2	13.2
Japan	4.80	6.75	1.97	6.42	4.37
Asia	6.86	2.02	1.49	7.49	6.26
Latin America and the Caribbean	1.45	1.10	0.46	1.43	2.94
Middle East and Africa	1.51	0.12	0.12	1.37	2.25
Emerging Europe	1.87	0.63	0.11	0.98	2.63

The data on public debt includes international and domestic debt securities and it is reported by the IMF Global Financial Stability Report based on data from Bank for International Settlements. Europe (advanced economies) represents Euro area countries, Denmark, Sweden, and the United Kingdom.

B Variables

Table 2: **Summary Statistics for Average Bank CDS Spreads**

ISOCODE	Mean	Max	Min	Std. Dev.	Obs.
AT	93	429	10	104	28
AU	53	160	6	51	28
BE	104	390	8	116	28
CH	65	217	8	66	28
DE	58	160	10	48	28
DK	47	199	4	52	28
ES	66	259	8	73	28
FR	49	147	6	48	28
GB	73	278	6	78	28
GR	166	989	6	289	28
IE	162	1052	7	244	28
IS	344	1340	24	376	24
IT	56	176	8	54	28
JP	45	120	7	36	28
KR	125	500	15	135	25
NE	49	170	5	51	28
PT	115	851	10	187	28
SE	52	194	8	52	28
US	70	300	10	67	28
All	92	1340	4	155	525

The table shows the mean, maximum, minimum, standard deviation and number of observations for quarterly average CDS spreads on banks. 19 countries are included in the sample from Q1 2004 to Q4 2010.

Table 3: **Summary Statistics for Sovereign CDS Spreads**

ISOCODE	Mean	Max	Min	Std. Dev.	Obs.
AT	35	177	2	49	28
AU	25	131	2	34	28
BE	36	222	1	54	28
CH	55	128	35	30	8
DE	15	59	1	19	28
DK	20	115	1	28	28
ES	58	350	2	89	28
FR	22	108	1	30	28
GB	42	123	2	41	19
GR	150	1010	4	275	28
IE	93	609	2	150	28
IS	220	977	3	288	28
IT	57	240	4	70	28
JP	26	95	3	30	28
KR	83	330	17	82	28
NE	25	91	1	28	22
PT	72	501	4	126	28
SE	22	124	2	32	28
US	16	67	1	21	28
All	57	1010	1	124	497

The table shows the mean, maximum, minimum, standard deviation and number of observations for quarterly CDS spreads on sovereigns. 19 countries are included in the sample from Q1 2004 to Q4 2010.

Table 4: **The Names of the Banks Included**

Country	Bank Name
AT	Erste Group Bank AG
AT	Raiffeisen Zentralbank Oesterreich AG
AU	National Australian Bank
AU	Westpac
BE	Dexia Group NV
BE	KBC Group NV
CH	UBS AG
CH	Credit Suisse Group AG
DE	Deutsche Bank AG
DE	Commerzbank AG
DK	Danske Bank AS
ES	Banco Santander SA
ES	Banco Bilbao Vizcaya Argentaria SA
FR	BNP Paribas
FR	Crédit Agricole-Crédit Agricole Group
GB	Royal Bank of Scotland Plc
GB	Barclays Bank Plc
GR	National Bank of Greece SA
GR	EFG Eurobank Ergasias SA
IE	Bank of Ireland Plc
IE	Allied Irish Banks Plc
IS	Landsbanki Islands hf.
IS	Kaupthing Bank hf.
IT	Unicredit SpA
IT	Intesa Sanpaolo SpA
JP	Mitsubishi UFJ Financial Group
JP	Sumitomo Mitsui Financial Group
KR	Kookmin Bank
KR	Woori Bank Co.
NE	ING Group NV
NE	Rabobank
PT	Banco Comercial Portugues SA
PT	Banco Espirito Santo SA
SE	Nordea Bank AB
SE	Skandinaviska Enskilda Banken AB
US	Bank of America Corporation
US	JP Morgan Chase Co.

Table 5: **Net Notional CDS Contracts Outstanding in Billions of U.S. Dollars**
Depository Trust & Clearing Corporation (DTTC) reports net notional CDS contracts outstanding on the top 1000 reference entities in the world. We report CDS data for our dataset where available. NA denotes not available. In the last column we report gross general government debt to GDP and the size of the banking groups relative to GDP. Sources: IMF World Economic Outlook and BankScope.

	2011 Year-end	2010 Year-end	2009 Year-end	2008 Year-end	Debt or Assets to GDP (2009)
AT: Sovereign	5.973	7.025	9.000	4.553	70
Erste Group Bank	0.521	0.709	0.521	NA	76
Raiffeisen Bank International AG	0.311	0.598	0.659	NA	56
AU: Sovereign	5.137	2.108	0.491	NA	17
National Australian Bank	1.753	1.327	1.352	1.168	58
Westpac	0.942	0.836	0.790	1.104	52
BE: Sovereign	5.653	5.669	5.615	3.999	96
Dexia	1.054	1.263	1.714	1.711	176
KBC Bank	0.321	0.351	0.315	NA	99
DE: Sovereign	19.43	15.14	11.93	9.694	74
Deutsche Bank AG	4.674	5.469	6.429	9.482	65
Commerzbank AG	2.048	2.256	3.059	2.878	36
DK: Sovereign	2.954	2.357	2.134	1.750	42
Danske Bank AS	0.492	0.494	0.416	0.674	193
ES: Sovereign	15.60	16.88	13.90	13.52	53
Banco Santander SA	2.720	3.030	3.020	3.263	109
Banco Bilbao Vizcaya Argentaria SA	2.472	3.077	2.474	3.054	53
FR: Sovereign	21.78	17.54	9.272	5.356	79
BNP Paribas	2.493	2.349	2.489	3.324	112
Crédit Agricole-Crédit Agricole Group	2.596	2.582	2.514	2.438	92
GB: Sovereign	12.21	11.92	3.930	2.541	68
Royal Bank of Scotland Plc	1.446	1.793	2.634	2.834	126
Barclays Bank Plc	3.330	3.932	3.817	4.983	103
IE: Sovereign	3.409	4.000	6.069	4.622	65
Bank of Ireland Plc	0.226	0.580	0.577	0.797	117
IT: Sovereign	20.04	26.39	23.80	18.22	116
Unicredit SpA	3.906	4.711	3.420	2.302	63
Intesa Sanpaolo SpA	1.942	2.312	3.092	3.462	42
JP: Sovereign	8.875	6.368	3.099	1.753	216
Mitsubishi Corp	0.730	0.671	0.575	0.513	38
Sumitomo Corp	0.531	0.490	0.449	0.652	23
NE: Sovereign	3.258	3.021	3.527	1.809	61
ING Bank NV	0.784	0.892	0.990	1.114	210
PT: Sovereign	5.002	7.961	8.625	NA	83
Banco Espirito Santo SA	1.362	1.596	2.481	2.886	59
Banco Comercial Portugues SA	0.794	0.794	1.175	1.162	51
SE: Sovereign	3.015	2.973	3.303	2.099	43
Nordea Bank AB	0.434	NA	NA	NA	180
Skandinaviska Enskilda Banken AB	0.195	0.212	0.249	NA	80
US: Sovereign	5.111	3.041	2.175	1.391	85
Bank of America Corporation	5.727	5.954	6.484	4.083	16
JP Morgan Chase Co.	5.653	5.126	5.828	4.664	14

Table 6: **Bank Variables**

Variable name	Frequency	Description	Source
B_CB_A	Quarterly	Banks' claims on the domestic central bank. Percent of GDP	IFS
B_GG_A	Quarterly	Banks' claims on the domestic general government. Percent of GDP	IFS
B_CREDIT	Quarterly	Banks' claims on other sectors in the country. Percent of GDP	IFS
B_EXT_A	Quarterly	Banks' claims on non-residents. Percent of GDP	IFS
B_DEP	Quarterly	Banks' deposits. Percent of GDP	IFS
B_BEXT_S	Quarterly	Banks' short-term external liabilities. Percent of GDP	QEDS
B_BEXT_L	Quarterly	Banks' long-term external liabilities. Percent of GDP	QEDS
B_CB_L	Quarterly	Banks' liabilities to the domestic central bank. Percent of GDP	IFS and Bank of England
B_GG_L	Quarterly	Banks' liabilities to the domestic general government. Percent of GDP	IFS
B_CAPITAL	Quarterly	Banks' shares and other equity (unweighted). Percent of total assets	IFS
B_GDP	Quarterly	Banks' consolidated assets. Percent of GDP	IFS
B_CDS	Quarterly	Unweighted average of 5-year CDS on domestic banks	CMA and Fitch
B_FINSNR	Quarterly	The Markit iTraxx Senior Financials Index comprises 25 equally-weighted European names	J.P.Morgan: DataQuery
B_SYN_GDP	Quarterly	Signed international syndicated credit facilities by nationality of borrower. Percent of GDP	BIS
F_HOUSE_REAL	Quarterly	Property prices divided by a CPI price index	BIS, OECD and IFS
F_R_EDF	Quarterly	The 5-year median EDF for firms associated with the real estate or construction sector. In Iceland we use the EDF for the corporate sector	Moody's KMV
F_STOCK	Quarterly	National share prices	IFS
M_GDP_REAL	Quarterly	Real GDP (seasonally adjusted)	OECD and Eurostat
M_UEMP	Quarterly	Unemployment rate (seasonally adjusted)	OECD MEI and IFS

The table shows a description of bank assets and liabilities as well as macro-financial variables related to bank credit risk. OECD MEI: OECD Main Economic Indicators. IFS: IMF International Financial Statistics. Banks are denoted "Other Depository Corporations" in the IFS database. QEDS: Quarterly External Debt Statistics. BIS: Bank for International Settelements.

Table 7: **Summary Statistics: Changes in Bank Variables**

Statistics	Mean	Maximum	Maximum	Minimum	Minimum	Std. Dev.	Skewness	Observations
Δ(B_CB_A)	0.07	8.0	SE	-10.1	DK	1.6	-0.2	532
Δ(B_GG_A)	0.18	10.8	IT	-4.2	CH	1.4	2.5	532
%Δ(B_CREDIT,4)	4.97	54.8	IS	-66.0	IS	9.5	-1.0	532
Δ(B_EXT_A)	0.88	220.3	IS	-481.5	IS	25.7	-11.3	532
Δ(B_DEP)	1.02	50.1	IS	-8.9	IS	3.4	6.4	532
Δ(B_BEXT_S)	0.34	61.8	IS	-272.3	IS	15.1	-11.7	532
Δ(B_BEXT_L)	0.37	73.1	IS	-373.3	IS	17.4	-18.5	532
Δ(B_CB_L)	0.30	30.6	IE	-29.6	IE	3.7	1.9	532
Δ(B_GG_L)	0.02	12.3	IE	-2.7	GB	0.9	6.4	476
Δ(B_CAPITAL)	0.00	0.0	IE	-0.1	IS	0.0	-3.2	532
Δ(B_GDP)	2.35	221.8	IS	-712.1	IS	35.6	-14.7	532
Δ(B_SYN_GDP)	0.01	18.8	IS	-18.8	IS	1.9	0.3	532
%Δ(F_HOUSE_REAL)	0.31	12.0	IS	-11.4	AT	2.3	-0.1	532
Δ(F_R_EDF)	0.04	8.7	IS	-13.8	IS	1.1	-3.1	532
%Δ(F_STOCK)	1.16	31.8	GR	-78.3	IS	11.3	-1.7	532
%Δ(M_GDP_REAL,4)	1.60	11.2	IS	-10.0	JP	3.2	-1.0	532
Δ(M_UEMP)	0.08	2.6	SE	-1.0	IS	0.4	2.0	532

The table shows summary statistics of quarterly changes in bank variables. For each variable we report the mean, the maximum and the name of the country, the minimum and the name of the country, the standard deviation, the skewness and the number of observations. $\Delta(\bullet)$ is the first difference over the quarter and $\%\Delta(\bullet, t)$ is the percentage change over t quarters. For United Kingdom and Switzerland the banking sector's gross liabilities to the general government are missing.

Table 8: **Sovereign Variables**

Variable name	Frequency	Description	Source
S_DEBT_GDP	Quarterly*	General government gross debt to GDP.	Eurostat, OECD and IFS
S_NDEBT_GDP	Quarterly*	General government net debt to GDP	Eurostat, OECD and IFS
S_REV_GDP	Quarterly*	General government revenue to GDP (four-quarter sum)	Eurostat, OECD and IFS
S_EXP_GDP	Quarterly*	General government expenditure to GDP (four-quarter sum)	Eurostat, OECD and IFS
S_FDEF_GDP	Quarterly	Average of year-end and year-ahead budget projection. % of GDP	OECD EO and IMF WEO
S_RESERVES_G	Quarterly	Monetary authority's external asset. Percent of GDP	IFS
S_IR_REV	Quarterly*	General government interest expenditure to revenue (four-quarter sum)	See below
S_IRN_REV	Quarterly*	General government net interest expenditure to revenue (four-quarter sum)	Fitch, Eurostat, IMF, OECD and IFS
S_FXDEBT_GDP	Quarterly	General government foreign currency debt share	Fitch Ratings
S_FIXED_TOTAL	Interpolated	Domestic government bonds with fixed interest rate. % total debt	BIS and OECD
S_MATURITY	Interpolated	Maturity of domestic central government debt outstanding	BIS and OECD
S_GEXT_L	Quarterly	General government's long-term external liabilities. Percent of GDP	QEDS
S_GEXT_S	Quarterly	General government's short-term external liabilities. Percent of GDP	QEDS
S_CDS	Quarterly	The 5-year sovereign CDS spread	CMA and Fitch
CDS_SOVX	Quarterly	The 5-year Itraxx SovX Western Europe Index comprises 15 sovereign names where all constituents are equally weighted (It is a theoretical price before the start of trading on 28 September 2009)	J.P.Morgan: DataQuery
F_NEER	Quarterly	Effective exchange rate. Nominal, broad Index. 2005: Index 100	BIS and OECD
F_FXUSD	Quarterly	Exchange rate. National currency per U.S dollar	IFS
F_C_EDF	Quarterly	Median of the 5-year EDFs' for domestic corporate sector	Moody's KMV
M_CA	Quarterly	Current account (seasonally adjusted). Percent of GDP	OECD MEI and IFS
M_FDI	Quarterly*	Direct investment abroad minus direct investment at home. Percent of GDP	IFS
M_NIIP	Quarterly*	The net international investment position. Percent of GDP	IFS
M_GDP_REAL	Quarterly	Real GDP (seasonally adjusted). Percent of GDP	OECD and Eurostat
M_UEMP	Quarterly	Unemployment rate (seasonally adjusted)	OECD MEI and IFS

The table shows a description of sovereign and macro-financial variables related to sovereign credit risk. * denotes quarterly or interpolated from yearly data. IFS: IMF International Financial Statistics. QEDS: Quarterly External Debt Statistics. MEI: OECD Main Economic Indicators. BIS: Bank for International Settelements. OECD EO: OECD Economic Outlook. IMF WEO: IMF World Economic Outlook.

Table 9: **Summary Statistics: Changes in Sovereign Variables**

Statistics	Mean	Maximum	Maximum	Minimum	Minimum	Std. Dev.	Skewness	Observations
Δ(S_DEBT_GDP)	0.83	17.6	GR	-10.6	AT	2.7	1.5	532
Δ(S_NDEBT_GDP)	0.35	13.4	GR	-13.4	GR	2.4	0.3	532
Δ(S_REV_GDP)	-0.01	7.3	AU	-8.3	AU	0.7	-0.7	528
Δ(S_EXP_GDP)	0.17	13.4	IS	-9.8	IS	1.2	1.7	528
Δ(S_FDEF_GDP)	-2.62	4.9	KR	-20.9	IE	3.7	-0.9	532
Δ(S_RESERVES_G)	0.32	17.9	CH	-6.7	IS	1.6	3.8	532
Δ(S_RESERVES_N)	-0.06	27.5	IE	-28.3	IE	3.6	-2.2	532
Δ(S_IR_REV)	0.01	4.5	GR	-3.8	GR	0.5	2.2	528
Δ(S_IRN_REV)	0.00	4.5	GR	-3.8	GR	0.5	2.3	528
Δ(S_FXDEBT_GDP)	0.03	4.8	IS	-3.5	IS	0.6	3.0	532
Δ(S_FIXED_TOTAL)	0.00	0.1	IS	0.0	GR	0.0	4.6	532
Δ(S_MATURITY)	0.03	0.8	IS	-1.9	AU	0.2	-3.3	532
Δ(S_MEXT_L)	0.03	7.1	IS	-3.3	IE	0.4	8.8	526
Δ(S_MEXT_S)	0.34	28.1	IE	-27.7	IE	3.5	2.8	532
Δ(S_GEXT_L)	0.35	12.0	IS	-10.5	GR	1.7	0.8	532
Δ(S_GEXT_S)	0.09	7.2	NE	-5.8	AT	1.1	0.5	532
%Δ(F_NEER)	-0.06	24.0	JP	-20.8	IS	3.3	-0.5	532
%Δ(F_FXUSD)	-0.02	28.0	IS	-15.3	AU	5.6	0.7	532
%Δ(F_C_EDF)	0.02	4.4	IS	-3.1	IS	0.4	2.2	532
M_CA	-0.01	12.1	CH	-15.2	IS	1.3	-0.8	532
Δ(M_FDI)	0.43	44.7	IS	-55.2	IS	4.5	-2.4	531
Δ(M_NIIP)	-0.14	133.7	IS	-90.7	IS	8.5	4.9	531
%Δ(M_GDP_REAL,4)	1.60	11.2	IS	-10.0	JP	3.2	-1.0	532
Δ(M_UEMP)	0.08	2.6	SE	-1.0	IS	0.4	2.0	532

The table shows summary statistics of quarterly changes in sovereign variables. For each variable we report the mean, the maximum and the name of the country, the minimum and the name of the country, the standard deviation, the skewness and the number of observations. $\Delta(\bullet)$ is the first difference over the quarter and $\%\Delta(\bullet, t)$ is the percentage change over t quarters.

C Correlation Matrices

Table 10: **Bank Variables**

Bank Variables																
Δ(B_CB_A)	1.00															
Δ(B_GG_A)	0.00	1.00														
%Δ(B_CREDIT,4)	0.07	-0.14	1.00													
Δ(B_EXT_A)	-0.02	-0.06	0.30	1.00												
Δ(B_DEP)	0.18	0.12	0.10	0.23	1.00											
Δ(B_BEXT_S)	-0.01	-0.09	0.31	0.91	0.13	1.00										
Δ(B_BEXT_L)	-0.05	-0.01	0.37	0.87	-0.03	0.83	1.00									
Δ(B_CB_L)	0.29	0.19	0.16	0.14	0.06	0.00	0.08	1.00								
Δ(B_GG_L)	-0.01	0.14	-0.03	-0.14	0.02	-0.30	-0.13	0.17	1.00							
Δ(B_CAPITAL)	-0.09	0.03	-0.10	-0.37	-0.46	-0.31	-0.12	-0.10	0.02	1.00						
Δ(B_SYN_GDP)	0.01	-0.09	-0.08	-0.04	-0.11	0.01	0.01	-0.02	-0.05	0.05	1.00					
%Δ(F_HOUSE_REAL)	-0.06	-0.22	0.29	0.10	-0.03	0.12	0.13	-0.08	-0.02	0.11	0.06	1.00				
Δ(F_R_EDF)	0.04	-0.07	0.04	-0.13	0.07	-0.10	-0.16	0.06	0.08	-0.17	-0.07	-0.09	1.00			
%Δ(F_STOCK)	-0.05	-0.09	0.17	0.28	-0.04	0.29	0.30	-0.17	-0.09	0.33	0.04	0.28	-0.42	1.00		
%Δ(M_GDP_REAL,4)	-0.03	-0.33	0.26	0.10	-0.03	0.10	0.08	-0.04	0.01	0.02	0.00	0.44	-0.05	0.17	1.00	
Δ(M_UEMP)	0.00	0.22	-0.09	-0.12	0.07	-0.15	-0.15	0.19	0.07	-0.08	0.02	-0.35	0.16	-0.25	-0.48	1.00

Table 11: **Sovereign Variables**

Sovereign Variables																
Δ(S_DEBT_GDP)	1.00															
Δ(S_NDEBT_GDP)	0.65	1.00														
Δ(S_REV_GDP)	-0.10	-0.13	1.00													
Δ(S_EXP_GDP)	0.32	0.30	0.23	1.00												
Δ(S_RESERVES_G)	0.15	0.07	-0.04	0.05	1.00											
Δ(S_IR_REV)	0.19	0.17	-0.24	0.00	0.03	1.00										
Δ(S_IRN_REV)	0.18	0.16	-0.15	0.01	0.02	0.96	1.00									
Δ(S_FXDEBT_GDP)	0.31	0.26	-0.18	0.11	0.16	0.12	0.09	1.00								
Δ(S_FIXED_TOTAL)	-0.12	-0.12	-0.02	-0.12	0.01	-0.05	-0.08	-0.21	1.00							
Δ(S_MATURITY)	-0.06	-0.06	0.19	-0.02	0.02	0.03	0.05	-0.07	0.01	1.00						
Δ(S_GEXT_L)	0.37	0.39	-0.06	0.09	0.13	0.12	0.11	0.09	-0.10	-0.02	1.00					
Δ(S_GEXT_S)	0.36	0.17	-0.02	-0.02	0.08	-0.02	-0.02	0.07	-0.02	-0.05	0.04	1.00				
%Δ(F_NEER)	-0.15	-0.13	0.11	-0.15	-0.12	-0.07	-0.05	-0.28	0.01	-0.12	-0.11	0.00	1.00			
%Δ(F_STOCK)	-0.25	-0.22	0.08	-0.19	0.04	-0.11	-0.12	-0.27	0.13	-0.01	0.01	-0.12	0.15	1.00		
M_CA	-0.27	-0.23	0.08	-0.16	0.00	-0.18	-0.14	-0.30	-0.08	0.01	-0.12	-0.03	0.12	0.20	1.00	
Δ(M_NIIP)	0.00	0.01	-0.08	0.29	0.02	0.03	0.02	0.02	-0.06	0.02	-0.12	-0.18	-0.05	-0.17	-0.01	1.00

D. Regression Results

Table 12: **Panel Unit Root Tests**
The table shows test statistics for four types of panel unit root tests with individual intercept: Levin, Lin and Chu (2002), Im, Pesaran and Shin (2003), and Fisher-type tests. The null hypothesis is a unit root whereas the alternative hypothesis is that at least one of individual series in the panel is stationary. The first test assumes a "common root" (common AR structure for all of the series). The later three tests assume "individual roots" (allow for different AR coefficients across cross-sections). One, two or three stars denote coefficients that are significant at the 10%, 5% or 1% level respectively. The panel unit roots test indicate that most of the variables are integrated of order 1 at the 1% significance level. Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.

Test for unit root in level	B_CDS-B_FINSNR	B_CB_L	S_CDS-S_NO	S_DEBT_GDP
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	6.376	0.845	8.753	5.842
Null: Unit root (assumes individual unit root process)				
Im, Pesaran & Shin W-stat	2.962	0.009	6.292	10.55
ADF - Fisher Chi-square	37.44	44.70	23.80	6.005
PP - Fisher Chi-square	45.16	51.17	31.42	3.294
Test for unit root in 1st difference	B_CDS-B_FINSNR	B_CB_L	S_CDS-S_NO	S_DEBT_GDP
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-6.964^{***}	-9.346^{***}	-9.588^{***}	-1.765^{**}
Null: Unit root (assumes individual unit root process)				
Im, Pesaran & Shin W-stat	-9.781^{***}	-11.47^{***}	-9.650^{***}	-5.427^{***}
ADF - Fisher Chi-square	182.2^{***}	199.7^{***}	151.3^{***}	113.0^{***}
PP - Fisher Chi-square	331.2^{***}	403.2^{***}	293.3^{***}	216.7^{***}

Table 13: **Explaining Bank Credit Default Swap Spreads in Changes**
Using a quarterly panel dataset between Q1 2004 and Q4 2010, we regress the change in bank credit default swap spreads relative to the iTraxx Senior Financial Index against the change in macro-financial variables listed below with ordinary least squares.

$$\Delta(\text{B\_CDS-B\_FINSNR})_{it} = c_{i1} + \beta_1' \times \Delta(\text{LOCAL BANK VARIABLES})_{it} + \epsilon_{it1}$$

$\Delta(\bullet)$ stands for first difference of the variable over the quarter. $\%\Delta(\bullet, t)$ stands for the percentage change of the variable over t quarter(s). The table reports the coefficients and t-statistics for the panel regressions. The standard errors are robust in the presence of heteroskedasticity and serial correlation in the residuals. One, two and three stars denote coefficients that are significant at the 10%, 5% and 1% level, respectively. 18 countries are included in the regression. Coefficients in bold are significant at the 1% significance level when excluding Iceland in the sample.

Δ(LOCAL BANK VARIABLES)	I	II	III	IV	V
INTERCEPT	1.474	0.253	−6.756	1.020	0.888
	(0.800)	(0.110)	(-1.442)	(1.643)	(0.800)
Δ(B_CB_A)	−3.287	−3.418*	−0.006		
	(-1.544)	(-1.679)	(-0.002)		
Δ(B_GG_A)	5.073	4.845	6.180		
	(1.449)	(1.475)	(1.475)		
$\%\Delta$(B_CREDIT,4)	0.246	0.555	0.774***		
	(0.508)	(1.378)	(3.357)		
Δ(B_EXT_A)	0.340	0.307	0.106		
	(0.716)	(0.670)	(0.211)		
Δ(B_DEP)	−2.807*	−2.690*	−0.337		
	(-1.915)	(-1.872)	(-0.257)		
Δ(B_BEXT_S)	−1.139	−1.142	−0.863		
	(-1.127)	(-1.146)	(-0.887)		
Δ(B_BEXT_L)	0.158	0.102	1.759***		
	(0.126)	(0.087)	(3.824)		
Δ(B_CB_L)	**5.682*****	**5.801*****	**5.870*****	**5.981*****	**6.185*****
	(4.521)	(4.919)	(5.853)	(5.982)	(6.569)
Δ(B_CAPITAL)	−0.130	−1.103	−4.024		
	(-0.016)	(-0.147)	(-0.639)		
Δ(B_SYN_GDP)	0.671	0.665	−3.111***		
	(0.322)	(0.329)	(-2.592)		
$\%\Delta$(F_HOUSE_REAL)	−0.040	−0.263	0.079		
	(-0.045)	(-0.337)	(0.086)		
Δ(F_R_EDF)	**9.467*****	**9.447*****	**10.03*****	**7.589*****	**7.630*****
	(3.091)	(3.256)	(4.297)	(3.166)	(3.355)
$\%\Delta$(F_STOCK)	0.154	0.181	−0.387		
	(0.393)	(0.465)	(-0.624)		
$\%\Delta$(M_GDP_REAL,4)	0.370	0.278	2.075		
	(0.363)	(0.308)	(1.403)		
Δ(M_UEMP)	7.949	8.107	14.43*	9.222	10.07*
	(1.287)	(1.432)	(1.928)	(1.636)	(1.896)
Adjusted R-squared	0.2941	0.3047	0.3631	0.2513	0.2629
Time fixed effect	N	N	N	N	N
Country fixed effect	Y	N	Y	Y	N
Iceland included	N	N	Y	N	N

Table 14: **Bank Equation: Panel Cointegration Tests**
The table reports panel cointegration tests by Pedroni (1999,2004) which are based on the Engle-Granger (1987) two-step (residual-based) cointegration tests. Pedroni suggests two classes of test statistics for the null hypothesis of no cointegration: (i) "panel statistics" that is equivalent to unit root tests against the homogeneous alternatives (common AR coeffcients) for all countries (ii) "group statistics" that is analogous to the panel unit roots test against the heterogeneous alternatives (individual AR coeffcients) for all countries. The lag length selection is based on the Schwarz Information Criteria. The table reports cointegration tests between excess bank credit spread (B_CDS-B_FINSNR) and short-term collateralised loans at the central bank. We reject the null hypothesis of no cointegration except for one statistic. One, two or three stars denote coefficients that are significant at the 10%, 5% or 1% level respectively.

Alternative hypothesis: common AR coefs. (within-dimension)	B_CDS-B_FINSNR
Panel v-Statistic	2.497^{***}
Panel rho-Statistic	-1.130
Panel PP-Statistic	-1.289^{*}
Panel ADF-Statistic	-1.317^{*}
Panel v-Statistic (weighted)	1.941^{**}
Panel rho-Statistic (weighted)	-4.233^{***}
Panel PP-Statistic (weighted)	-4.605^{***}
Panel ADF-Statistic (weighted)	-5.105^{***}
Alternative hypothesis: individual AR coefs. (between-dimension)	
Group rho-Statistic	-1.658^{**}
Group PP-Statistic	-2.618^{***}
Group ADF-Statistic	-3.308^{***}

Table 15: **Explaining Bank Credit Default Swap Spreads in Levels**
Using a quarterly panel dataset between Q1 2004 and Q4 2010, we regress bank credit default swap spreads relative to the iTraxx Senior Financial Index against macro-financial variables listed below with ordinary least squares.

$$(\text{B\_CDS-B\_FINSNR})_{it} = c_{i2} + \beta_2' \times (\text{LOCAL BANK VARIABLES})_{it} + \epsilon_{it2}$$

$\%\Delta(\bullet, t)$ stands for the percentage change of the variable over t quarter(s). The table reports the coefficients and t-statistics for the panel regressions. The standard errors are robust in the presence of heteroskedasticity and serial correlation in the residuals. One, two and three stars denote coefficients that are significant at the 10%, 5% and 1% level, respectively. 18 or 19 countries are included in the regressions. Coefficients in bold are significant at the 1% significance level when excluding Iceland in the sample.

LOCAL BANK VARIABLES	I	II	III	IV
INTERCEPT	49.35	230.2**	−31.44**	−18.33***
	(0.902)	(2.137)	(-2.507)	(-2.748)
B_CB_A	−0.677	−2.620		
	(-0.343)	(-1.349)		
B_GG_A	1.928	−2.110		
	(0.860)	(-0.581)		
B_CREDIT	0.697	−1.390		
	(0.743)	(-1.274)		
B_EXT_A	0.012	−0.127		
	(0.032)	(-0.426)		
B_DEP	−0.783	2.076		
	(-0.588)	(1.338)		
B_BEXT_S	−1.169	−0.563		
	(-1.291)	(-0.584)		
B_BEXT_L	0.028	1.541		
	(0.027)	(1.474)		
B_CB_L	**7.505*****	**8.808*****	**7.444*****	**5.444*****
	(3.926)	(6.026)	(3.892)	(4.229)
B_CAPITAL	−5.475	−23.08***		
	(-0.897)	(-2.544)		
B_SYN_GDP	−0.647	−8.069***		
	(-0.185)	(-3.537)		
$\%\Delta$(F_HOUSE_REAL)	−1.076	−3.219		
	(-0.427)	(-1.282)		
F_R_EDF	−1.681	1.343		
	(-0.276)	(0.190)		
F_STOCK	0.066	−0.493		
	(0.267)	(-1.010)		
$\%\Delta$(M_GDP_REAL,4)	−1.230	2.553		
	(-0.420)	(0.735)		
M_UEMP	−0.100	0.846		
	(-0.036)	(0.254)		
Adjusted R-squared	0.5961	0.6417	0.5797	0.4302
Time fixed effect	N	N	N	N
Country fixed effect	Y	Y	Y	N
Iceland included	N	Y	N	N

Table 16: **Explaining Sovereign Credit Default Swap Spreads in Changes**
Using a quarterly panel dataset between Q1 2004 and Q4 2010, we regress the change in sovereign credit default swap spreads relative to the Norwegian CDS spread against the change in macro-financial variables listed below with ordinary least squares. The results are broadly the same if we use the S_SOVX index as the benchmark.

$$\Delta(\text{S\_CDS-S\_NO})_{it} = c_{i3} + \beta_3' \times \Delta(\text{LOCAL SOVEREIGN VARIABLES})_{it} + \epsilon_{it3}$$

$\Delta(\bullet, t)$ stands for first difference of the variable over t quarter(s). $\%\Delta(\bullet)$ stands for the percentage change of the variable over the quarter. The table reports the coefficients and t-statistics for the panel regressions. The standard errors are robust in the presence of heteroskedasticity and serial correlation in the residuals. One, two and three stars denote coefficients that are significant at the 10%, 5% and 1% level, respectively. 19 countries are included in the regression.

Δ(LOCAL SOVEREIGN VARIABLES)	I	II	III	IV
INTERCEPT	17.18	−2.136	4.760***	4.575***
	(1.592)	(-0.478)	(6.854)	(2.191)
S_REV_GDP-S_EXP_GDP+S_IRN_GDP	−2.409	−1.356		
	(-1.447)	(-1.137)		
S_IRN_REV	−3.455	1.230***		
	(-1.363)	(3.561)		
Δ(S_DEBT_GDP-S_FXDEBT_GDP)	4.204**	4.562***	4.143***	4.143***
	(2.333)	(3.123)	(3.358)	(3.358)
Δ(S_FXDEBT_GDP)	10.48**	6.261	13.22*	11.00**
	(2.044)	(1.344)	(2.586)	(2.207)
Δ(S_GEXT_S)	−6.997*	−7.236**		
	(-1.773)	(-2.165)		
Δ(S_GEXT_L)	−9.370**	−8.995**	−8.518**	−7.978**
	(-2.553)	(-2.559)	(-2.320)	(-2.211)
Δ(S_RESERVES_G)	1.297	1.453		
	(0.972)	(1.276)		
Δ(S_FIXED_TOTAL,4)	−3.317	−3.648		
	(-1.139)	(-1.222)		
Δ(S_MATURITY,4)	1.184	1.527		
	(0.336)	(0.460)		
$\%\Delta$(F_NEER)	−2.536***	−2.746***		
	(-3.395)	(-3.520)		
Δ(F_C_EDF)	37.89***	37.70***	41.82***	41.41***
	(5.854)	(6.915)	(7.650)	(8.008)
Δ(M_CA)	−11.11***	−11.21***	−8.838***	−9.212***
	(-7.897)	(-5.886)	(-3.187)	(-3.672)
$\%\Delta$(M_GDP_REAL,4)	1.458	1.195		
	(1.327)	(1.230)		
Adjusted R-squared	0.467	0.452	0.393	0.382
without $\%\Delta$(F_C_EDF)	0.376	0.363		
without $\%\Delta$(F_C_EDF) and $\%\Delta$(F_NEER)	0.334	0.313	0.272	0.266
Time fixed effect	N	N	N	N
Country fixed effect	Y	N	Y	N
Iceland included	Y	Y	Y	Y

Table 17: **The Sovereign Equation: Panel Cointegration Tests**
The table reports panel cointegration tests by Pedroni (1999,2004) which are based on the Engle-Granger (1987) two-step (residual-based) cointegration tests. Pedroni suggests two classes of test statistics for the null hypothesis of no cointegration: (i) "panel statistics" that is equivalent to unit root tests against the homogeneous alternatives (common AR coeffcients) for all countries (ii) "group statistics" that is analogous to the panel unit roots test against the heterogeneous alternatives (individual AR coeffcients) for all countries. The lag length selection is based on the Schwarz Information Criteria. The first column reports cointegration tests between the excess sovereign credit spread (S_CDS-S_NO) and sovereign variables (debt to GDP and the median corporate EDF). Eight of the eleven statistics reject the null hypothesis of no cointegration at 5% significance level. One, two or three stars denote coefficients that are significant at the 10%, 5% or 1% level respectively.

Alternative hypothesis: common AR coefs. (within-dimension)	S_CDS-S_NO
Panel v-Statistic	6.064^{***}
Panel rho-Statistic	3.002
Panel PP-Statistic	-2.221^{**}
Panel ADF-Statistic	-5.288^{***}
Panel v-Statistic (weighted)	2.873^{***}
Panel rho-Statistic (weighted)	3.242
Panel PP-Statistic (weighted)	-3.176^{***}
Panel ADF-Statistic (weighted)	-7.111^{***}
Alternative hypothesis: individual AR coefs. (between-dimension)	
Group rho-Statistic	5.450
Group PP-Statistic	-2.193^{**}
Group ADF-Statistic	-6.959^{***}

Table 18: **Explaining Sovereign Credit Default Swap Spreads in Levels**
Using a quarterly panel dataset between Q1 2004 and Q4 2010, we regress the sovereign credit default swap spreads relative to the Norwegian CDS spread against the macro-financial variables listed below with ordinary least squares.

$$\text{S\_CDS-S\_NO}_{it} = c_{i4} + \beta_4' \times (\text{LOCAL SOVEREIGN VARIABLES})_{it} + \epsilon_{it4}$$

$\%\Delta(\bullet)$ stands for the percentage change of the variable over the quarter. The table reports the coefficients and t-statistics for the panel regression. The standard errors are robust in the presence of heteroskedasticity and serial correlation in the residuals. One, two and three stars denote coefficients that are significant at the 10%, 5% and 1% level, respectively. 19 countries are included in the regression. D(POST Q3 2008) is dummy variable which equals one after the collapse of Lehman Brothers

(LOCAL SOVEREIGN VARIABLES)	I	II	III	IV
INTERCEPT	31.63	−32.55	−247.9***	−30.37***
	(0.196)	(-0.437)	(-4.102)	(-3.375)
S_REV_GDP-S_EXP_GDP+S_IRN_GDP	0.334	−4.340		
	(0.075)	(-1.069)		
S_IRN_REV	−1.531	−5.262		
	(-0.155)	(-1.334)		
S_DEBT_GDP	5.375*	0.151	3.375***	
	(1.739)	(0.659)	(3.667)	
D(POST Q3 2008)*S_DEBT_GDP				0.451*
				(1.806)
S_FXDEBT_GDP	−6.493**	−0.238		
	(-2.555)	(-0.131)		
S_GEXT_S	−14.17**	−1.074		
	(-2.509)	(-0.485)		
S_GEXT_L	0.076	1.068*		
	(0.026)	(1.907)		
S_RESERVES_G	0.127	1.452*		
	(0.073)	(1.784)		
S_FIXED_TOTAL	−3.535	0.021		
	(-1.457)	(0.033)		
S_MATURITY	−6.060	−1.676		
	(-1.212)	(-0.534)		
$\%\Delta$(F_NEER)	−2.822***	−3.615***		
	(-3.679)	(-3.447)		
F_C_EDF	58.81***	48.04***	43.27***	52.59***
	(5.520)	(4.085)	(4.433)	(10.34)
M_CA	−10.93***	−2.722***	−10.49***	−2.867***
	(-4.378)	(-2.693)	(-4.141)	(-2.812)
$\%\Delta$(M_GDP_REAL,4)	1.118	−0.772		
	(0.565)	(-0.385)		
Adjusted R-squared	0.755	0.624	0.697	0.589
Time fixed effect	N	N	N	N
Country fixed effect	Y	N	Y	N
Iceland included	Y	Y	Y	Y

Table 19: **Granger Causality Tests**
The table reports pairwise granger causality tests between CDS spreads and banks' short-term collateralised loans at the central bank. All p-values are adjusted for autocorrelation and heteroskedasticity. One, two and three stars denote coefficients that are significant at the 10%, 5% and 1% level, respectively. We cannot reject that sovereign and bank credit spread does not granger cause banks' collateralised loans the central bank. However, we reject that banks' collateralised loans do not granger cause sovereign and bank CDS spreads. $\Delta(\bullet, t)$ stands for first difference of the variable over t quarter(s).

	t-Statistic
Δ(B_CB_L) does not Granger Cause Δ(S_CDS)	1.693*
Δ(S_CDS) does not Granger Cause Δ(B_CB_L)	0.090
Δ(B_CB_L) does not Granger Cause Δ(B_CDS)	2.436**
Δ(B_CDS) does not Granger Cause Δ(B_CB_L)	1.307

Table 20: **Interaction of Sovereign and Bank Credit Risk in Changes**
Using a quarterly panel dataset between Q1 2004 and Q4 2010, we regress the change in sovereign credit default swap spreads relative to the Norwegian CDS spread against the changes in macro-financial variables listed below with ordinary least squares.

$$\Delta(\text{S\_CDS-S\_NO})_{it} = c_{i5} + \beta_5' \times \Delta(\text{LOCAL SOVEREIGN VARIABLES})_{it} + \gamma_5' \times \Delta(\text{LOCAL BANK VARIABLES})_{it} + \epsilon_{it5}$$

$$\Delta(\text{B\_CDS-B\_FINSNR})_{it} = c_{i6} + \beta_6' \times \Delta(\text{LOCAL SOVEREIGN VARIABLES})_{it} + \gamma_6' \times \Delta(\text{LOCAL BANK VARIABLES})_{it} + \epsilon_{it6}$$

$\Delta(\bullet, t)$ stands for first difference of the variable over t quarter(s). The table reports the coefficients and t-statistics for the panel regression. The standard errors are robust in the presence of heteroskedasticity and serial correlation in the residuals. One, two and three stars denote coefficients that are significant at the 10%, 5% and 1% level, respectively. 18 countries are included in the regression.

	Δ(S_CDS-S_NO)	Δ(B_CDS-B_FINSNR)
INTERCEPT	5.962***	3.052
	(2.676)	(1.408)
Δ(B_CB_L)	3.139***	6.167***
	(5.957)	(5.838)
Δ(F_R_EDF)	2.712**	11.40***
	(2.157)	(6.719)
Δ(S_DEBT_GDP-S_FXDEBT_GDP)	3.018***	2.005*
	(5.300)	(1.763)
Δ(S_FXDEBT_GDP)	26.24	23.72
	(1.373)	(1.290)
Δ(S_GEXT_L)	−8.181**	−8.148***
	(-2.362)	(-2.591)
Δ(F_C_EDF)	26.44***	−21.83
	(2.709)	(-1.297)
Δ(M_CA)	1.302	0.105
	(0.455)	(0.025)
Adjusted R-squared	0.400	0.320
Time fixed effect	N	N
Country fixed effect	N	N
Iceland included	N	N

Table 21: **Interaction of Sovereign and Bank Credit Risk in Levels**
Using a quarterly panel dataset between Q1 2004 and Q4 2010, we regress bank credit default swap spreads relative to the iTraxx Senior Financial Index against macro-financial variables listed below with ordinary least squares.

$$\begin{aligned}(\text{S\_CDS-S\_NO})_{it} = c_{i7} + \beta_7' \times (\text{LOCAL SOVEREIGN VARIABLES})_{it} \\ +\gamma_7' \times (\text{LOCAL BANK VARIABLES})_{it} + \epsilon_{it7}\end{aligned}$$

$$\begin{aligned}(\text{B\_CDS-B\_FINSNR})_{it} = c_{i8} + \beta_8' \times (\text{LOCAL SOVEREIGN VARIABLES})_{it} \\ +\gamma_8' \times (\text{LOCAL BANK VARIABLES})_{it} + \epsilon_{it8}\end{aligned}$$

The table reports the coefficients and t-statistics for the panel regressions. The standard errors are robust in the presence of heteroskedasticity and serial correlation in the residuals. One, two and three stars denote coefficients that are significant at the 10%, 5% and 1% level, respectively. 18 countries are included in the regression.

	S_CDS-S_NO	B_CDS-B_FINSNR
INTERCEPT	-189.0^{***}	-71.25
	(-3.935)	(-1.615)
B_CB_L	3.559^{**}	6.686^{**}
	(2.414)	(5.122)
S_DEBT_GDP-S_FXDEBT_GDP	2.957^{**}	0.933
	(2.444)	(0.633)
S_FXDEBT_GDP	9.256	15.87
	(0.726)	(1.258)
S_GEXT_L	-2.073	-2.325
	(-0.798)	(-0.842)
F_C_EDF	42.43^{***}	21.30^{*}
	(3.241)	(1.832)
M_CA	-2.394	-0.469
	(-0.741)	(-0.203)
Adjusted R-squared	0.666	0.625
Time fixed effect	N	N
Country fixed effect	Y	Y
Iceland included	N	N

	S_CDS-S_NO	B_CDS-B_FINSNR
INTERCEPT	-189.0^{***}	-71.25
	(-3.935)	(-1.615)
B_CB_L	3.559^{**}	6.686^{***}
	(2.414)	(5.122)
S_DEBT_GDP-S_FXDEBT_GDP	2.957^{**}	
	(2.444)	
F_C_EDF	42.43^{***}	21.30^{**}
	(3.241)	(1.832)
Adjusted R-squared	0.659	0.610
Time fixed effect	N	N
Country fixed effect	Y	Y
Iceland included	N	N

Table 22: **IMF-supported Programs**

Countries with access to IMF Stand-By Arrangements (SBA) or Extended Fund Facility (EFF) in our sample from 2004 to 2010 as reported by the database on Monitoring of Fund Arrangement (MONA). We exclude IMF-supported programs where GDP per capita is less than 5000 in U.S. dollars (current prices) at the time of initiation.

Country	Type	Approval date
Hungary	SBA	11/06/2008
Iceland	SBA	11/19/2008
Latvia	SBA	12/23/2008
Romania	SBA	05/04/2009
Greece	SBA	05/09/2010
Ireland	EFF	12/16/2010

Table 23: **Explaining IMF-supported Programs**
Using a quarterly panel data between Q1 2004 and Q4 2010, we regress the approval of an IMF-supported program against the macro-financial variables listed below with a logit specification. $MOVAV(\bullet, t)$ stands for the moving average of the variable over t quarters. Coefficients are reported with t-statistics below them in parentheses. One, two or three stars denote coefficients that are significant at the 10%, 5% or 1% level respectively.

Variable	19 countries	38 countries
INTERCEPT	-12.19^{***}	-6.547^{***}
	(-2.936)	(-8.878)
B_CB_L-MOVAV(B_CB_L,8)	0.064^{**}	0.047^{***}
	(2.545)	(2.182)
S_DEBT_GDP-MOVAV(S_DEBT_GDP,8)	0.399^{**}	0.178^{***}
	(2.439)	(4.349)

Table 24: **Explaining Bank Credit Default Swap Spreads in Changes**
Using a quarterly panel dataset between Q1 2004 and Q4 2010, we regress the change in bank credit default swap spreads against the change in macro-financial variables listed below with ordinary least squares.

$$\Delta(\text{B\_CDS})_{it} = c_{it9} + \beta_9' \times \Delta(\text{LOCAL BANK VARIABLES})_{it} + \epsilon_{it9}$$

$\Delta(\bullet)$ stands for first difference of the variable over the quarter. $\%\Delta(\bullet, t)$ stands for the percentage change of the variable over t quarter(s). The table reports the coefficients and t-statistics for the panel regressions. The standard errors are robust in the presence of heteroskedasticity and serial correlation in the residuals. One, two and three stars denote coefficients that are significant at the 10%, 5% and 1% level, respectively. 18 or 19 countries are included in the regression. Coefficients in bold are significant at the 1% significance level when excluding Iceland in the sample.

Δ(LOCAL BANK VARIABLES)	I	II	III
INTERCEPT	11.78***	9.217***	−2.413
	(4.245)	(3.223)	(-0.413)
Δ(B_CB_A)	−3.018	−3.047	0.632
	(-1.452)	(-1.490)	(0.177)
Δ(B_GG_A)	5.061	4.680	7.097
	(1.552)	(1.563)	(1.616)
$\%\Delta$(B_CREDIT,4)	0.059	0.423	1.180***
	(0.143)	(1.198)	(3.550)
Δ(B_EXT_A)	0.237	0.201	0.025
	(0.432)	(0.397)	(0.046)
Δ(B_DEP)	−1.399	−1.377	1.502
	(-1.001)	(-1.004)	(1.077)
Δ(B_BEXT_S)	−1.120	−1.136	−1.036
	(-1.061)	(-1.099)	(-1.077)
Δ(B_BEXT_L)	0.330	0.200	1.940***
	(0.278)	(0.183)	(4.899)
Δ(B_CB_L)	**5.264****	**5.410****	**6.020****
	(4.267)	(4.470)	(5.494)
Δ(B_CAPITAL)	3.525	2.559	−1.697
	(0.499)	(0.387)	(-0.266)
Δ(B_SYN_GDP)	−0.664	−0.673	−2.927***
	(-0.315)	(-0.330)	(-3.211)
$\%\Delta$(F_HOUSE_REAL)	0.763	0.391	0.524
	(0.944)	(0.497)	(0.573)
Δ(F_R_EDF)	**9.525****	**9.649****	**12.51****
	(4.723)	(5.272)	(3.829)
$\%\Delta$(F_STOCK)	−1.249*	−1.168	−1.945**
	(-1.736)	(-1.628)	(-2.172)
$\%\Delta$(M_GDP_REAL,4)	−2.270**	−1.566*	1.005
	(-1.992)	(-1.922)	(0.553)
Δ(M_UEMP)	8.495	9.266	12.47**
	(1.399)	(1.641)	(2.146)
Adjusted R-squared	0.5619	0.5682	0.5339
Time fixed effect	Y	Y	Y
Country fixed effect	Y	N	Y
Iceland included	N	N	Y

Table 25: **Explaining Bank Credit Default Swap Spreads in Levels**
Using a quarterly panel dataset between Q1 2004 and Q4 2010, we regress bank credit default swap spreads against macro-financial variables listed below with ordinary least squares.

$$\text{B\_CDS}_{it} = c_{it10} + \beta'_{10} \times (\text{LOCAL BANK VARIABLES})_{it} + \epsilon_{it10}$$

$\%\Delta(\bullet, t)$ stands for the percentage change of the variable over t quarter(s). The table reports the coefficients and t-statistics for the panel regressions. The standard errors are robust in the presence of heteroskedasticity and serial correlation in the residuals. One, two and three stars denote coefficients that are significant at the 10%, 5% and 1% level, respectively. 18 or 19 countries are included in the regression. Coefficients in bold are significant at the 1% significance level when excluding Iceland in the sample.

LOCAL BANK VARIABLES	I	II	III	IV
INTERCEPT	273.6	348.7**	31.74**	46.03***
	(1.431)	(2.178)	(2.379)	(6.259)
B_CB_A	−0.461	−2.017		
	(-0.215)	(-1.101)		
B_GG_A	0.860	−3.007		
	(0.395)	(-0.877)		
B_CREDIT	0.579	−1.277		
	(0.538)	(-1.218)		
B_EXT_A	0.033	−0.216		
	(0.092)	(-0.586)		
B_DEP	−0.956	2.246		
	(-0.517)	(1.101)		
B_BEXT_S	−1.271	−0.705		
	(-1.406)	(-0.729)		
B_BEXT_L	−0.427	1.857*		
	(-0.335)	(1.705)		
B_CB_L	**6.775*****	**8.559*****	**7.395*****	**5.215*****
	(4.436)	(6.196)	(3.634)	(4.077)
B_CAPITAL	−8.230	−22.20**		
	(-0.944)	(-2.164)		
B_SYN_GDP	−3.122	−8.902***		
	(-0.663)	(-3.746)		
%Δ(F_HOUSE_REAL)	−0.307	−2.714		
	(-0.135)	(-1.135)		
F_R_EDF	−0.803	4.694		
	(-0.106)	(0.491)		
F_STOCK	−0.419	−1.059		
	(-0.612)	(-1.056)		
%Δ(M_GDP_REAL,4)	−9.047	−2.513		
	(-1.442)	(-0.339)		
M_UEMP	−1.019	−0.956		
	(-0.335)	(-0.333)		
Adjusted R-squared	0.7657	0.7521	0.7535	0.6533
Time fixed effect	Y	Y	Y	Y
Country fixed effect	Y	Y	Y	N
Iceland included	N	Y	N	N

Table 26: **Explaining Sovereign Credit Default Swap Spreads in Changes**
Using a quarterly panel dataset between Q1 2004 and Q4 2010, we regress the change in sovereign credit default swap spreads against the change in macro-financial variables listed below with ordinary least squares.

$$\Delta(\text{S\_CDS})_{it} = c_{it} + \beta'_{11} \times \Delta(\text{LOCAL SOVEREIGN VARIABLES})_{it} + \epsilon_{it11}$$

$\Delta(\bullet, t)$ stands for first difference of the variable over t quarter(s). $\%\Delta(\bullet)$ stands for the percentage change of the variable over the quarter. The table reports the coefficients and t-statistics for the panel regressions. The standard errors are robust in the presence of heteroskedasticity and serial correlation in the residuals. One, two and three stars denote coefficients that are significant at the 10%, 5% and 1% level, respectively. 19 countries are included in the regression.

Δ(LOCAL SOVEREIGN VARIABLES)	I	II	III	IV
INTERCEPT	30.11*	1.730	4.912***	4.683**
	(1.785)	(0.275)	(5.036)	(2.189)
S_REV_GDP-S_EXP_GDP+S_IRN_GDP	−0.963	−0.156		
	(-0.468)	(-0.145)		
S_IRN_REV	−5.298	1.043*		
	(-1.482)	(1.950)		
Δ(S_DEBT_GDP-S_FXDEBT_GDP)	5.380***	5.542***	4.796***	4.897***
	(2.942)	(3.578)	(3.200)	(3.289)
Δ(S_FXDEBT_GDP)	8.133*	3.975	11.21***	9.129**
	(1.684)	(0.971)	(2.996)	(2.246)
Δ(S_GEXT_S)	−7.707**	−7.607***		
	(-2.220)	(-2.684)		
Δ(S_GEXT_L)	−9.333***	−8.619***	−7.837**	−7.223**
	(-2.800)	(-2.789)	(-2.368)	(-2.268)
Δ(S_RESERVES_G)	0.171	0.086		
	(0.130)	(0.070)		
Δ(S_FIXED_TOTAL,4)	−4.182	−4.537		
	(-1.592)	(-1.603)		
Δ(S_MATURITY,4)	2.180	2.752		
	(1.064)	(1.370)		
$\%\Delta$(F_NEER)	−2.514***	−2.807***		
	(-3.352)	(-3.425)		
Δ(F_C_EDF)	32.82***	33.06***	41.08***	40.53***
	(4.311)	(4.314)	(6.171)	(5.853)
Δ(M_CA)	−10.06***	−10.72***	−8.488***	−8.855***
	(-4.764)	(-4.591)	(-3.188)	(-3.716)
$\%\Delta$(M_GDP_REAL,4)	−1.573	−0.491		
	(-0.603)	(-0.243)		
Adjusted R-squared	0.566	0.549	0.514	0.503
Time fixed effect	Y	Y	Y	Y
Country fixed effect	Y	N	Y	N
Iceland included	Y	Y	Y	Y

Table 27: **Explaining Sovereign Credit Default Swap Spreads in Levels**
Using a quarterly panel dataset between Q1 2004 and Q4 2010, we regress the sovereign credit default swap spreads against the macro-financial variables listed below with ordinary least squares.

$$\text{S\_CDS}_{it} = c_{it12} + \beta'_{12} \times (\text{LOCAL SOVEREIGN VARIABLES})_{it} + \epsilon_{it12}$$

$\Delta(\bullet, t)$ stands for first difference of the variable over t quarter(s). $\%\Delta(\bullet)$ stands for the percentage change of the variable over the quarter. The table reports the coefficients and t-statistics for the panel regressions. The standard errors are robust in the presence of heteroskedasticity and serial correlation in the residuals. One, two and three stars denote coefficients that are significant at the 10%, 5% and 1% level, respectively. 19 countries are included in the regression.

(LOCAL SOVEREIGN VARIABLES)	I	II	III	IV
INTERCEPT	275.5	39.69	−250.2***	−22.28**
	(1.194)	(0.488)	(-3.979)	(-2.522)
S_REV_GDP-S_EXP_GDP+S_IRN_GDP	−1.421	−1.373		
	(-0.383)	(-0.277)		
S_IRN_REV	−2.816	−9.139*		
	(-0.300)	(-1.737)		
S_DEBT_GDP	3.776*	0.051	3.532***	
	(1.764)	(0.257)	(3.729)	
D(POST Q3 2008)*S_DEBT_GDP				0.593**
				(2.193)
S_FXDEBT_GDP	−8.509***	−2.168		
	(-2.973)	(-0.956)		
S_GEXT_S	−11.58***	−1.615		
	(-3.064)	(-0.569)		
S_GEXT_L	0.164	1.515***		
	(0.080)	(2.765)		
S_RESERVES_G	−1.126	0.304		
	(-0.568)	(0.297)		
S_FIXED_TOTAL	−4.496*	−0.028		
	(-1.861)	(-0.039)		
S_MATURITY	−8.796	−3.794		
	(-1.310)	(-1.168)		
$\%\Delta$(F_NEER)	−2.804***	−3.597***		
	(-3.504)	(-3.275)		
F_C_EDF	65.63***	51.57***	47.35***	54.31***
	(5.454)	(3.994)	(4.510)	(11.05)
M_CA	−10.78***	−3.113***	−11.21***	−2.761***
	(-3.829)	(-4.017)	(-4.902)	(-2.605)
$\%\Delta$(M_GDP_REAL,4)	−7.763	−10.28		
	(-1.482)	(-1.501)		
Adjusted R-squared	0.811	0.707	0.715	0.613
Time fixed effect	Y	Y	Y	Y
Country fixed effect	Y	N	Y	N
Iceland included	Y	Y	Y	Y

Financial Sector Linkages and the Dynamics of Bank and Sovereign Credit Spreads

René Kallestrup
David Lando
Agatha Murgoci*

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Abstract

We show that financial linkages across borders are priced in the CDS markets beyond what can be explained by exposure to common factors. Information on the relative size and riskiness of aggregate exposures of banks in one country to non-nationals is used to construct a dynamic measure of the risk arising from foreign exposures. We also construct a measure which in addition takes into account the relative size and riskiness of bank exposures to domestic government bonds and other domestic residents. Both measures help explaining the dynamics of bank CDS premia after controlling for country specific and global risk factors. Finally, a dynamic measure of the size of the implicit guarantee, that the sovereign may be assumed to extend for the domestic banking system, strongly impacts sovereign CDS premia.

Credit risk, banks, sovereign risk; **JEL:** G01; G15; G21

* David Lando is corresponding author. All authors are at the Department of Finance, Copenhagen Business School, Solbjerg Plads 3, DK-2000 Frederiksberg, Denmark (e-mails: dl.fi@cbs.dk, rk.fi@cbs.dk, and avm.fi@cbs.dk). We thank Erika Jimenez and Jing Zhang of Moody's Analytics for providing us with EDF data. We are grateful to Mads Stenbo Nielsen, Gustavo Suarez and seminar participants at Tilburg University and the Conference on Systemic Risk and Data Issues for valuable suggestions. Lando and Murgoci acknowledge support from the Danish Social Science Research Council.

1. Introduction

A key concern in the current European sovereign crisis is that restructuring of sovereign debt will increase the financial stress on banks already under pressure. The fear is that banks are vulnerable through their holdings of government debt. While exposures to sovereign debt are clearly important, they are relatively small compared to total balance sheets. For example, by the end of 2010, holdings of foreign sovereign debt accounted for only 19% of total foreign claims held by all banks reporting to the Bank for International Settlements (BIS). Holdings of domestic sovereign debt are also low compared to the assets of the banks on average representing 8% across all reporting banks in our sample.

A larger source of risk on the banks' asset side is the claims on banks and the non-bank private sector in other countries. We show in this paper that these exposures help explaining the dynamics of bank CDS premia even after controlling for country specific and global risk factors. Specifically, we show that two exposure risk measures based on consolidated banking statistics from BIS are highly significant in explaining movements in bank CDS spreads. The first measure uses information on the relative size and riskiness of aggregate exposures of banks in one country to non-nationals, i.e. the public sector, bank and non-banks, in other countries. These cross-country exposures are obtained from BIS statistics and we combine this information with CDS data to obtain a risk-weighted exposure measure. Our construction captures that large exposures to one country are primarily important when the credit risk of that country is high. The measure thus captures financial network effects in the banking system and does so dynamically. Our second measure combines the first risk measure with information on the relative size and riskiness of exposures to domestic government bonds and other domestic residents. The domestic exposures are combined with measures of sector specific default risk as captured by Moody's KMV's so-called Expected Default Frequency (EDF) measures. The EDF measures give us access to market-based measures of default risk for a very large number of firms in each country. We use these data to construct median sector default risk measures for both the non-financial corporate sector and for a real-estate related sector which also comprises construction. Both measures are shown to be significant in explaining changes in bank CDS spreads, and this is the case even if we spilt our sample into a period ending in Q4:2007 close to the Bear Sterns collapse and a sample ranging from Q1:2008 to Q4:2010. The role of the exposures is therefore not just related to the current financial crisis, even if the effects are stronger in the second half of our sample. We argue that proxy hedging behavior may be an explanation.

Furthermore, we consider the effect of the contingent liabilities of sovereigns arising from implicit or explicit guarantees of the banking system. Here we use a measure which combines the size of the banking system relative to GDP with the riskiness measured both through CDS premia and bank EDFs. As one would expect, these guarantees greatly influence sovereign CDS premia, even after controlling for traditional local fiscal

measures and global factors.

The literature on banking crises and on the role of bank risk in explaining sovereign debt crises is extensive. We focus on quantifying cross-country interlinkages that can be identified by looking at the asset side of the banks' balance sheets and we show that the measures we propose have explanatory power in addition to both global common factors and local measures of default risk of large classes of domestic borrowers. There are several theoretical reasons why we would expect such linkages to matter. For example, Kaminsky, Reinhart, and Vegh (2003) argue that a crisis of one country may spill into other countries in the presence of a "large common creditor" who in the face of losses in one country has to delever positions in other countries. This common creditor might be collections of other banks, financial institutions, or hedge finds. The same type of mechanism is explained in more detail in Tressel (2010) who specifically models the deleveraging of banks in countries whose banks have been exposed to losses in one country. In his calibration, Tressel (2010) also uses the consolidated banking statistics from BIS for his model calibration but he does not focus on the detailed time series of these statistics.

Whether network effects survive as explanatory variables once global common factors have been accounted for is not widely agreed upon. For example, Eichengreen, Mody, Nedeljkovic, and Sarno (2009) use dynamic principal component analysis to identify common latent factors underlying the dynamics of CDS premia for 45 banks in the US and 8 European countries. In their analysis of all possible combinations of pairwise influences, they find a very limited role of direct contagion. Our risk-weighted aggregate measure of exposure to all other banks does survive even after correcting for observable common factors. Rose and Spiegel (2010) find "remarkably little evidence that the intensity of the crisis across countries can be easily modeled using quantitative techniques and standard data that is either country specific or links countries to the source of the crisis." This paper shows that BIS statistics and CDS spreads do indeed contribute to our understanding of cross-border contagion. Degryse, Elahi, and Penas (2010) also use BIS consolidated banking statistics as a basis for simulating how shocks to one country's banking system may propagate through the international linkages and cause contagious defaults. Their focus is not on CDS spreads and their data end in 2006 whereas we cover the current financial crisis all through 2010.

Our paper supplements Acharya, Drechsler, and Schnabl (2011) in several aspects. They focus on the two-way feedback effect between sovereign and bank credit risk (see also Bolton and Jeanne (2011)) which we strongly confirm but with several important differences in the empirical analysis. While we also consider sovereign risk factors in our explanation of bank CDS spreads, we also include private exposures - both foreign and domestic - in our bank fundamentals. This is important since the bulk of banks' foreign exposures are to the private sector and not sovereigns. The decomposition of bank exposures to which we have access to gives a clear picture of the role of financial linkages in the determination of bank credit risk and our EDF measures also add information on

the risk of bank assets. In this sense our explanatory variables are closer to true bank fundamentals than bank equity returns used in Acharya, Drechsler, and Schnabl (2011). Furthermore, for the purpose of analyzing the role of banking risk for sovereign credit risk, we extend the modeling of government guarantees. As in Acharya, Drechsler, and Schnabl (2011) we include the size of the explicit guarantees made in the wake of the Lehman default, but we use different measures to quantify the size of the guarantees. We also include a dynamic measure of the size of the contingent liability (or implicit guarantee) that the sovereign may be assumed to give for the domestic banking system.

Our paper is also related to literature on the dynamics of sovereign credit spreads, as presented for example in Longstaff, Pan, Pedersen, and Singleton (2011). The authors here show large commonality with the first principal component explaining 75% of variations in sovereign CDS spreads in the period 2007-2010. Most of the commonality in their study is driven by global factors, risk premiums and investment flows rather than local factors. We show that the risk of banks is a large component in sovereign credit spreads and that in turn, the interlinkages between banking systems across borders help explain variations in bank credit spreads.

2 The Risk-weighted Exposure Matrix

The key data describing the financial sector linkages are summarized in what we label the BIS exposure matrix. We now describe how this is used together with CDS premia to construct our risk measure for the major banks in each country. As an illustration, we use the case of Austria.

The publicly available consolidated banking statistics from BIS provide consolidated foreign claims of a national banking system in one country on all residents (i.e. public sector, banks and the non-bank private sector) of other countries. For example, the size of exposures of Austrian banks to residents of Hungary represents the aggregate claims of all Austrian-owned bank branches and subsidiaries around the world on all residents of Hungary, i.e. public sector, banks and the non-bank private sector. While this number includes the exposure to the Hungarian sovereign debt, the biggest contributor is from private-sector debt. For example, the total claims held in Q4:2010 by BIS reporting banks on banks, the public sector and the non-bank private sector in Hungary were 10%, 30% and 60%, respectively. This decomposition is only available as an aggregated number and we do not have access to data for, say, the decomposition of Austria's exposures to Hungary.

A further indication of the prevalence of non-bank private sector exposure is the figures for BIS reporting banks' foreign claims on all the countries in the world. These were split between approximately 23% on banks, 19% on public sector and 58% on the non-bank private sector in Q4:2010.

Since we will need to pair the exposures with information on CDS premia either

on large banks or sovereigns, we include the foreign exposures of 17 countries: Austria (AT), Australia (AU), Belgium (BE), Switzerland (CH), Germany (DE), Denmark (DK), Spain (ES), France (FR), United Kingdom (GB), Greece (GR), Ireland (IE), Italy (IT), Japan (JP), Netherlands (NE), Portugal (PT), Sweden (SE), and United States (US).[1] The period covered is as with all our data Q1:2004 - Q4:2010.[2] Exposures of each of the 17 countries may well be to countries outside this set of 17 countries, and this is no problem as long as we have CDS data available for the banks or sovereigns for those other countries. For example, Korea and Iceland are not in our sample of 17 countries, since their banks do not report to BIS, but we are able to measure the riskiness of exposures *to* those two countries since there are CDS data available for their largest banks.

We do not include all foreign exposures of a country's banks, since for some countries a time series of CDS premia is not available for the sovereign or the banks. For that reason we choose to limit the counting of exposures until we have reached 85% of the total foreign exposure. More precisely, consider the banks of country A. Order the countries to which the banks in country A are exposed by the average exposure over the sample period, and pick enough countries so that the exposure in Q4:2010 is at least 85% of total exposure. This creates a list of countries to which the banks in country A have the most significant exposures. We measure the riskiness of the foreign exposures by weighing each exposure with an appropriate CDS spread. If available, we use average bank CDS spreads for the two largest banks in the country of the exposure. The idea is that the riskiness of the private sector exposures in a given country are reflected in the CDS spreads of the banks in that country. When bank CDS spreads are not available, as is typically the case for emerging markets, we use the sovereign CDS spreads instead. In emerging markets, a large part of the riskiness of an exposure is related to political risk and currency risk and these risks are also reflected in the sovereign CDS spreads. Empirical results in Dittmar and Yuan (2008) confirm the strong correlation between corporate credit spreads and sovereign credit spreads in emerging markets.

To illustrate the use of the BIS data, we consider the case of Austria. Table 1 shows the exposures to the countries towards which the Austrian banking system has its 19 largest exposures until 85% of the exposures are accounted for. The remaining exposures are collected under 'others'.

The table lists each aggregate foreign exposure as it was reported in Q4:2010. For example, the exposure to Germany was USD 42.9 bn on average throughout the entire

[1]We exclude Canada because we have no CDS data on Canadian sovereign debt, and we exclude BIS bank statistics reporting emerging markets because we have no CDS data for their banks.

[2]We use BIS consolidated statistics with residency of the ultimate obligor when available. The ultimate obligor refers to the counterparty who is ultimately responsible for servicing any outstanding obligations in the event of a default by the immediate borrower. Suppose that an Austrian bank extends a loan to a company based in Hungary and the loan is guaranteed by a US bank. On an immediate borrower basis, the loan would be considered a claim of an Austrian bank on Hungary, as the immediate borrower resides in Hungary. On an ultimate risk basis, however, the loan would be regarded as a claim of an Austrian bank on the United States since that is where the ultimate risk reside.

Table 1: **The foreign exposure matrix: Austria**

Rank	Country	Average (USD bn)	Q4 2010 (USD bn)	Share	Acc	Spread	Type	Share*CDS
1	DE	42.9	48.2	0.10	0.10	126	Bank	13
2	CZ	34.8	59.6	0.13	0.23	91	Sov	12
3	HU	23.2	35.0	0.07	0.34	378	Sov	28
4	RO	23.1	39.5	0.08	0.42	297	Sov	25
6	GB	21.6	15.8	0.03	0.26	169	Bank	6
5	HR	19.5	31.3	0.07	0.49	256	Sov	17
7	SK	18.8	27.9	0.06	0.55	82	Sov	5
9	US	17.4	16.3	0.03	0.58	132	Bank	5
8	IT	17.1	22.2	0.05	0.63	176	Bank	8
10	RU	11.0	15.2	0.03	0.66	147	Sov	5
11	NE	10.8	15.7	0.03	0.70	113	Bank	4
12	PL	9.6	14.3	0.03	0.73	144	Sov	4
13	SI	8.4	15.4	0.03	0.80	77	Sov	3
14	FR	8.3	9.3	0.02	0.75	142	Bank	3
15	RS	7.7	7.0	0.01	0.76	256	Sov	4
16	CH	7.7	11.2	0.02	0.82	100	Bank	2
17	UA	6.1	8.8	0.02	0.84	510	Sov	10
18	IE	6.0	2.9	0.01	0.83	1052	Bank	6
19	ES	5.5	6.7	0.01	0.86	259	Bank	4
-	Others	-	66.3	0.14	1.00	-	-	-
-	Total	-	468.7	1.00	1.00	-	-	163

The table shows the exposures to the countries towards which the Austrian banking system has its 19 largest exposures until 85% of the exposures are accounted for. There is not liquid historical CDS spread on Serbia (RS) and we thus use the one on Croatia (HR).

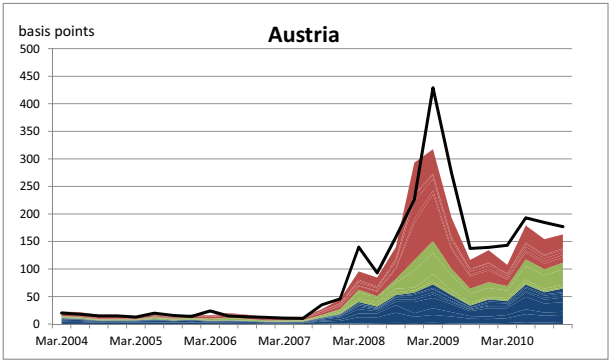
period and it was USD 48.2 bn in Q4:2010. The list is ordered according to the largest average exposure. At the end of Q4 2010 the total foreign exposure of the Austrian banking system was USD 468.7 bn and as we see the exposure to Germany accounted for roughly 10% of this. At the end of Q4 the average CDS premium for the two largest banks was 126 bps. The risk-weighted sum of CDS spreads (in which the weights only sum to 0.86) is 163 basis points. Hence the weighted average CDS spread of the exposures that enter the sample is 1/0.86 * 163 bps = 190 bps. Note that this measure is a risk-weighted average of Austrian banks' exposure to other countries in Q4:2010. The measure changes through time as the weights of the exposures shifts between countries and as the CDS spreads for the countries change. The risk-weighted foreign exposure is only expected to matter if the size of the exposure is large enough relative to other exposures. As shown in Table 2 the total exposure of the Austrian banking system is USD 1010 bn, i.e. the foreign exposures account for almost half of the total exposure. The 5-yr CDS spread for Austrian banks depicted in Figure 1 shows the clear covariation with the exposure measure.

Table 2: **The total exposure: Austria**

Claims on	USD bn	% GDP	Share
Non-nationals	468.7	124	0.46
Domestic sovereign	77.7	20	0.08
Other domestic residents	464.0	122	0.46
Total	1010.4	266	1.00

The table shows the composition of assets for Austrian banks. The claims on the domestic sovereign include the domestic general government and the central bank.

Figure 1: Austria dynamic exposure



The graph shows the exposure measure decomposed into major geographical regions. Red: Eastern Europe non-neighboring countries. Green: Eastern Europe neighboring countries (Czech Republic, Hungary, Slovakia and Slovenia). Blue: Other countries. The black curve shows the average CDS spread of the two largest Austrian banks.

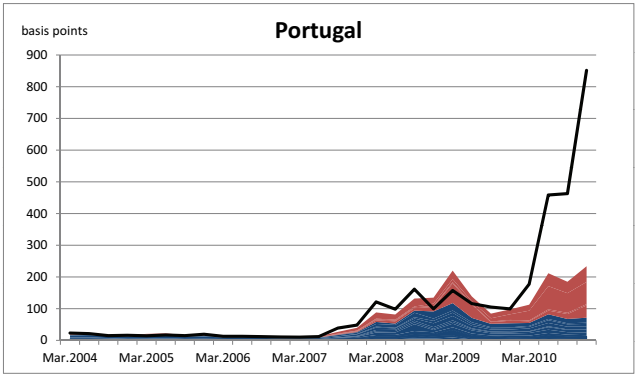
2.1 Adding Domestic Exposures

In contrast to Austria, Portugal's BIS matrix exposure does not seem to explain the movement of Portugal's average bank CDS spread as seen in Figure 2. To better understand the domestic drivers of default risk, we will also rely on so-called Expected Default Frequency (EDF) measures, which are estimates of default probabilities. We will return to these measures below. For now, it suffices to think of them as measuring probabilities of default. Figure 3 shows the dynamics of median firm EDFs in three sectors: banking, non-financial corporates and for the real estate sector. While EDFs for both the corporate sector and the real estate sectors increase for Austria, they are at moderate levels compared to Portugal, who sees a very large spike in the real estate EDFs and a also a higher level of corporate EDFs than Austria. The spike in bank EDFs in Portugal is very large and in combination, figures 1, 2 and 3 suggest that the crisis in Portugal was much more driven by domestic factors and Austris'a much more driven by foreign exposures. In Figure 4, looking at CDS spreads for Austria and Portugal, we see the CDS spread for banks and sovereigns and the domestic banks' CDS foreign exposure-weighted spread.

Table 3 lists the largest banks used to find the bank CDS spreads. In Austria, there is a high co-movement between the CDS spread for banks and the Austrian banks' foreign exposure-weighted CDS spreads. It indicates that Austrian banks were hit by a shock originating abroad, especially Eastern Europe. On the contrary, in Portugal we see a low co-movement, indicating that the the credit risk primarily originated in the domestic economy.

Table 4 shows summary statistics on foreign exposures for each of the 17 countries. The table shows the relative size and the (foreign) country of the largest exposure. It also shows the standard deviation of the time-series variation in the relative size of the largest exposure. This standard deviation ranges from 0.02 to 0.1. While this does show some time-series variation in exposures, a much larger source of variation in our exposures measures comes from the huge fluctuations in CDS premia. In addition, there is huge geographical variation in the countries to which different banks are exposed.

Figure 2: Portugal dynamic exposure

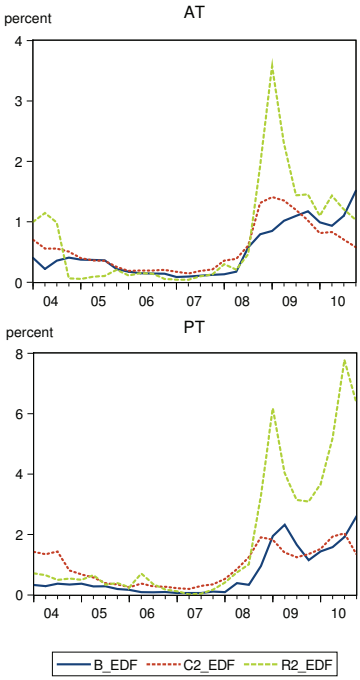


The graph shows the exposure measure decomposed into major geographical regions. Red: Greece, Spain, Italy and Ireland. Blue: Other countries. The black curve shows the average CDS spread of the two largest Portuguese banks.

3 The Data

The fundamental measure of bank and sovereign risk that we are trying to explain is CDS premia. In this section we detail the nature of the CDS data and the local and global variables that we use in our regressions. More details are available in Table 5 and Table 6.

Figure 3: Bank, corporate and real estate EDFs



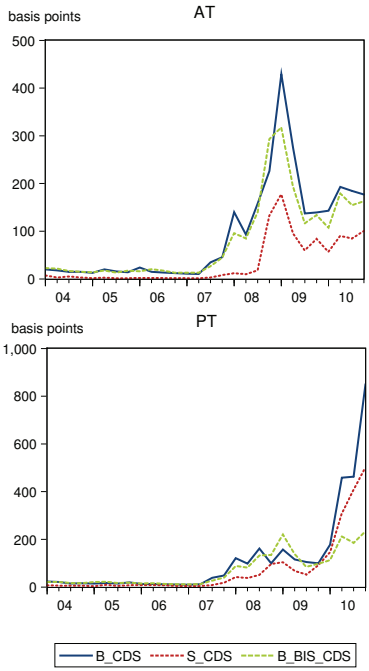
Austrian banks exposed to some increase in real estate and corporate risk, but the order of magnitude is far from that of Portugal. Green: Real estate 5-yr EDFs; Blueish: Bank 5-yr EDFs; Red: Non-bank corporate 5-yr EDFs.

3.1 CDS Data

We use a core sample of 5-yr CDS spreads on 17 sovereigns where the contracts are denominated in US dollar or Euro. Table 7 shows summary statistics on sovereign CDS spreads. Note that every country for which we have data for the full sample period at some point had single digit spreads in basis points on their CDS contracts. The largest observed end-of-quarter premium is 1010 bps for Greece. The two countries with the lowest maximum observed premia are Germany (59 bps) and the US (67 bps).

Bank CDS data are denominated in the local currency. They are 5-yr contracts and have senior unsecured debt as reference obligation. Table 8 shows summary statistics on bank CDS spreads. The largest maximum spreads are for Greece and Ireland, and the lowest are for Japanese banks. Table 9 shows summary statistics on the risk-weighted CDS spreads. The lowest maximum is for the US whereas the highest maximum is for Greece and Austria. Note the considerable time-series variability of our measure for each country.

Figure 4: Bank and sovereign CDS, exposure: Austria and Portugal



For Austria and Portugal we see the CDS spread for banks and sovereigns and the domestic banks' foreign exposure-weighted CDS spread. In Austria, there is a high co-movement between the CDS spread for banks and the Austrian banks' foreign exposure-weighted CDS spreads. It indicates that Austrian banks were hit by a shock originating abroad, especially Eastern Europe. On the contrary, in Portugal we see a low co-movement, indicating that the the credit risk primarily originated in the domestic economy. Blue: Average Bank CDS; Red: Sovereign CDS; Green: Weighted CDS exposure.

We obtain the CDS data from CMA which sources their information on executable and indicative prices directly from the largest and most active credit investors in the OTC market. Data from CMA are available daily since 2004 but we use end-of-quarter observations. There are some holes in the data most notably in the early period which are filled using the Fitch CDS pricing source. The included bank and sovereign CDS data often appear among the top references entities in the world with respect to net notional outstanding as reported by the Depository Trust & Clearing Corporation (DTCC).

3.2 Local Bank Variables

To proxy for default risk for, we use an extensive data set of EDFs (Expected Default Frequencies) obtained from Moody's Analytics (Moody's KMV). EDFs provide an estimate of the default probability of a borrower. The estimate is obtained by using a structural

model to back out firm asset value and asset volatility from observed equity prices and accounting information on leverage. From the estimated asset value and asset volatility, 'distance-to-default' (DD) is computed, and finally a non-parametric regression on historical data is used to find the empirical connection between DD and EDF. Our extensive data set of EDF covers all countries used in our exposure matrix calculations and the data allow us to compute aggregate measures of default risk for a number of different sectors in the economy. We have sorted the EDFs into the following categories: banks, other financials, real estate, and corporate, according to their SIC codes. The EDFs in the real estate category are the ones with SIC codes for real estate firms, real estate investment firms and construction firms. In a robustness check, we have kept the EDFs in the real estate category using only those with SIC codes representing real estate firms and real estate investment firms, and included the construction firms in the corporate EDF category. For each country, we consider the median of the EDFs for each category as the relevant risk measure. We have tried using other quantiles of the EDF distribution as well, but this did not change our results. While EDFs in general have strong predictive power, the level for banks has been suspected to be too low. Since we are focusing mainly on changes in EDFs this is a lesser concern in our paper, see Moody's (2010). Summary statistics on corporate EDFs are shown in Table 10, and Table 11 shows the correpsonding statistics for the broad real estate category i.e. the one including construction firms.

3.3 Local Government Variables

For use in our regressions for sovereign CDS spreads, we have collected quarterly balance sheet data for the individual countries from IMF International Financial Statistics (IFS), OECD and Eurostat. We define sovereign debt using nominal values of debt from the "general government sector" which comprises the subsectors of central government, state government, local government and social security funds. We include net interest payments relative to revenue and changes in the estimated budget deficit. The latter variable requires further explanation: The quarterly lending revision is calculated as the sum of the most recent year-end and year-ahead budget projection by the OECD or the IMF minus the second most recent forecast for the same period provided by the same organization. In quarters where they do not update a new budget projection we interpolate a forecast.

3.4 Global Variables

We include a number of global variables that have been used in other works to explain movements in sovereign credit spreads, see for example Longstaff, Pan, Pedersen, and Singleton (2011). The variables we use are:

- Excess return for the U.S. stock market - computed as the difference between the value-weighted return on all NYSE, AMEX, and NASDAQ stocks (from CRSP) - and the three-month Treasury bill.

- Percentage changes in the 5 year constant maturity treasury yields.
- Percentage changes in the corporate yield spreads. The investment-grade yield spreads are computed on the basis-point yield spread between BBB and AAA industrial bond indices. The percentage changes in high-yield spreads are computed for the basis-point yield spread between BB and BBB industrial bond indexes. The used indices represent average yields of a broad cross-section of noncallable AAA-, BBB-, and BB-rated bonds with maturities approximately equal to five years. The source for the yield data is Bloomberg.
- The volatility risk premium. This is computed as the difference between the VIX index and the realized volatility for the S&P 500 index over the preceding three months. Source: Bloomberg.
- Percentage changes in the Libor-OIS spread which measures the difference between swap rates linked to collateralized and uncollateralized lending. Source: Bloomberg.
- Itraxx SovX Western Europe comprising 15 names from the Eurozone region plus Denmark, Norway, Sweden and United Kingdom that trade on Western European documentation. All constituents are equally weighted and we use a computed theoretical price based on individual CDS premia before the start of trading on 28 September 2009.
- The Markit iTraxx Non-Financials index comprising 100 equally-weighted European entities and the Markit iTraxx Non-Financials index which comprises 25 equally-weighted European entities. For both the underlying reference obligations are senior unsecured debt.

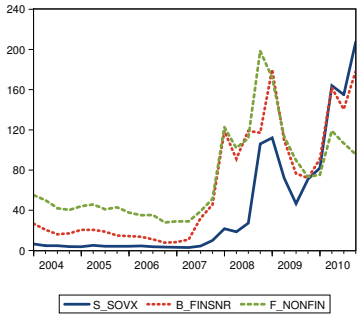
Figure 5 shows the time-series behavior of the iTraxx indices. The figure clearly illustrates how the crisis which started in the banking sector and the corporate sector over time develops into a sovereign debt crisis.

4 Bank Foreign Exposures Help Explain Bank CDS Dynamics

Our first task is to investigate whether movement in our risk-weighted exposure measure is capable of explaining movements in bank CDS spreads. Specifically, we analyze whether changes in the average of the CDS spreads of the two largest banks in a country can in part be explained by a change in the relative size and the riskiness of foreign exposures. We start by running the following crude panel regression:

$$\begin{aligned}\Delta(\text{B\_CDS})_{k,t} &= \alpha_{k,0} + \alpha_1 \times \Delta(\text{B\_BIS\_CDS})_{k,t} \\ &+ \alpha_2' \times \Delta(\text{Local Bank Variables})_{k,t} \\ &+ \alpha_3' \times \Delta(\text{Global Variables})_t + \epsilon_{k,t}\end{aligned}$$

Figure 5: iTraxx Financial, Non-Financial and SovX



The evolution in three major iTraxx CDS indices used for controlling for general levels of credit risk.

Here, as in all that follows, $\Delta(B\_CDS)_{k,t}$ denotes the change from quarter $t-1$ to t in average bank CDS spreads for country k. Similarly, $\Delta(B\_BIS\_CDS)_{k,t}$ denotes the change in our exposure-weighted credit spread over a quarter. Local Bank Variables are EDF measures for different sectors which control for the risk of domestic borrowers. Finally, the Global Variables is a vector of variables listed in section 3.4. The result is reported in Table 15. We perform the regression both for the full sample and for two subperiods. The first subperiod is from Q1:2004 until Q4:2007 and the second subperiod starts from Q1:2008 - the quarter in which Bear Stearns was rescued - and runs until the end of 2010. The regression uses Ordinary Least Squares (OLS) with robust standard errors.

The exposure-weighted credit spread is highly significant in the full sample and in both subsamples. Using the full sample results, a 100 basis point increase in the exposure-weighted credit spread corresponds to a 100 basis point increase in the average bank CDS spreads. Note that this is a panel regression result - i.e. we are estimating the same coefficient for all 17 countries.

The real estate EDF measure, R2_EDF, which measures median default probabilities in the real estate sector (broadly defined), is also highly significant in the full sample and in the second subsample consistent with the important role played by real estate in bank losses during the financial crisis. In contrast, none of the other local or global variables are significant even at the 5% level in the full sample. Surprisingly, the more general corporate EDF measure for the entire corporate sector, C2_EDF is not significant. This could be due to a multi-collinearity effect. When we regress Bank CDS premia on the EDF measure for the entire corporate sector, it is highly significant.

It is conceivable that the significance of the exposure-weighted credit spread does not reflect financial linkages but that it rather captures general movements in CDS premia which also affect Bank CDS premia. To check whether this is the case, we run new

regressions in which we control for general movements of CDS premia:

$$\begin{aligned}\Delta(\text{B\_CDS})_{k,t} &= \alpha_{k,0} + \alpha_1 \times \Delta(\text{B\_BIS\_CDS})_{k,t} \\ &+ \alpha_2' \times \Delta(\text{Local Bank Variables})_{k,t} \\ &+ \alpha_3' \times \Delta(\text{Global Variables})_t \\ &+ \alpha_4' \times \Delta(\text{CDS Indices})_t + \epsilon_{k,t}\end{aligned}$$

The results are reported in Table 16 and include two ways of controlling. First, we include three general European CDS indices: The iTraxx Sovereign Western Europe, iTraxx Senior Financials and iTraxx Non-Financials. The exposure-weighted credit spread remains highly significant. Second, we regress changes in the exposure-weighted credit spread on changes in these indices and use the residual of this regression as explanatory variable in a new regression. This residual clearly carries information on the risk of exposures that are due to linkages but not to general movements in the CDS market and even this residual explains changes in CDS spreads. In results not reported here, we have shown this to apply also in our second subsample, whereas in the first subsample the coefficient is positive but insignicant. Both when including indices and when using residuals, we find that the real estate EDF measure remains highly significant. Among the iTraxx indices, only the index for senior financials is significant in the full sample. Due to the quarterly sampling, it is difficult to show a role of government guarantees in lowering bank credit spreads over the full time series. We will return to the role of government guarantees in connection with sovereign spreads below.

The fact that interlinkages are priced in CDS markets throughout the entire sample may have several explanations. A common practice among hedge funds and risk managers is to hedge exposures through 'proxy hedging' - i.e. hedging through correlated but 'cheaper' hedging vehicles (see e.g. IMF (2010) and Association for Financial Markets in Europe (2011a)). For example, a bank may wish to hedge emerging market credit risk in Eastern Europe, either because it has exposure to sovereigns itself (as a direct exposure or as counterparty risk in large derivatives contracts) or because it wishes to hedge a large loan exposure in such countries using a 'macro' hedge. A cheaper solution may be to buy protection on Austrian banks which are known to have large exposures in these countries. This would explain the co-movement of bank CDS spreads across countries and why market participants seem to follow these interlinkages carefully. Interestingly, the pricing effects are stronger in the second half of our sample - a period where the hedging demand due to counterparty credit risk has increased, both because the risk itself has increased and because of regulatory requirements in Basel III. This is consistent with the use of proxy hedging as a driver of CDS spreads.

Another cheaper 'proxy hedge' than the hedge using CDS on the Austrian banks mentioned above is one using the CDS on the Austrian government since the banking sector has an implicit sovereign guarantee. The new Basel III rules encourage banks to use sovereign CDS to hedge Credit Value Adjustments (CVA). Banks are required

to hold capital against potential mark-to-market losses (i.e. CVA risk) associated with deterioration in the credit worthiness of a counterparty. One way to manage this risk is to buy a CDS referencing the country. The Basel rules encourage an appropriate proxy spread when a CDS spread is not available or illiquid. First, a bank that grants credit to corporations and banks located in a particular country may use sovereign CDS to hedge the associated credit or counterparty exposures. Second, buying of sovereign CDS protection can be used to hedge the credit risk of sovereign counterparties who are not posting collateral in, for example, large interest rate and currency swap transactions with banks. Association for Financial Markets in Europe (2011b) document that the expected potential exposure of dealers to European sovereigns may total as much as USD 70bn or around 50 percent of net notional CDS contracts outstanding on these reference entities. The report concludes: *"What is not known is how much of the exposure is actually hedged. It is, however, reasonable to assume that, during this period, the amount of hedging has increased due to turmoil in the market for sovereign risk and the impact of CVA on dealers' income statements."*

While foreign exposures clearly are important contributors to bank risk, it is still unlikely to capture the full picture. Banks have large domestic corporate exposures and they often have exposures to their own government and central bank as well. For example, as shown in Table 2, at the end of Q4:2010 Austrian banks had total exposures of USD 1010 bn corresponding to 266% of Austrian GDP. Of these exposures, 46% are foreign exposures reported to BIS, 8% are exposures to own government and central bank and the remaining 46% are other domestic exposures. We therefore wish to construct another risk measure that takes all these three types of exposures into account. To measure the risk of domestic government debt, the CDS premium on the sovereign would seem a natural choice. However, as we show below, sovereign CDS spreads and bank CDS spreads are simultaneously determined, and we therefore follow Kallestrup (2011) and use the following measure: We regress sovereign CDS premia on a number of explanatory variables of sovereign credit risk. In our regression, four variables are significant and these are domestic debt, foreign currency debt, long-term external debt, and the current account balance. S_RISK is then the fitted value of the CDS spread from this regression and it is used to measure that part of sovereign which is not related to the banking sector. Note that S_RISK is significant in the regression performed in Table 16.

There is no CDS measure which captures the risk of domestic exposures. Instead, we use the EDF for the real estate sector as the risk measure. While an EDF is not equal to a CDS spread, it is likely to be of the same order of magnitude. In a risk neutral world, the EDF measured in basis points would be larger than the CDS spread which would be roughly equal to the EDF multiplied by the loss rate in default. But risk premia are likely to make CDS spreads larger than this risk neutral level by some factor. Since, in addition, we are looking at changes in these variables, it is reasonable to assume that EDF levels and CDS premia are at the same scale. The extended bank exposure risk

measure we propose to measure is then the following:

$$\begin{aligned}\Delta(\text{Bank Credit Risk})_{k,t} &= \left(\frac{\text{Foreign claims}}{\text{Total}}\right)_{k,t} \times \Delta(\text{B\_BIS\_CDS})_{k,t} \\ &+ \left(\frac{\text{Domestic credit}}{\text{Total}}\right)_{k,t} \times \Delta(\text{R2\_EDF})_{k,t} \\ &+ \left(\frac{\text{Claims on sovereign}}{\text{Total}}\right)_{k,t} \times \Delta(\text{S\_RISK})_{k,t}\end{aligned}$$

The BIS exposure-weighted credit spread is now weighted by the fraction of foreign exposures to total bank assets. In addition, the fitted value of the domestic sovereign CDS premium is weighted by the relative size of this exposure and the median corporate EDF is weighted by the fraction of domestic exposures to total exposure. One might alternatively use exposures relative to book value of equity but this does not change our conclusions. Summary statistics for all three risk weights are shown in Table 12, Table 13 and Table 14. As seen in Table 17 this new measure is also highly significant. Changes in the iTraxx Senior Financials remain significant. Note that our extended measure is significant even after splitting into the two subsamples with the rescue of Bear Sterns marking the beginning of the second subsample.

5 Sovereign CDS Spreads and Contingent Liabilities

So far we have focused on the asset side of banks' balance sheets focusing on measures of asset quality that include financial linkages and shown that they can help explaining bank risk as measured by CDS premia. Implicit and explicit government guarantees imply that bank risk plays a huge role on the liability side of sovereign's balance sheet. In this section we show that bank risk has become a dominating factor in the determination of sovereign credit spreads. The regression now has the following form:

$$\begin{aligned}\Delta(\text{S\_CDS})_{k,t} &= \alpha_{k,0} + \alpha_1' \times \Delta(\text{Domestic Government Variables})_{k,t} \\ &+ \alpha_2' \times (\text{Guarantees})_{k,t} \\ &+ \alpha_3' \times \Delta(\text{Global Variables})_t + \epsilon_{k,t}\end{aligned}$$

where Global Variables and Domestic Government Variables are defined above. The fiscal variables are traditionally viewed as determinants of sovereign default risk. The term Guarantees refers to variables seeking to measure the size and riskiness of implicit and explicit guarantees made to the domestic banking system. The explicit guarantee (labeled Guarantee in Table 18) is a variable which is only active (i.e. non-zero) in quarters where a country has issued an explicit guarantee on parts of banks' liabilities.[3] When this is the case, the variable takes on a value equal to the size of the guarantee,

[3]There have been many types of financial support schemes, such as capital injections, purchases of assets, central bank support and liquidity provisions. These are not included here.

as reported by IMF (2009), relative to GDP. For all countries, this guarantee is made in Q4:2008.[4]

We have two additional variables seeking to measure the size of the sovereign's 'contingent liability' on the banking sector. The first variable is the size of the domestic banking system (measured as claims on domestic entities and non-nationals) relative to GDP multiplied by the average CDS premium of the two largest banks. This measure seeks to combine the size of the potential liability and its riskiness into one measure. The second variable uses median bank EDF instead of bank CDS to measure riskiness.

Columns I and II of Table 18 report the result of the regression when we use the CDS-based measure of the size of the implicit guarantee. Column I does not include the Q4:2008 explicit guarantees, column II does. Both implicit and explicit guarantees are highly significant. In columns III and IV the CDS-based measure of implicit guarantees is replaced by an EDF-based measure. Again, both implicit and explicit guarantees are highly significant. In all four regressions, the excess return on the US equity market, and changes in yield spreads on investment grade and high yield bonds are highly significant - consistent with the findings in Longstaff, Pan, Pedersen, and Singleton (2011).

Interestingly, changes in the domestic government variables are not seen to have a significant impact on the CDS premia. The negative sign on the LIBOR-OIS spread in somewhat puzzling. An increase in this variable should indicate an increase in general bank credit risk and we would therefore expect a positive sign of the regression coefficient.

Column V addresses the possibility of endogeneity of bank CDS premia, i.e. that sovereign and bank CDS are determined jointly. To demonstrate that Bank CDS premia do indeed influence sovereign CDS premia, we choose as instrument for bank credit risk the amount of central bank funding of banks - typically done through collateralized lending. The idea is that increases in central bank funding is a sign of increased bank credit risk. See Kallestrup (2011) for more on this.

Table 19 includes iTraxx indices as explanatory variables, but apart from this we proceed exactly as in Table 18. Implicit guarantees are still significant, and the explicit guarantees are also significant, albeit on one of the regressions only at the 10% level. Unsurprisingly, the general level of sovereign credit risk as measured by iTraxx Sovereign is significant. The presence of this variable removes the significance of the excess return on the US stock market, but not of the yield spreads on high yield bonds.

Instead of using as regressor the general level of sovereign credit spreads as measured by the iTraxx SovX index, in Table 20 we regress the deviations of the country-specific CDS spreads from the SovX index on the same variables used in Table 18. Explicit and implicit guarantees remain significant. Interestingly, when we use EDFs to measure the riskiness of the banking system (columns III and IV), global variables with exception of

[4]The guarantee on the Irish banking system was given September 29 and in force September 30. The price impact seems to mostly take place in Q4, and therefore we have used this as the relevant quarter for Ireland also.

changes in the 5-yr Constant Maturity Treasury interest rate are insignificant.

6 Conclusion

We show that financial linkages across borders are priced in the CDS markets beyond what can be explained by exposure to both global and country-specific factors. Financial linkages are measured using BIS consolidated banking statistics and these statistics are combined with CDS spreads to construct a risk-weighted foreign exposure measure for banking systems in 17 countries.

We also construct a measure which takes into account the entire asset side of banking systems by combining the information on foreign exposures with information on the relative size and riskiness of exposures to domestic government bonds and to other domestic residents. This measure also helps explaining bank CDS premia.

While the first measure is relevant for proving that banks' foreign financial exposures are reflected in CDS spreads, the second measure is a better candidate for detecting riskiness of a banking system when the risk arises both from exposure to foreign and to domestic factors. The De Larosière Report (2009) (p.63) advocates the establishment of a common data base containing relevant information on risk exposures of financial institutions and markets, both at the national and international level. The analysis here shows that markets seem to have taken such exposures into account in the pricing of CDS contracts and to the extent that CDS premia do reflect default risk, this is evidence in support of the idea, that such information could help building early warning systems. We argue that a likely explanation for the significant effect of linkages - even before the onset of the financial crisis - could be the use of proxy hedging. This would be consistent with the stronger effect found in the second half of our sample which covers the current financial crisis.

Having established that the bank asset side provides evidence on the contagion effects of banking systems, we turn to sovereign risk and consider the effect of the contingent liabilities of sovereigns arising from implicit or explicit guarantees of the banking system. We use a dynamic measure for the implicit guarantees and a measure of the explicit guarantee after the Lehman bankruptcy and show that they help quantify how the banking system contributes to sovereign credit risk. Since banks' foreign linkages are a big factor in explaining bank risk, and bank risk clearly help explain sovereign risk, our analysis also shows that the interlinkages in the banking system contribute to systemic sovereign risk.

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A Summary Statistics and Variable description

Table 3: **Banking groups as percentage of GDP, 2009**

Country	Bank Name	Size of bank USD bn	GDP USD bn	%GDP
AT	Erste Group Bank AG	291	382	76
AT	Raiffeisen Zentralbank Oesterreich AG	213	382	56
AU	National Australian Bank	576	994	58
AU	Westpac	519	994	52
BE	Dexia Group NV	832	472	176
BE	KBC Group NV	467	472	99
CH	UBS AG	1301	492	264
CH	Credit Suisse Group AG	1001	492	203
DE	Deutsche Bank AG	2162	3339	65
DE	Commerzbank AG	1216	3339	36
DK	Danske Bank AS	597	310	193
ES	Banco Santander SA	1600	1468	109
ES	Banco Bilbao Vizcaya Argentaria SA	771	1468	53
FR	BNP Paribas	2964	2656	112
FR	Crédit Agricole-Crédit Agricole Group	2440	2656	92
GB	Royal Bank of Scotland Plc	2749	2179	126
GB	Barclays Bank Plc	2234	2179	103
GR	National Bank of Greece SA	163	331	49
GR	EFG Eurobank Ergasias SA	121	331	37
IE	Bank of Ireland Plc	261	222	117
IE	Allied Irish Banks Plc	251	222	113
IT	Unicredit SpA	1338	2118	63
IT	Intesa Sanpaolo SpA	900	2118	42
JP	Mitsubishi UFJ Financial Group	1930	5069	38
JP	Sumitomo Mitsui Financial Group	1144	5069	23
NE	ING Group NV	1676	797	210
NE	Rabobank	875	797	110
PT	Banco Comercial Portugues SA	138	233	59
PT	Banco Espirito Santo SA	119	233	51
SE	Nordea Bank AB	731	406	180
SE	Skandinaviska Enskilda Banken AB	324	406	80
US	Bank of America Corporation	2223	14119	16
US	JP Morgan Chase Co.	2032	14119	14

The table lists the largest banks in each country used to find the average bank CDS spread.

Table 4: Summary Statistics: Foreign exposures

Country	Share of Exposure Explained in Q4 2010	Countries Included	Maximum Exposure	Country with Maximum Exposure	Standard Deviation of Maximum Exposure
AT	0.86	19	0.16	DE	0.02
AU	0.87	9	0.49	NZ	0.02
BE	0.87	13	0.63	NE	0.02
CH	0.85	17	0.51	US	0.04
DE	0.85	32	0.24	GB	0.03
DK	0.86	7	0.29	GB	0.02
ES	0.86	9	0.36	GB	0.04
FR	0.86	25	0.27	US	0.03
GB	0.86	20	0.36	US	0.03
GR	0.85	13	0.31	TR	0.05
IE	0.85	9	0.39	GB	0.03
IT	0.85	19	0.35	DE	0.10
JP	0.86	16	0.47	US	0.02
NE	0.88	13	0.28	US	0.04
PT	0.86	16	0.21	ES	0.02
SE	0.85	9	0.28	DK	0.04
US	0.85	19	0.23	GB	0.03

The table shows the relative size and the country of the largest exposure. It also display the time-series variation in the relative size of the largest exposure. Source: Bank for International Settlements and own calculations. Exposure data for Ireland exists from 2006 to 2010.

Table 5: Bank and sovereign variables

Variable name	Frequency	Description	Source
S_DEBT_GDP	Quarterly*	General government gross debt to GDP.	Eurostat, OECD and IFS
S_FDEF_GDP	Quarterly	The quarterly lending revision is calculated as the sum of the most recent year-end and year-ahead budget projection by the OECD or the IMF minus the second most recent forecast for the same period provided by the same organization. In quarters where they do not update a new budget projection we interpolate a forecast	OECD EO and IMF WEO
GUARANTEES	Quarterly	Sovereign guarantees to the banking sector	See IMF (2009)
S_IR_REV	Quarterly*	General government interest expenditure to revenue	Eurostat, IMF, OECD and IFS
S_IRN_REV	Quarterly*	General government net interest expenditure to revenue	Fitch, Eurostat, IMF, OECD and IFS
S_RISK	Quarterly	A fitted value from a regression of sovereign CDS spread on domestic, foreign currency and long-term external debt, and the current account	See Kallestrup (2011)
C2_EDF	Quarterly	Median of the 5-year EDFs' for domestic corporate sector	Moody's KMV
R2_EDF	Quarterly	Median of the 5-year EDFs' for real estate firms, real estate investment firms and construction firms	Moody's KMV
B_CB_A	Quarterly	Banks' claims on the domestic central bank. Percent of GDP	IFS
B_GG_A	Quarterly	Banks' claims on the domestic general government. Percent of GDP	IFS
B_CREDIT	Quarterly	Banks' claims on other sectors in the country. Percent of GDP	IFS
B_EXT_A	Quarterly	Banks' claims on non-nationals. Percent of GDP	BIS
B_CB_L	Quarterly	Banks' liabilities to the domestic central bank. Percent of GDP	IFS and the Bank of England
B_CDS	Quarterly	Average of 5-year CDS on domestic banks	CMA and Fitch CDS Pricing
B_BIS_CDS	Quarterly	Exposure-weighted credit spread. See the main text	BIS
S_CDS	Quarterly	The 5-year sovereign CDS spread	CMA and Fitch CDS Pricing

*Quarterly or interpolated from yearly data. IFS: IMF International Financial Statistics.

Table 6: CDS indices and Global Variables

Variable name	Frequency	Description	Source
B_FINSNR	Quarterly	The Markit iTraxx Senior Financials index comprises 25 equally-weighted European names	J.P.Morgan: DataQuery
F_NONFIN	Quarterly	The Markit iTraxx Non-Financials index comprises 100 equally-weighted European names	J.P.Morgan: DataQuery
S_SOVX	Quarterly	The 5-year Itraxx SovX Western Europe index comprises 15 sovereign names where all constituents are equally weighted (It is a theoretical price before the start of trading on 28 September 2009)	J.P.Morgan: DataQuery
VPSPX	Quarterly	Volatility Risk Premium. Computed as the difference between the VIX index and the realized volatility for the S&P 500 index over the preceding three months	Bloomberg
ER3M	Quarterly	Excess Return for the U.S. Stock Market. It is computed as the difference between the value-weighted return on all NYSE, AMEX, and NASDAQ stocks and the three-month Treasury-bill return	Bloomberg. The Center for Research in Security Prices
%Δ(OISUS)	Quarterly	Percentage change in the 3 month US LIBOR - OIS spread	Bloomberg
%Δ(5YCMT)	Quarterly	Percentage change in the 5 year constant maturity treasury yields	Federal Reserve/Bloomberg
%Δ(HY)	Quarterly	Percentage change in the US corporate yield spreads. The investment-grade yield spreads are computed on the basis-point yield spread between BBB and AAA industrial bond indices. The percentage changes in high-yield spreads are computed for the basis-point yield. The used indices represent average yields of a broad cross-section of noncallable AAA-, BBB-, and BB-rated bonds with maturities approximately equal to five years	Bloomberg
%Δ(IG)	Quarterly	Percentage change in the US corporate yield spreads. Spread between BB and BBB industrial bond indexes. See above	Bloomberg

Table 7: Sovereign CDS spreads

ISOCODE	Mean	Max	Min	Std. Dev.	Obs.
AT	35	177	2	49	28
AU	25	131	2	34	28
BE	36	222	1	54	28
CH	55	128	35	30	8
DE	15	59	1	19	28
DK	20	115	1	28	28
ES	58	350	2	89	28
FR	22	108	1	30	28
GB	42	123	2	41	19
GR	150	1010	4	275	28
IE	120	609	2	164	21
IT	57	240	4	70	28
JP	26	95	3	30	28
NE	25	91	1	28	22
PT	72	501	4	126	28
SE	22	124	2	32	28
US	16	67	0	21	28
All	46	1010	0	100	434

Summary statistics on sovereign CDS spreads. Note that every country for which we have data for the full sample period have had single digit spreads in basis points on their CDS contracts. The largest observed end-of-quarter premium is 1010 bps for Greece. The two countries with the lowest maximum observed premia are Germany (59 bps) and the US (67 bps).

Table 8: Average bank CDS spreads

ISOCODE	Mean	Max	Min	Std. Dev.	Obs.
AT	93	429	10	104	28
AU	53	160	6	51	28
BE	104	390	8	116	28
CH	65	217	8	66	28
DE	58	160	10	48	28
DK	47	199	4	52	28
ES	66	259	8	73	28
FR	49	147	6	48	28
GB	73	278	6	78	28
GR	166	989	6	289	28
IE	162	1052	7	244	28
IT	56	176	8	54	28
JP	45	120	7	36	28
NE	49	170	5	51	28
PT	115	851	10	187	28
SE	52	194	8	52	28
US	70	300	12	67	28
All	78	1052	4	123	476

The table shows summary statistics on bank CDS spreads. The largest maximum spreads are for Greece and Ireland, and the lowest are for Japanese banks.

Table 9: Risk-weighted sum of CDS spreads

ISOCODE	Mean	Max	Min.	Std. Dev.	Obs.
AT	81	318	10	87	28
AU	47	164	5	46	24
BE	60	195	7	62	28
CH	59	217	10	55	28
DE	65	210	9	63	28
DK	51	175	7	52	28
ES	74	206	10	55	28
FR	63	204	9	60	28
GB	57	215	10	53	28
GR	107	344	20	94	28
IE	69	161	7	53	20
IT	64	210	9	62	28
JP	57	210	9	54	28
NE	58	180	10	52	28
PT	72	234	10	72	28
SE	48	190	6	51	28
US	57	160	10	45	28
All	64	344	5	62	464

The table shows summary statistics on the risk-weighted CDS spreads. The lowest maximum is for the US whereas the highest maximum is for Greece and Austria.

Table 10: Corporate EDFs

ISOCODE	Mean (%)	Max (%)	Min (%)	Std. Dev.	Obs.
AT	0.6	1.4	0.1	0.4	28
AU	1.0	2.8	0.4	0.7	28
BE	0.4	0.9	0.2	0.2	28
CH	0.3	0.6	0.1	0.1	28
DE	0.9	1.8	0.4	0.5	28
DK	0.6	2.2	0.1	0.6	28
ES	0.3	0.9	0.1	0.3	28
FR	0.9	2.1	0.3	0.5	28
GB	1.0	2.9	0.4	0.7	28
GR	2.7	7.0	0.5	1.8	28
IE	0.8	2.6	0.2	0.7	28
IT	0.7	1.9	0.2	0.6	28
JP	0.9	2.4	0.3	0.6	28
NE	0.5	1.3	0.1	0.3	28
PT	0.9	2.0	0.2	0.6	28
SE	1.0	2.6	0.3	0.6	28
US	1.3	4.2	0.4	0.9	28
All	0.9	7.0	0.1	0.9	476

The table shows summary statistics on the median corporate expected default frequency in each country. The maximum is for Greece.

Table 11: Real estate EDFs

ISOCODE	Mean (%)	Max (%)	Min (%)	Std. Dev.	Obs.
AT	0.7	3.6	0.0	0.9	28
AU	1.4	7.2	0.2	1.9	28
BE	0.2	0.5	0.1	0.2	28
CH	0.2	0.4	0.1	0.1	28
DE	0.9	2.2	0.2	0.7	28
DK	1.2	3.9	0.2	1.1	28
ES	0.7	2.4	0.1	0.8	28
FR	0.5	1.5	0.1	0.4	28
GB	0.9	3.3	0.1	0.9	28
GR	2.9	6.0	0.8	1.5	28
IE	3.0	19	0.1	4.8	28
IT	0.7	2.1	0.1	0.7	28
JP	2.3	6.2	0.6	1.5	28
NE	0.6	3.0	0.1	0.7	28
PT	1.8	7.8	0.0	2.3	28
SE	0.7	2.6	0.1	0.7	28
US	1.4	6.8	0.3	1.7	28
All	1.2	19	0.0	1.8	476

The table shows summary statistics on the median for the broad real estate category (i.e. the one including construction firms) in each country. The maximum is for Ireland.

Table 12: The share of banks' claims on foreigners

ISOCODE	Mean (%)	Max (%)	Min (%)	Std. Dev.	Obs.
AT	0.44	0.52	0.23	0.10	28
AU	0.26	0.27	0.23	0.01	28
BE	0.63	0.72	0.40	0.11	28
CH	0.71	0.78	0.60	0.06	28
DE	0.44	0.48	0.39	0.02	28
DK	0.25	0.32	0.10	0.06	28
ES	0.28	0.33	0.23	0.02	28
FR	0.47	0.52	0.40	0.04	28
GB	0.42	0.45	0.37	0.02	28
GR	0.19	0.28	0.11	0.04	28
IE	0.56	0.64	0.44	0.04	28
IT	0.22	0.31	0.14	0.06	28
JP	0.15	0.19	0.10	0.02	28
NE	0.55	0.63	0.42	0.07	28
PT	0.25	0.27	0.20	0.02	28
SE	0.51	0.56	0.40	0.04	28
US	0.11	0.18	0.08	0.03	28
All	0.38	0.78	0.08	0.18	476

The table shows summary statistics on the share of banks' claims on foreigners in each country. The Swiss banking system has the largest exposure abroad.

Table 13: The share of banks' claims on the domestic sovereign

ISOCODE	Mean (%)	Max (%)	Min (%)	Std. Dev.	Obs.
AT	0.08	0.12	0.05	0.02	28
AU	0.01	0.02	0.00	0.01	28
BE	0.09	0.13	0.06	0.02	28
CH	0.03	0.06	0.02	0.01	28
DE	0.11	0.13	0.09	0.01	28
DK	0.04	0.10	0.01	0.03	28
ES	0.07	0.11	0.05	0.02	28
FR	0.09	0.11	0.07	0.01	28
GB	0.02	0.04	0.00	0.01	28
GR	0.15	0.20	0.10	0.03	28
IE	0.03	0.08	0.02	0.01	28
IT	0.14	0.17	0.09	0.02	28
JP	0.26	0.31	0.23	0.03	28
NE	0.04	0.07	0.02	0.01	28
PT	0.03	0.07	0.02	0.01	28
SE	0.03	0.06	0.01	0.01	28
US	0.08	0.13	0.05	0.03	28
All	0.08	0.31	0.00	0.06	476

The table shows summary statistics on the share of banks' claims on the domestic sovereign in each country. The Japanese banking system has the largest exposure towards its own government.

Table 14: The share of banks' claims on domestic residents

ISOCODE	Mean (%)	Max (%)	Min (%)	Std. Dev.	Obs.
AT	0.49	0.65	0.43	0.08	28
AU	0.73	0.75	0.71	0.01	28
BE	0.28	0.47	0.21	0.09	28
CH	0.26	0.35	0.21	0.05	28
DE	0.45	0.49	0.42	0.02	28
DK	0.71	0.81	0.67	0.04	28
ES	0.65	0.69	0.61	0.02	28
FR	0.44	0.49	0.41	0.03	28
GB	0.56	0.63	0.52	0.03	28
GR	0.66	0.71	0.58	0.04	28
IE	0.41	0.48	0.35	0.04	28
IT	0.64	0.74	0.57	0.07	28
JP	0.59	0.65	0.53	0.04	28
NE	0.41	0.52	0.34	0.06	28
PT	0.72	0.76	0.70	0.02	28
SE	0.46	0.58	0.42	0.04	28
US	0.81	0.86	0.70	0.06	28
All	0.55	0.86	0.21	0.16	476

The table shows summary statistics on the share of banks' claims on domestic residents in each country. The U.S. banking system has the largest exposure towards its own residents.

B Regression Results

Table 15: **Regressing bank CDS spreads on exposure-weighted spreads in different periods.** This table reports the coefficients and t-statistics for the panel regression:

$$\begin{aligned}\Delta(\text{B\_CDS})_{k,t} &= \alpha_{k,0} + \alpha_1 \times \Delta(\text{B\_BIS\_CDS})_{k,t} + \alpha_2' \times \Delta(\text{Local Bank Variables})_{k,t} \\ &\quad + \alpha_3' \times \Delta(\text{Global Variables})_t + \epsilon_{k,t}\end{aligned}$$

$\Delta(\bullet)$ and $\%\Delta(\bullet)$ stand for first difference and percentage change of the variable over the quarter, respectively. k is the index for countries and t is the index for time. We perform the analysis first for the whole sample from the first quarter of 2004 to the last quarter of 2010. Afterwards we perform the same analysis on sub-periods. All equations are estimated with OLS and country fixed effects.

VARIABLES	FULL SAMPLE	Q1 2004 - Q4 2007	Q1 2008 - Q4 2010
INTERCEPT	1.110	−0.431	9.078**
	(0.414)	(-1.069)	(2.274)
Δ(B_BIS_CDS)	1.004***	0.460**	0.981***
	(5.533)	(2.442)	(4.777)
Δ(R2_EDF)	10.18***	1.187	11.46***
	(6.055)	(1.151)	(9.190)
Δ(C2_EDF)	11.23	−1.486	1.376
	(0.374)	(-0.491)	(0.037)
ER3M	−65.03	−4.164	−17.37
	(-0.994)	(-0.307)	(-0.161)
VPSPX	1.558	0.408***	1.102
	(1.575)	(3.114)	(0.953)
%Δ5YCMT	7.061	−8.697***	25.76
	(0.731)	(-4.251)	(0.737)
%ΔHY	−16.24	7.074***	7.774
	(-1.031)	(3.374)	(0.158)
%ΔIG	−11.11	5.403***	−33.05
	(-0.885)	(3.824)	(-1.232)
%Δ(OISUS)	4.295*	0.124	12.13**
	(1.667)	(0.408)	(2.056)
Adjusted R-squared	0.3818	0.5266	0.3806

Table 16: **Controlling for the comovement of the CDS market - Introducing the CDS index.** This table reports the coefficients and t-statistics for the panel regression:

$$\begin{aligned}\Delta(\text{B\_CDS})_{k,t} &= \alpha_{k,0} + \alpha_1 \times \Delta(\text{B\_BIS\_CDS})_{k,t} + \alpha_2' \times \Delta(\text{Local Bank Variables})_{k,t} \\ &\quad + \alpha_3' \times \Delta(\text{Global Variables})_t + \alpha_4' \times \Delta(\text{CDS Indices})_t + \epsilon_{k,t}\end{aligned}$$

$\Delta(\bullet)$ and $\%\Delta(\bullet)$ stand for first difference and percentage change of the variable over the quarter, respectively. k is the index for countries and t is the index for time. In Column I, we simply introduce the indexes along the BIS matrix. In column II, we have regress the BIS matrix on the CDS indexes and use the residuals from this regression as a variable to explain the CDS spreads. All equations are estimated with OLS and country fixed effects.

VARIABLES	I	II	III
INTERCEPT	−2.201	−1.258	0.462
	(-0.791)	(-0.489)	(0.244)
Δ(B_BIS_CDS)	0.465***		0.922***
	(3.555)		(5.085)
Δ(B_BIS_RES)		0.207***	
		(2.930)	
Δ(R2_EDF)	10.67***	10.37***	12.07***
	(7.476)	(7.438)	(7.105)
Δ(C2_EDF)	−5.234	−0.770	−4.726
	(-0.222)	(-0.028)	(-0.192)
ER3M	16.65	−0.949	−78.44
	(0.266)	(-0.015)	(-1.249)
VPSPX	0.976	0.609	1.614
	(1.421)	(0.776)	(2.258)
%Δ5YCMT	−2.253	−6.512	−5.114
	(-0.277)	(-0.824)	(-0.600)
%ΔHY	−4.109	13.74	−16.76
	(-0.563)	(1.176)	(-1.057)
%ΔIG	10.21	1.575	−6.693
	(0.969)	(0.148)	(-0.577)
%Δ(OISUS)	1.590	1.976	4.531
	(0.806)	(0.959)	(1.576)
Δ(S_RISK)	0.798***	0.796***	0.850***
	(3.379)	(3.400)	(4.095)
Δ(S_SOVX)	0.236	0.240	
	(0.808)	(0.811)	
Δ(F_NONFIN)	−0.279	−0.346	
	(-1.237)	(-1.588)	
Δ(B_FINSNR)	0.735***	1.128***	
	(3.312)	(5.526)	
Adjusted R-squared	0.4637	0.4603	0.4328

Table 17: **Total bank credit risk.** This table reports the coefficients and t-statistics for the panel regression:

$$\begin{aligned}\Delta(\text{B\_CDS})_{k,t} &= \alpha_{k,0} + \alpha_1 \times \Delta(\text{Bank Credit Risk})_{k,t} \\ &\quad + \alpha_2' \times \Delta(\text{Global Variables})_t + \alpha_3' \times \Delta(\text{CDS Indices})_t + \epsilon_{k,t}\end{aligned}$$

The variable Δ(Bank Credit Risk) uses the exposure measure obtained by combining foreign exposures (weighted by CDS spreads) with domestic exposures weighted by the fitted value of the CDS spreads (for domestic government bonds) or EDFs for other exposures as explained in equation 4. $\Delta(\bullet)$ and $\%\Delta(\bullet)$ stand for first difference and percentage change of the variable over the quarter, respectively. k is the index for countries and t is the index for time. The equation is estimated with OLS and country fixed effects.

VARIABLES	FULL SAMPLE	Q1 2004 - Q4 2007	Q1 2008 - Q4 2010
INTERCEPT	−2.524	−0.659	−2.184
	(-0.785)	(-1.439)	(-0.457)
Δ(B_CREDIT_RISK)	0.182***	0.017***	0.188**
	(3.124)	(3.752)	(2.517)
ER3M	−14.20	29.76**	39.37
	(-0.195)	(2.511)	(0.367)
VPSPX	0.818	0.190	0.688
	(1.163)	(1.369)	(0.401)
%Δ5YCMT	3.868	6.384***	6.447
	(0.415)	(3.387)	(0.285)
%ΔHY	−5.043	3.486**	−14.83
	(-0.877)	(2.175)	(-0.213)
%ΔIG	13.90	1.531	22.87
	(1.444)	(1.302)	(0.929)
%Δ(OISUS)	1.669	0.952***	9.679*
	(1.086)	(3.049)	(1.908)
Δ(S_SOVX)	0.386	2.312***	0.268
	(1.150)	(4.155)	(0.706)
Δ(F_NONFIN)	−0.447*	0.216**	−0.315
	(-2.269)	(1.988)	(-1.030)
Δ(B_FINSNR)	1.097**	0.065	1.108***
	(4.533)	(0.583)	(4.319)
Adjusted R-squared	0.4050	0.6157	0.3898

Table 18: **The Sovereign CDS equation.** This table reports the coefficients and t-statistics for the panel regression:

$$\begin{aligned}\Delta(\text{S\_CDS})_{k,t} &= \alpha_{k,0} + \alpha_1' \times \Delta(\text{Domestic Government Variables})_{k,t} \\ &\quad + \alpha_2' \times (\text{Guarantees})_{k,t} + \alpha_3' \times \Delta(\text{Global Variables})_t + \epsilon_{k,t}\end{aligned}$$

$\Delta(\bullet)$ and $\%\Delta(\bullet)$ stand for first difference and percentage change of the variable over the quarter, respectively. k is the index for countries and t is the index for time. In column III and IV we use the EDFs as a measure of risk for the banking systems instead of the CDS's. All equations are estimated with OLS and country fixed effects. Column V is estimated with 2SLS where the change in central bank collateralized loans is an instrument for Δ(S_CDS).

VARIABLES	I	II	III	IV	V
INTERCEPT	1.012	0.341	−0.076	−0.805	1.140
	(0.359)	(0.119)	(-0.020)	(-0.212)	(0.271)
Δ(S_IRN_REV)	−5.550	−5.309	−4.905	−4.694	−6.944**
	(-1.088)	(-1.046)	(-0.816)	(-0.791)	(-2.182)
S_FDEF_GDP	0.646	1.067**	0.053	0.520	3.592*
	(1.223)	(2.199)	(0.050)	(0.538)	(1.851)
GUARANTEES		0.399***		0.407***	0.441***
		(4.734)		(4.356)	(6.502)
Δ(B_CDS)*B_GDP	0.098***	0.099***			0.250**
	(2.803)	(2.862)			(2.362)
Δ(B_EDF)*B_GDP			2.197***	2.305***	
			(9.885)	(11.48)	
ER3M	−46.32**	−50.54***	−188.0***	−192.5***	189.0*
	(-2.376)	(-2.750)	(-3.175)	(-3.272)	(1.939)
VPSPX	1.282*	1.391**	2.448**	2.572**	−0.286
	(1.900)	(2.045)	(2.038)	(2.129)	(-0.562)
%Δ5YCMT	−12.65	−10.64	−21.03*	−18.91*	5.893
	(-1.381)	(-1.212)	(-1.931)	(-1.809)	(0.526)
%ΔHY	30.23***	24.46**	17.78***	12.08*	51.54**
	(2.874)	(2.304)	(2.727)	(1.855)	(2.472)
%ΔIG	24.57***	21.00***	24.69***	21.12***	21.37***
	(3.839)	(3.337)	(3.102)	(2.723)	(2.784)
%Δ(OISUS)	−4.735***	−3.684***	−1.325*	−0.264	−9.901**
	(-3.643)	(-2.754)	(-1.723)	(-0.344)	(-2.567)
Adjusted R-squared	0.4029	0.4201	0.2109	0.2284	

Table 19: **The Sovereign CDS equation with indices.** This table reports the coefficients and t-statistics for the panel regression:

$$\begin{aligned}\Delta(\text{S\_CDS})_{k,t} &= \alpha_{k,0} + \alpha_1' \times \Delta(\text{Domestic Government Variables})_{k,t} + \alpha_2' \times (\text{Guarantees})_{k,t} \\ &\quad + \alpha_3' \times \Delta(\text{Global Variables})_t + \alpha_4' \times \Delta(\text{CDS Indices})_t + \epsilon_{k,t}\end{aligned}$$

$\Delta(\bullet)$ and $\%\Delta(\bullet)$ stand for first difference and percentage change of the variable over the quarter, respectively. k is the index for countries and t is the index for time. In column III and IV we use the EDFs as a measure of risk for the banking systems instead of the CDS's. All equations are estimated with OLS and country fixed effects. Column V is estimated with 2SLS where the change in central bank collateralized loans is an instrument for Δ(S_CDS).

VARIABLES	I	II	III	IV	V
INTERCEPT	−0.059	−0.374	−3.008	−3.336	4.893*
	(-0.021)	(-0.140)	(-0.730)	(-0.834)	(1.678)
Δ(S_IRN_REV)	−5.126	−5.094	−5.554	−5.532	−5.154**
	(-1.526)	(-1.496)	(-1.447)	(-1.435)	(-2.094)
S_FDEF_GDP	0.148	0.307	−0.824	−0.649	3.465*
	(0.281)	(0.627)	(-1.101)	(-0.841)	(1.816)
GUARANTEES		0.143**		0.146*	0.179**
		(2.362)		(1.859)	(2.128)
Δ(B_CDS)*B_GDP	0.084**	0.084**			0.233**
	(2.545)	(2.570)			(2.374)
Δ(B_EDF)*B_GDP			1.600***	1.636***	
			(7.522)	(7.490)	
ER3M	25.52*	24.01	14.89	13.18	30.39
	(1.697)	(1.602)	(0.708)	(0.640)	(0.792)
VPSPX	0.139	0.223	0.746	0.835	−0.685*
	(0.326)	(0.549)	(1.136)	(1.334)	(-1.771)
%Δ5YCMT	−16.11*	−15.57*	−20.68**	−20.13*	−6.256
	(-1.708)	(-1.684)	(-1.990)	(-1.957)	(-0.638)
%ΔHY	7.337**	7.129**	7.482***	7.303***	9.773*
	(2.456)	(2.328)	(3.555)	(3.424)	(1.921)
%ΔIG	3.736	3.870	11.97**	12.09**	−13.54*
	(0.730)	(0.746)	(2.426)	(2.412)	(-1.794)
%Δ(OISUS)	−1.883***	−1.786***	−1.476**	−1.377**	−2.596**
	(-3.854)	(-3.598)	(-2.234)	(-2.181)	(-2.584)
Δ(S_SOVX)	0.843***	0.815***	0.959***	0.931***	0.585***
	(4.273)	(3.918)	(3.579)	(3.313)	(4.059)
Δ(F_NONFIN)	−0.002	−0.020	−0.100	−0.118**	0.177
	(-0.034)	(-0.266)	(-1.556)	(-1.829)	(1.215)
Δ(B_FINSNR)	−0.213*	−0.190	0.078	0.101*	−0.784***
	(-1.805)	(-1.509)	(1.339)	(1.654)	(-2.630)
Adjusted R-squared	0.5274	0.5284	0.4120	0.4128	

Table 20: **The Sovereign CDS equation minus the SovX index.** This table reports the coefficients and t-statistics for the panel regression:

$$\begin{aligned}\Delta(\text{S\_CDS-S\_SOVX})_{k,t} &= \alpha_{k,0} + \alpha_1' \times \Delta(\text{Domestic Government Variables})_{k,t} \\ &+ \alpha_2' \times (\text{Guarantees})_{k,t} + \alpha_3' \times \Delta(\text{Global Variables})_t + \epsilon_{k,t}\end{aligned}$$

$\Delta(\bullet)$ and $\%\Delta(\bullet)$ stand for first difference and percentage change of the variable over the quarter, respectively. k is the index for countries and t is the index for time. All equations are estimated with OLS and country fixed effects. In column III and IV we use the EDFs as a measure of risk for the banking systems instead of the CDS's. All equations are estimated with OLS and country fixed effects. Column V is estimated with 2SLS where the change in central bank colleralised loans is an instrument for Δ(S_CDS).

VARIABLES	I	II	III	IV	V
INTERCEPT	−1.922	−2.090	−2.597	−2.780	−1.364
	(-0.724)	(-0.772)	(-0.778)	(-0.822)	(-0.350)
Δ(S_IRN_REV)	−5.516*	−5.456*	−5.346	−5.291	−6.943***
	(-1.762)	(-1.753)	(-1.415)	(-1.412)	(-3.687)
S_FDEF_GDP	−0.456	−0.351	−0.854	−0.732	1.945
	(-0.863)	(-0.640)	(-1.271)	(-1.111)	(1.000)
GUARANTEES		0.100**		0.106**	0.137**
		(2.445)		(2.311)	(2.155)
Δ(B_CDS)*B_GDP	0.070**	0.071**			0.208**
	(2.297)	(2.307)			(2.305)
Δ(B_EDF)*B_GDP			1.631***	1.659***	
			(10.26)	(10.41)	
ER3M	112.0***	111.0***	10.62	9.453	328.7***
	(4.513)	(4.475)	(0.178)	(0.158)	(4.178)
VPSPX	−0.175	−0.147	0.648	0.679	−1.672***
	(-0.257)	(-0.214)	(0.592)	(0.615)	(-3.296)
%Δ5YCMT	−12.44	−11.94	−18.87**	−18.33*	3.088
	(-1.378)	(-1.330)	(-1.990)	(-1.955)	(0.305)
%ΔHY	9.609	8.168	0.581	−0.904	32.78*
	(0.954)	(0.816)	(0.094)	(-0.149)	(1.837)
%ΔIG	7.914	7.021	7.533	6.586	7.362
	(1.472)	(1.327)	(1.200)	(1.073)	(1.055)
%Δ(OISUS)	−2.819**	−2.557**	−0.392	−0.117	−8.210***
	(-2.396)	(-2.149)	(-0.521)	(-0.146)	(-2.631)
Adjusted R-squared	0.2392	0.2392	0.0872	0.0872	

The Collapse of the Icelandic Banking System

René Kallestrup

David Lando *

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Abstract

The collapse of Iceland's three largest banks in late September and early October 2008 is the biggest banking failure relative to the size of an economy in modern history. We show that commonly used early warning indicators of banking crises were very strong in the case of Iceland and document how the Icelandic banks managed to continue their aggressive growth despite a funding crisis in early 2006. Strong reported financial key figures masked the true riskiness of the Icelandic business model and the extreme concentration risk in the financial system. In addition, investors and rating agencies overestimated the value of potential sovereign support from a country whose fiscal capacity was limited compared to the size of the banks' assets. Helped by strong credit ratings and an implicit sovereign guarantee, the banks were able to fund their risky business model through foreign deposits and by accessing bond markets outside of Europe. While central bank liquidity facilities have been critical in saving the global banking system, the Icelandic case study also reveals how such facilities may prolong a crisis, make it deeper and ultimately contribute to a crash of a floating exchange rate.

Credit risk, banks, sovereign risk; **JEL:** G01; G15; G21

* René Kallestrup is corresponding author. The authors are at the Department of Finance, Copenhagen Business School, Solbjerg Plads 3, DK-2000 Frederiksberg, Denmark. We would like to thank Ásgeir Daníelsson, Kim Abildgren, Rune Mølgaard and Martin Seneca for helpful comments. Any remaining errors are the responsibility of the authors.

1 Introduction

The collapse of Iceland's three largest banks in late September and early October 2008 is the biggest banking failure relative to the size of an economy in modern history. Financial crises are of course always easier to spot with the benefit of hindsight, but it is fair to say that there were many indications that the fall of the Icelandic banking system was an accident waiting to happen. Not only were commonly used early warning indicators of banking crises very strong in the case of Iceland, but there had in fact already been a mini funding crisis in early 2006. In this chapter we list the warning indicators and document how the Icelandic banks managed to continue their aggressive growth despite the funding crisis in 2006. Strong reported financial key figures masked the true riskiness of the Icelandic business model and the extreme concentration risk in the financial system. In addition, investors and rating agencies overestimated the value of potential sovereign support from a country whose fiscal capacity was limited compared with the size of the banks' assets. Helped by strong credit ratings and implicit sovereign guarantees, the banks were able to fund their risky business model through foreign deposits and by accessing bond markets outside of Europe. While central bank liquidity facilities have been critical in saving the global banking system, the Icelandic case study also reveals how such facilities may prolong a crisis, make it deeper and ultimately contribute to a crash of a floating exchange rate. The chapter is organised as follows: the next section describes the severity of the banking crisis, the currency crisis and the public debt crisis. We then focus on early warning indicators of a financial crisis in Iceland. The subsequent section documents the fact that the focus of regulators and rating agencies on apparently strong financial key figures downplayed the true riskiness of the banks' business model. In the next section we analyse the asset side of the balance sheet and show the extreme concentration risk in the Icelandic financial system. We then document how the banks were able to fund their risky business model by accessing bond markets, through foreign deposits and using central bank liquidity facilities. Sovereign support and credit ratings probably played an important role in this process. We give our conclusion in the final section.

Our analysis is based on a wide range of publicly available statistics and information. Institutions such as the Central Bank of Iceland (2009a, 2010), the International Monetary Fund (2008b) and the OECD (2009) have also published reports on the crisis in Iceland. Verbal reviews can also be found in Fridriksson (2009), Jännäri (2009) and Jónsson (2009). In April 2010, the Icelandic Parliament's Special Investigation Commission published a report on the collapse of the Icelandic banking system (Special Investigation Commission 2010). The report, which runs to more than 2,000 pages, documents the fact that the banks did not comply with the domestic laws and regulations, and this may eventually lead to prosecutions. Although we will describe some questionable business practices, our focus is mainly on using the data that was available to supervisors or the

public. We consider only the history up to the collapse in early October 2008.

2. A Triple Crisis in Iceland

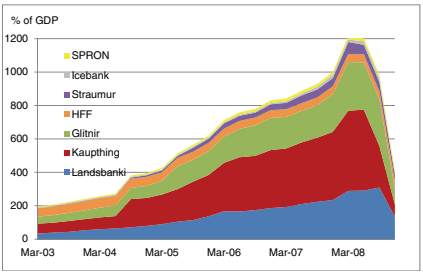
As a starting point, we briefly describe the extent of the triple crisis which culminated in the default of the three largest banks in October 2008. At its peak in March 2008, the book assets of three banks, Kaupthing, Landsbanki and Glitnir, stood at more than 1,000% of GDP (Figure 1).[1] The banks maintained branches and subsidiaries in more than 20 countries, but they focused primarily on Iceland, the UK, Denmark and Norway. When the three largest banks collapsed, they accounted for around 85% of the Icelandic banking system. Six months later, when savings and loan funds (Reykjavik Savings Bank and Icebank) as well as the investment bank Straumur-Burdaras were in financial trouble, more than 90% of the banking system was in wind-up proceedings. The write-downs were very large. As of October 2008, independent auditors assessed asset values of the three banks after write-downs to be around 300% of GDP, down from book values of assets around 835% of GDP. The write-downs as a percentage of assets were 69.4, 65.2 and 54.2 for Kaupthing, Glitnir and Landsbanki, respectively. Write-downs on loans to holding companies and the banks' largest customers were the biggest contributors. The share of non-performing loans was very high compared with other recent systemic banking crises, as shown in Figure 2. This is, of course, in part due to the fact that the failure of the Icelandic banks took place during the most serious international financial crisis since the Great Depression.

In addition to the systemic banking crisis, large market pressure to sell assets denominated in the Icelandic króna (IKr) put heavy pressure on the currency. Ultimately there was an effective collapse of the freely floating exchange rate. The sharp depreciation posed a risk for the small open economy depending on imports and domestic households as well as companies with foreign currency denominated loans. The International Monetary Fund (IMF) therefore, as part of a rescue package, recommended capital controls to stabilise the exchange rate at a higher level than determined in the free market. In Figure 3 we show the drop in the real exchange rate and compare it with other drops in banking crises after 1990. Later, we will see that the drop in the exchange rate in the "offshore market", ie, the market for Icelandic króna outside of Iceland, was much larger.

The high gross cost of recapitalising the banking system and future public deficits will also lead to a strong increase in public sector debt. As seen in Figure 4, the rise in public sector debt relative to GDP is higher for Iceland than other countries experiencing

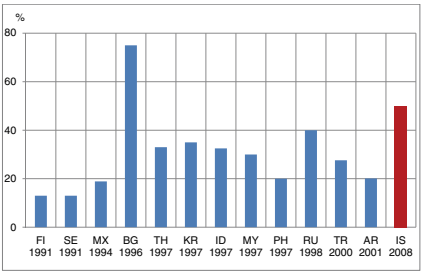
[1] Assets are henceforth measured as consolidated assets, meaning the assets of the parent company including the assets of foreign subsidiaries (except if mentioned otherwise). The rapid rise in assets relative to GDP in 2008 was partly caused by the depreciation of the domestic currency relative to the rise in the domestic price level. The value of foreign currency assets measured in domestic currency is calculated using the onshore exchange rate, whereas the GDP is measured in current prices. In foreign currency terms, the three banks' balance sheets peaked in euro terms at more than 120 billion in Q4 2007. At the same time Iceland's annual GDP was more than 14 billion.

Figure 1: **Assets of the Icelandic banks**



Book values of assets for the seven largest Icelandic banks from 2003 to Q2 2008. In Q3-Q4 2008, data is based on information from the accounting firm Deloitte LLP and the consulting firm Oliver Wyman. The values of assets after write-downs are shown in Q4 2008. Source: Consolidated financial accounts and the Special Investigation Commission.

Figure 2: **Non-performing loans in systemic banking crises**



The highest level of non-performing loans is shown as percentage of total loans during the years [t, t+5], where t is the initial year of the crisis. In Iceland, the share of non-performing loans is assessed to be around 50%. FI, Finland; SE, Sweden; MX, Mexico; BG, Bulgaria; TH, Thailand; KR, Korea; ID, Indonesia; MY, Malaysia; PH, Philippines; RU, Russia; TR, Turkey; AR, Argentina; IS, Iceland. For example, FI is at 13% in 1991, which means the peak in non-performing loans in the period from 1991 to 1996 is 13%. Source: Laeven and Valencia (2008) and Andersen (2009).

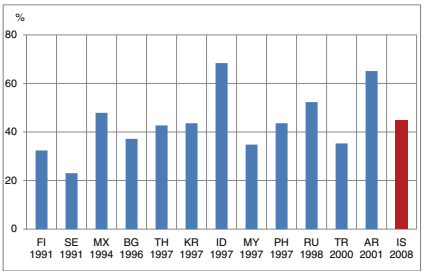
a systemic banking crisis. The Republic of Iceland avoided a sovereign default because the government had an initial low debt burden and a balanced public budget prior to the crisis. In terms of non-performing loans, drop in exchange rate and relative increase in public debt, the Icelandic crisis was arguably the worst triple crisis since 1990.[2]

3 Early Warning Crisis Indicators

Reinhart and Rogoff (2009) note that *"economists do not have a terribly good idea of what kinds of events shift confidence and of how to concretely assess confidence vulnerability.*

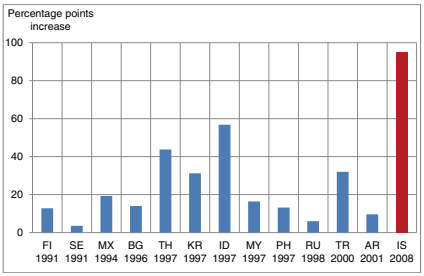
[2]It is difficult to compare output losses across countries when banking crises reflect unsustainable economic developments before the crises.

Figure 3: **Real currency drop in systemic banking crises**



The depreciation of the domestic real (onshore) exchange rate is shown. It is measured as the fall from the peak to the trough. The year of the systemic banking crisis (which may be different from the year of the exchange rate crisis) is shown. Source: Bank for International Settlements.

Figure 4: **Increase in fiscal debt in systemic banking crises**



The increase in gross government debt is shown as a percentage of GDP over the period [t, t+5], where t denotes the starting year of the crisis. The data for Iceland is based on the Central Bank of Iceland's 2012 forecast. The year of the systemic banking crisis (which may be different from the year of the sovereign debt crisis) is shown. The net fiscal cost, which includes the recovery proceeds over the same period, is not shown. Source: Laeven and Valencia (2008) and the Central Bank of Iceland.

What one does see, again and again, in the history of financial crises is that when an accident is waiting to happen, it eventually does".

While each crisis is different, there do exist a number of indicators which signal that a systemic banking crisis is waiting to happen. Important indicators are a rapid expansion of the banking system, a private-sector credit boom, a large rise in equity and property prices, a rapid real exchange rate appreciation in combination with balance sheet mismatches in the economy, a large current account deficit and a large external short-term debt build-up.[3] In the sections below, we briefly recall why these indicators are relevant predictors of banking crises and we document that the indicator levels in the case of Iceland were exceptionally high compared with both non-crisis and crisis countries.

[3]See also Borio and Lowe (2002), Bordo and Jeanne (2002), Borio and Drehmann (2009) as well as Reinhart and Rogoff (2009, 2010).

3.1 Large Bank Balance Sheets Relative to the Economy

We first look at the growth and the size of the Icelandic banks' balance sheets relative to the domestic GDP in the years leading up to the crisis. The sizes of the assets are measured relative to the Icelandic GDP, since around one-third of the banks' loans were to Icelandic entities according to the banks' reported balance sheets.[4] Rapid organic growth can be a signal of problems because it is often accompanied by lower asset quality (ie, riskier loans) and growth through acquisitions is associated with a risk of overpaying for assets. The rapid rise in the Icelandic banks' balance sheets relative to GDP has been without historical precedent. The banks' assets expanded from around 100% of GDP in 2003 to more than 1,000% of GDP by 2008. In the period from 2003 to 2008, the primary driver behind the expansion of the banks' balance sheets was the growth in existing activities (internal growth), whereas external growth through acquisitions accounted for around 160% ofGDP. The latter was especially pronounced in 2004 and 2005, when Kaupthing acquired the Danish bank FIH Erhvervsbanks and the British bank Singer & Friedlander, respectively.

The overall size of the banking sector relative to the domestic GDP is also a relevant indicator, since it may reflect the sovereign's contingent liabilities in times of financial trouble. On this scale, the size of the Icelandic banking system was large but broadly similar to that of Ireland and Switzerland (Figure 5). The main difference, however, was that the large Swiss banks were assessed to be systemically important outside of Switzerland, as demonstrated, for example, by the liquidity swap facilities in foreign currency provided by the European Central Bank and the Federal Reserve to the Swiss National Bank. In contrast, the Icelandic banking system was not assessed as too big to fail outside of Iceland. Interestingly, the relative size of the Icelandic banking system was much smaller than in Luxembourg, a country which did not face severe banking problems in 2008. As shown in Figure 6, the banks' assets in Luxembourg primarily belonged to subsidiaries of foreign banks and this may lower the sovereign's willingness to assist these banks in the case of financial problems. Later we will also see that both Switzerland and Luxembourg were large net external creditor nations, whereas Iceland was a large net external debitor.

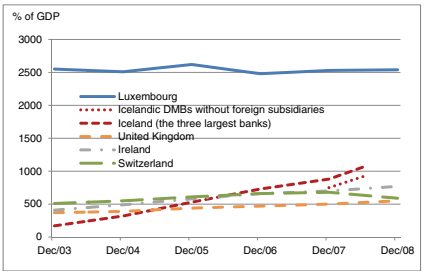
3.2 Iceland's Private Sector Credit Boom

The rapid growth of the banks' assets was partly a result of a rapid expansion of credit to the private sector in Iceland.[5] As with the growth in assets, this is an indicator of lower marginal asset quality of the banks' loan portfolios, but deteriorating marginal asset quality is particularly likely in a small, less diversified country like Iceland. Domestic credit provided by deposit money banks to households and companies as well as holding

[4]That said, the location of the assets is complicated by the fact that the banks lent large sums to holding companies that operated both in Iceland and outside the country.

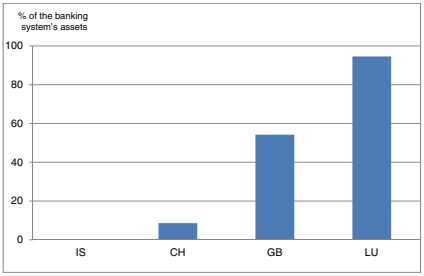
[5]According to stated financial reports, around one-third of the banks' loans were to Icelandic entities.

Figure 5: **Bank assets relative to GDP**



The end-of-year assets of domestically registered banks (excluding assets of foreign subsidiaries) in countries with large banking systems are shown relative to GDP. The three largest Icelandic banks' consolidated assets (ie, including the assets of the banks' foreign subsidiaries) are shown from 2003 to Q2 2008, since data on the assets of domestically registered Icelandic banks is only available from Q2 2007. Source: OECD (2009).

Figure 6: **Banking systems: the share that is 50% or more foreign**



The capital of the Icelandic banks was domestically owned, whereas the banks in Luxembourg were primarily owned by foreigners (year-end 2005 data). IS, Iceland; CH, Switzerland; UK, United Kingdom; LU, Luxembourg. Source: World Bank.

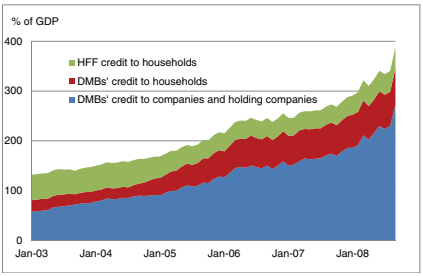
companies accounted for around 250% of GDP by year-end 2007. In addition, the state-guaranteed mortgage lender, the HF Fund, provided credit to households for around 40% of GDP (Figure 7).[6] The bank credit expansion to residents in Iceland has been without historical precedence, as seen in Figure 8, where we see countries with a high amount of bank credit to GDP.

3.3 A Rapid Rise in Stock Prices and House Prices

A rapid rise in stock prices and house prices is often associated with more collateralised borrowing, which fuels further increases in asset prices. When the market turns, there is the danger of a negative price spiral in which collateral value erodes because of forced

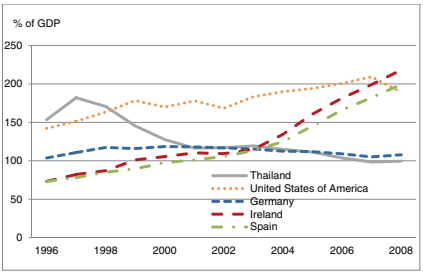
[6]The Housing Financing Fund (the HF Fund) is a residential mortgage lender with an explicit state guarantee and an objective to support the government's housing policy.

Figure 7: **Bank and the HF Fund's credit to the private sector**



Icelandic deposit money banks' (DMBs) credit to Icelandic households and companies (including holding companies) is shown. Credit provided by the Housing Financing Fund is also shown. Source: The Central Bank of Iceland, OECD and the authors' calculations.

Figure 8: **Bank credit to the private sector**

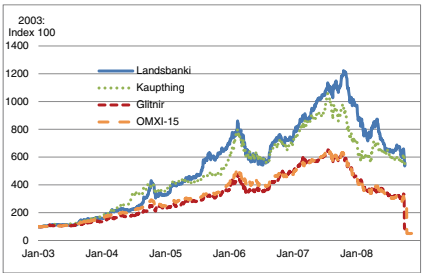


Countries with high stocks of domestic credit to the private sector and non-financial public sector enterprises provided by deposit money banks are shown. Data for Iceland is shown Figure 7. Source: Fitch Ratings.

asset sales and unwinding of positions. The banks' lending to the private sector in Iceland was channelled into the domestic equity market. Remarkably, a large part of this rise was driven by domestic demand. The Special Investigation Commission (2010) has documented that the large increase of stock prices until mid-2007 was driven by the increasing domestic leverage in stock purchases (see also the next section). Foreign capital was also channelled into the stock market but the foreign ownership was estimated at only around 10 to 15% in mid-2007 (International Monetary Fund 2007). The Icelandic stock market benchmark index rose by close to 500% between January 2003 and July 2007, when it peaked with a market capitalisation around 270% of GDP (Figure 9).

The banks' lending to the private sector in Iceland was also channelled into non-tradeable sectors, which triggered price and wage inflation and thus a general loss of competitiveness. Real house prices rose by more than 80% over eight years to the peak in year-end 2007. It was especially pronounced in 2005 after the banks started to expand their mortgage lending (Figure 7). That said, the rise in house prices in Iceland was

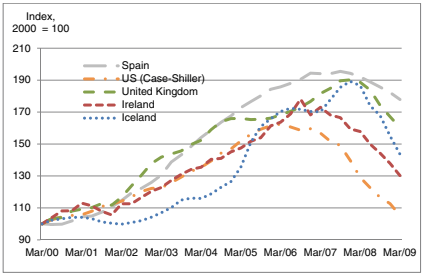
Figure 9: **Stock market performance**



The OMX Iceland 15 (OMXI-15) was the benchmark index based on 15 companies with the highest market capitalisation. Trading was suspended in the banks on October 6, 2008. Source: Bloomberg.

similar to the rise in other advanced economies (Figure 10).

Figure 10: **Real house prices**



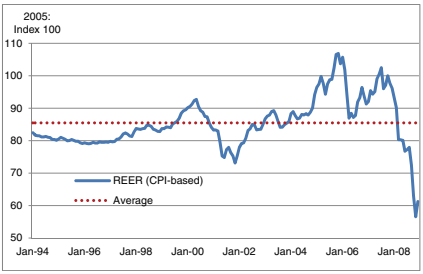
Iceland's real house price inflation was comparable with the sharp rises in other developed economies. Source: OECD.

3.4 Real Exchange Rate Appreciation

Domestic households and companies had large amounts of loans indexed to foreign currency despite mainly owning krna-denominated assets. This asset-liability mismatch made households and companies vulnerable to a depreciation of the domestic currency. The banks' massive domestic lending to the private sector in Iceland, combined with investment projects, large wealth effects and tax cuts, resulted in a consumption boom. This was the main reason why, in order to curb the rise in inflation, the Central Bank of Iceland repeatedly raised its policy rate, which eventually reached double figures in early 2006. Inflation remained well above its trading partners though. An unfortunate by-product of the tight monetary policy was the attractiveness of currency carry trading. The high interest resulted in a massive inflow of capital into Iceland as well as further borrowing in foreign currency by households and companies and a strengthening of the

real exchange rate relative to its recent trend.[7] As shown in Figure 11, the domestic currency experienced two episodes of rapid appreciation in the years leading up to the crisis. The inflow of capital was of course a by-product of the large current account deficit, as seen in the next subsection. In mid-2007, it was estimated that foreigners held around 25-30% of the fixed income market (International Monetary Fund 2007). In addition, there were a large number of other high-yielding instruments available for the currency carry trader such as krna-denominated Eurobonds, FX swaps, etc. Later in this chapter we take a closer look at borrowing in foreign currency.

Figure 11: **Real effective exchange rate**



The real exchange rate is shown relative to its long-term average (with 2005 as a base year). Source: Bank for International Settlements.

3.5 A Persistent Current Account Deficit

The consumption spree in Iceland and the strong currency were the main factors behind the increased demand for foreign goods.[8] As of 2006, the current account deficit was more than 20% of GDP and the largest in the world. It reflected a deficit on goods and services (a trade deficit) and interest rate payments on the country's external debt (see the items in Figure 12).[9] In 2003-5 interest rate payments to foreigners accounted for around 2-5% of GDP and they rose to more than 20% in 2008.

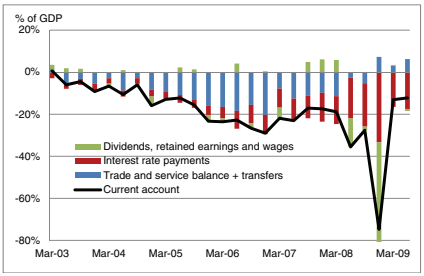
A country with a current account deficit is running down its net foreign asset position. The net international investment position (NIIP), ie, the sum of external assets minus the stock of external liabilities, for Iceland was -131% of GDP at year-end 2007, as seen in Figure 13. The negative NIIP increased as a result of the accumulation of current account deficits and valuation effects on the external assets and debt. Iceland's high net debt burden clearly reflected an unsustainable position and the economy was vulnerable

[7] An assessment of the central bank's interest rate policy is beyond the score of this chapter. See Special Investigation Commission (2010) for further comments.

[8] Large investments in aluminium and power also accounted for a part of the deficit. (See also Figure 16.)

[9] The largest ever quarterly deficit was recorded at 78% of GDP in Q4 2008, fuelled by losses by Icelandic entities on a foreign exposure (which is registered as a negative dividend and/or retained earnings).

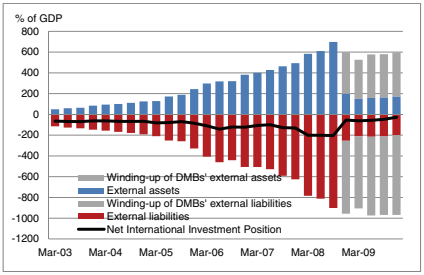
Figure 12: **A large current account deficit**



Iceland's current account was constantly in deficit. The current account balance shows exports and imports of goods and services, together with income and transfers. Source: The Central Bank of Iceland.

to a sudden capital flow reversal. Macroeconomic theory predicts that countries with a large negative NIIP should experience a depreciation of real exchange in order to generate a trade surplus to pay interest rates on the external liabilities. In Iceland, a depreciation of the currency would have the unfortunate effect of increasing the cost of servicing debt for households and companies that had loans indexed to foreign currency. We will return to this point later.

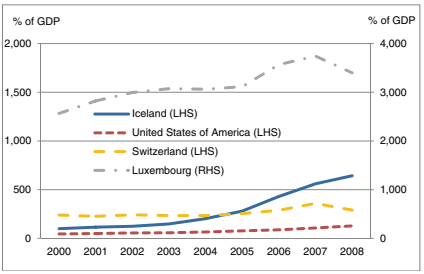
Figure 13: **The net international investment position**



Iceland's net international investment position (NIIP) is the sum of net external debt and net external equity positions. Assets and liabilities are shown with deposit money banks (DMBs) undergoing wind-up proceedings after Q3 2008. Source: The Central Bank of Iceland.

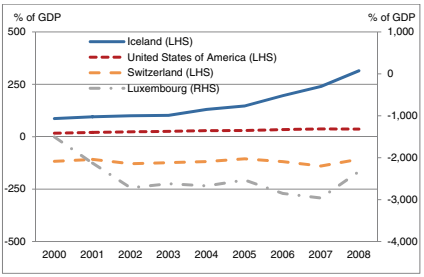
It is common to exclude the net external equity position in the NIIP. Iceland's net external debt (the stock of external debt minus the stock of external assets) amounted to around 230% of GDP at yearend 2007. According to Fitch data, Iceland's net external debt was the second highest level in the world (the highest being in Bermuda), whereas the gross debt was higher in a few other countries (Bahrain, Ireland, Bermuda and Luxembourg). Figures 14 and 15 compare debt in Iceland with that in selected countries with high gross external debt levels.

Figure 14: **Gross external debt as a percentage of GDP**



Source: Fitch Ratings.

Figure 15: **Net external debt as a percentage of GDP**



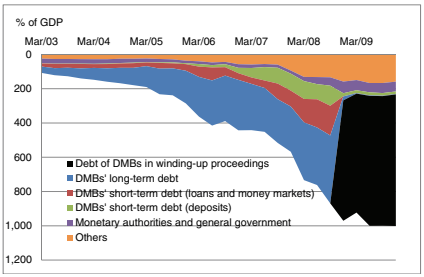
Net external debt position of the countries shown in Figure 14. Source: Fitch Ratings.

3.6 A High Amount of Short-term External Debt

Rolling over short-term debt in foreign currency exposes the banks to funding risk in foreign exchange markets. Iceland's gross external debt (liabilities of residents to foreigners) reached around 520% of GDP in year-end 2007, while Icelandic deposit money banks accounted for around 455% of GDP.[10] After the onset of the global credit crisis in 2007, the banks' share of short-term external debt rose sharply, as seen in Figure 16. This reveals the large exposure of the banks' parent companies to potential foreign exchange funding liquidity risk. The banks' external short-term debt covers deposits in foreign branches and loans, where repurchase agreements are treated as loans. We return to Iceland's short-term external debt later.

[10]Gross external debt is the stock of all debt of residents to non-residents. In 2008, a large part of the increase relative to GDP can be attributed to depreciation of the króna relative to the domestic price level (see the explanation in footnote 1).

Figure 16: **Gross external debt**



DMBs accounted for the majority of Iceland's gross external debt (according to parent company data). Short-term debt is defined as an original maturity of less than one year. The banks' liabilities being wound up are shown separately after Q3 2008. Direct investments are included in the "others" component. Source: The Central Bank of Iceland.

3.7 The Mini Crisis of Early 2006

The strong economic imbalances, almost all of which were public knowledge, were not ignored by the markets. In late 2005 and early 2006, doubts about the Icelandic banks' business models began to emerge. Market participants were worried about the banks' growth pace and their underlying asset quality, the high dependence on bond financing in the European market and their low deposit base as well as cross-shareholding between the banks themselves and between banks and major financial undertakings. In February 2006, the rating agency Fitch changed the outlook from stable to negative on the sovereign, stating that it had been *"triggered by a material deterioration in Iceland's macro-prudential risk indicators, accompanied by an unsustainable current account deficit and soaring net external indebtedness."* In March 2006, doubts over Icelandic vulnerabilities turned into fears. Merrill Lynch's (2006) banking report stated *"we think the banks should be compared less with other European banks and more with emerging market banks, since the systemic risks we see in Iceland have much more in common with emerging markets.* Danske Bank's (2006) macro report stated *"we look at early warning indicators for financial crises and conclude that Iceland looks worse on almost all measures than Thailand did before its crisis in 1997, and only moderately more healthy than Turkey before its 2001 crisis.*

The negative "publicity" resulted in a re-evaluation of the risk associated with the Icelandic banking system. Access to the European bond markets effectively closed and several money market funds refused to roll over the banks' extendable notes in March 2006 (see, for example, The Times 2006). It resulted in a significant downward pressure on the currency and equity market as well as wider credit default swap (CDS) spreads on the banks.[11] It was named the mini crisis of 2006. But why did this mini crisis not

[11] The depreciation of the króna sparked an unwinding of the currency carry trades around the world, for instance in the high-yielding New Zealand dollar. In fact, the króna achieved the nickname "the

grow into a much more severe crisis? It is hard to document econometrically, but there is certainly evidence to suggest that reassurances from different sources played a large role. Reports from other investment banks pointed to an overreaction towards credit fears in Iceland, and Moody's (2006) issued a special comment in April with the title "Iceland's Solvency and Liquidity Are Not at Risk" *stating Iceland is well positioned to deal with any potential claims on government resources that might emanate from a systemic problem in any sector of the economy. Our Aaa rating for Iceland is compatible with such an extreme scenario.* Furthermore, a strong counterattack was provided in a report by Herbertsson and Mishkin (2006), sponsored by the Iceland Chamber of Commerce. The report analysed a few early warning crisis indicators in Iceland. In particular, the focus was on the very low net government debt relative to GDP as well as the banks' (moderate) exposure to Icelandic households and businesses. In the words of the authors: *"our analysis indicates that the sources of financial instability that triggered financial crisis in emerging market countries in recent years are just not present in Iceland, so that comparisons of Iceland with emerging market countries are misguided.* They concluded that the probability of an emerging-market-style financial crisis was very low in light of Iceland's developed economy and floating exchange rate. That said, they also mentioned the risk of a self-fulfilling prophecy by investors pulling away from Icelandic exposure en masse.

After reviewing the Mishkin report, Morgan Stanley (2006) analysts, for example, concluded that there was no risk of a financial crisis in Iceland and recommended investing in Tier 1 capital of the banks. It is difficult to establish a direct causal link, but the banks' CDS spreads subsequently narrowed and the mini crisis ended in May 2006. It did have some lasting effects, however. The CDS spreads on the Icelandic banks stabilised at a higher level than on other Nordic banks. Also, in response to the international criticism, the Icelandic banks decided to diversify their funding mix: a strategy made possible by the banks' relatively strong credit ratings (see the next section). Furthermore, the banks tried to scale down their opaque cross-ownership structures.

It is interesting to note that, at the time of the mini-crisis in early 2006, market participants were concerned that the size of the three banks stood at between five and six times GDP and the banks' gross external debt at three times GDP. At the time of the collapse in 2008, these two figures had, in fact, doubled.

4 How can Bank Fundamentals look sound despite Problems?

In this section we take a closer look at arguments behind the high ratings assigned to the three largest Icelandic banks. We focus on Moody's setup, since Standard & Poor's only

canary in the coal mine", as a sell-off in the króna signalled investors' elevated risk aversion in the currency markets.

rated one of the banks and Fitch consistently rated the banks 'A' in the period from 2003 to 2007. Moody's bank senior debt and deposit rating is a function of the "bank financial strength rating" (BFSR), reflecting an opinion of a bank's stand-alone financial strength relative to other rated banks globally, and an assessment of the degree of sovereign or other support in the event of financial distress. A bank's final credit rating may thus be higher than its BFSR. Moody's BFSR scorecard assigns equal weighting to quantitative financial fundamentals and qualitative indicators in mature markets like Iceland. Figure 17 shows Moody's (2007b) assessment of fundamental and qualitative indicators for the Icelandic banks in November 2007. Iceland's overall credit risk assessment was less benign than their average Nordic peers, but it did not signal any immediate cause for concern. In the sections below, we investigate in detail Moody's assessment of quantitative financial fundamentals and qualitative indicators, as well as sovereign support factors.

Figure 17: **Moody's stand-alone assessment of the Icelandic banking**

Moody's assessment of the banks' quantitative and qualitative fundamentals in Icelandic and in the Nordic region. Quantitative financial fundamentals are profitability, capital, liquidity, efficiency and asset quality, whereas qualitative fundamentals are franchise value, risk positioning and regulatory as well as operating environment. Source: Moody's (2007b).

4.1 Window Dressing Quantitative Financial Fundamentals

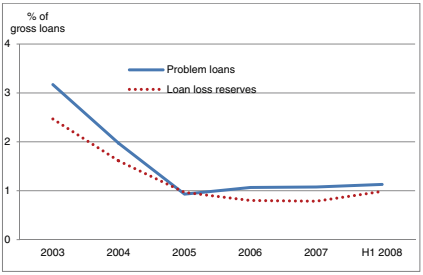
Moody's five factors behind financial quantitative fundamentals are asset quality, profitability, total capital, liquidity and efficiency. At first sight, traditional indicators of these factors for the Icelandic banks were relatively favourable right up to the crash of the banking system. How could this happen? Below, we address this question for all factors except "efficiency", which plays a smaller role in assessing the risk of bank failure. In summary, we argue that Moody's indicators of "asset quality" were based on the banks' (backward-looking) loan loss reserves and therefore did not capture the deteriorating asset quality. Inadequate loan loss reserves inflated profitability, and total capital was grossly exaggerated because of overestimation of asset value and failure to account for "weak capital", ie, bank-funded purchases of their own stocks. "Liquidity" was based on the banks' own estimates which, similar to banks in other countries, failed to account for

the drastic dry-up in market liquidity during the crisis. In Iceland, the banks were also dependent on smoothly functioning foreign exchange markets. Some of these issues were problems of rating methodology and an over-reliance on figures reported by the banks themselves. Others, such as the problem with "weak capital", point to a weakness in financial supervision which, for example, should have detected the extent of weak capital.

Remarkably modest Problem Loans

In 2006 and 2007, the three banks' average loan loss reserves for future asset quality deteriorations were less than 1% of the gross outstanding loans. These tracked the banks' historical strong credit performance. The amount of reported problem loans, ie, the sum of doubtful and non-performing loans, was broadly in line with their Nordic peers. As shown in Figure 18, the number of problem loans was in fact lower in 2005-8 than in 2003-4. The implementation of the new accounting standard explains the decline in loan loss reserves in 2004-5: the International Financial Reporting Standard (IFRS), which applied to Icelandic banks from 2005, required the banks to recognise loan loss reserves only after a loss or trigger event was identified. However, the drastic write-downs in asset values after the collapse suggest that there must also have been misreporting of loan performance. To quote the Special Investigation Commission (2010): *When the banks collapsed there was an inevitable and significant reduction in the value of their assets. It is, however, the Commission's finding that the quality of loan portfolios had started to erode at least 12 months before the collapse and continued to erode until the collapse, even though this was not reported in the banks' financial statements.* The same commission reports that loan "renegotiations" had been common for large loans in order to avoid the need to report them as non-performing.

Figure 18: **Problem loans and loan loss reserves**



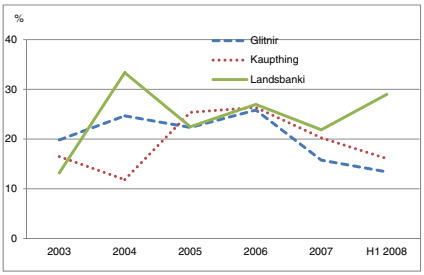
The average share of loan loss reserves made by the three banks. Problem loans are defined as the sum of doubtful and non-performing loans. Source: Moody's.

Reported High Returns on Equity

According to their published financial statements, the Icelandic banks appeared to be very profitable despite the high capital ratios. The average return on equity (ROE) was higher than in the rest of the Nordic region, as can be seen in Figures 17 and 19. Ex

post, it is clear that the high ROE was boosted by the insufficient loan loss reserves and insufficient recognition of problem loans.

Figure 19: **Icelandic banks' return on book value of equity**



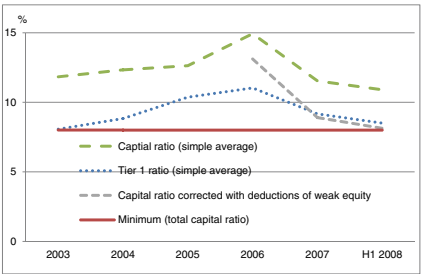
Returns are based on reported net income (period end). Returns for H1 2008 areannualised. Source: Moody's.

Capital Ratios and Leverage

The reported regulatory capital ratios stated by the Icelandic banks placed them among the best-capitalised banks in the world. Although an International Monetary Fund (2009) study documents that the capital ratios for eventually failing banks before 2008 were higher than for non-failing banks, high capital ratios are normally associated with financial robustness. As seen in Figure 20, the Icelandic banks' average total capital ratio was around 13% in the period between 2003 and mid-2007. In 2008, it dropped slightly but remained well above the statutory minimum requirements at 8% (ie, the total capital base divided by risk-weighted assets). The banks had internal targets of total capital ratios of 10-11%. If we trust that assets were worth par, as recorded by the Icelandic banks (which certainly was not the case), the leverage ratio on the total capital base was around 12. The ratio of asset to shareholder equity was around 17 and the ratio of asset to shareholder equity minus intangible assets was around 26. Hence, the banks' leverage, which is not influenced by the banks' reported risk-weighted assets, appeared to be moderate. The average Tier 1 capital, which is closest to equity but includes hybrid capital, was also relatively high. In the next section, we will consider underestimation of risk when the banks computed risk-weighted assets. Below, we focus on the low quality of the banks' reported capital.

After the onset of the global financial crisis, the banks extended their direct loans with collateral in their own shares and raised the positions of forward contracts on their own shares. The direct financing by the banks of their own shares can be called "weak equity" (Special Investigation Commission 2010). In Figure 21 we see the weak equity relative to the total capital. In mid-2008, it represented around 25% of the combined capital base or more than 50% of the core capital (total capital base excluding subordinated loans). Cross-financing in stocks between the banks peaked in 2007. If we include cross-financing

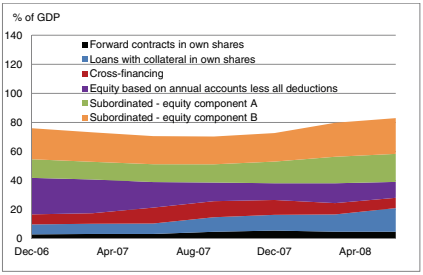
Figure 20: **Total capital ratios and Tier 1 capital**



The Icelandic regulators allowed Tier 1 capital to include up to 33% of hybrid capital.Weak equity is defined as the direct financing by the banks of their own shares. Total capital is measured as Tier 1 capital plus subordinated loans excluding hybrid core capital. RWAs are reported by the banks. Source: Moody's and the Special Investigation Committee.

in the "weak equity" measure, it amounted to around 34% of total capital and more than 70% of core capital in mid-2008.

Figure 21: **Total capital of the three banks**

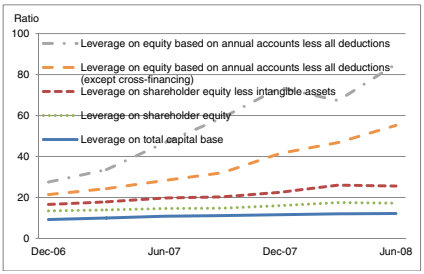


The total capital base of the three Icelandic banks was around 83% of GDP in Q2 2008. Subordinated debt represented around 53% of the capital base. The banks' direct financing by the banks of their own shares and cross-financings of shares accounted for around 34% of the capital base. Equity based on annual accounts minus the above-mentioned deductions accounted for the remaining 13% of the capital base. Source: The Special Investigation Commission.

It is also interesting to take a close look at the banks' leverage. The leverage on book equity minus all deductions (own and cross-financing equity financing as well as subordinated debt) stood around 85 in mid-2008, as seen in Figure 22. Therefore, the de facto equity cushion of the banks did not offer much protection to the banks' creditors. In fact, the banks had reduced their economic capital without it being apparent in their balance sheets.

Prudential supervision by the Icelandic Financial Supervisory Authority would have required that loans exclusively secured with the banks' shares were subtracted from the capital. In Figure 20 we see that this factor alone would have pulled capital towards the

Figure 22: **Leverage of the three banks**



The banks' real leverage based on different measures of capital, which are defined in Figure 21. Leverage is defined as assets divided by equity. Source: The Special Investigation Commission and the authors' calculations.

8% statutory minimum requirement in mid-2008 (for Landsbanki the ratio was below the 8% ratio in mid-2007). In addition, individual capital requirement for the banks should have been raised on the back of the higher risks associated with the banks' investment banking activities and the elevated risk of an economic downturn in Iceland (and thus higher loan losses). Stricter capital rules are allowed within the Basel II rules.

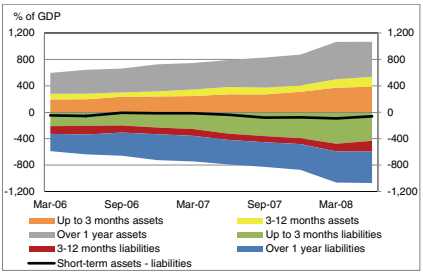
Future bank regulation is likely to partly address the issue. The Basel III bank regulation proposes raising the quality, consistency and transparency of the capital base as well as promoting the stability of the financial system as a whole. In the words of the Basel Committee on Banking Supervision (2009): *The reforms strengthen bank-level, or microprudential, regulation, which will help raise the resilience of individual banking institutions to periods of stress. The reforms also have a macroprudential focus, addressing system wide risks that can build up across the banking sector as well as the procyclical amplification of these risks over time. Clearly these two micro and macroprudential approaches to supervision are interrelated, as greater resilience at the individual bank level reduces the risk of system wide shocks.* Micro-prudential capital requirements would have excluded the Icelandic banks' subordinated capital in the calculations of Tier 1 capital. Furthermore, macro-prudential capital requirements would have been raised in the light of the three banks' contribution to systemic risk in the economy. The capital requirements would have been very high given the three banks' systemic importance in the economy.

Satisfactory liquidity positions

The Icelandic banks' reported maturity mismatch between assets and liabilities was not extensive relative to other global banks. The maturity profile of the banks' assets and liabilities is illustrated in Figure 23. In addition to the liquid assets shown, the banks' longer term asset portfolio and undrawn committed credit facilities were important sources of liquidity. Following the mini crisis of early 2006, the Icelandic banks decided to have liquidity policies that ensured sufficient liquid funds if the banks were unable to access

capital markets or interbank markets over at least the next 12 months (but with an assumption of stable deposits). As of year-end 2007, the Icelandic banks reported that they passed Moody's 12-month liquidity test even with a partial run on retail and corporate deposits.

Figure 23: **Short-term versus long-term assets and liabilities**



The banks' reported maturities of assets and liabilities. Assets are shown as positive and liabilities as negative numbers. The black line shows the difference between assets and liabilities with a maturity of less than one year. Deposits are shown as short-term liabilities even though they are typically not required to be repaid in a short period of time. Source: annual and interim reports.

Banks may pledge securities (like government bonds and other related securities) as collateral in return for central banks, investment banks and money market funds providing short-term funding (see also the penultimate section). Also, committed lines of credit can in principle be drawn up to their maximum. In reality, however, lines of credit are not totally committed liquidity insurance. In Iceland, many of the credit lines were contingent upon a minimum credit rating (Moody's Baa2). Furthermore, the liquidity facility provider to the Icelandic banks was often allowed to set the yield on the loans according to quotes in the CDS market (Special Investigation Commission 2010). The main risks for the Icelandic banks were that creditors would not roll over the debt (or refinance at much wider credit spreads) and repo lenders as well as trading counterparties required more collateral before long-term assets fully matured. Ex post, it was evident that the banks severely underestimated funding liquidity risk in foreign currency, but this problem was not unique to the Icelandic banks. Furthermore, the banks' reported liquidity pools, like the sale of bonds and subsidiaries of the banks, turned out to be very difficult to monetise in a distressed market environment.

4.2 Qualitative Fundamentals below their Nordic Peers

We now turn to Moody's assessment of the Icelandic banks' qualitative factors: franchise value, regulatory environment and operating environment, as well as risk positioning. The first three factors were assessed as "moderate" but with the banks' risk position having a low score. Moody's "franchise value" consists of an assessment of four sub-factors: mar-

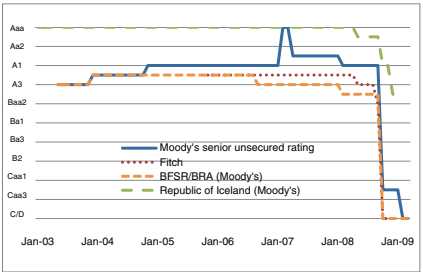
ket share and sustainability, geographical diversification, earnings stability and earnings diversification. The banks' earnings were considered unstable, as economic stability was assessed to be more volatile in Iceland (exacerbated by large macroeconomic imbalances). That said, the loan portfolio was judged to be partly diversified, as foreign operations of the banks accounted for a growing share of the total assets. Icelandic regulation and enforcement of regulation was not a cause for concern for the credit rating agencies since it was in line with Basel and EU regulation. Furthermore, the level of corruption was very low. Moody's "risk positioning" score consists of an assessment of corporate governance, controls and risk management, financial reporting transparency, credit risk concentration, liquidity management and market risk appetite. Moody's considered the overall "risk positioning" score to be low. The banks' credit scores on qualitative and quantitative fundamentals in the "polygon" (Figure 17) can be used to understand the BFSR by year-end 2007.

4.3 The Icelandic banks' way in to the Aaa League

It is illustrative to take a closer look at Moody's rating of Kaupthing, the largest of the three Icelandic banks, over time (Figure 24). The ratings of the two other Icelandic banks broadly followed the same pattern. Prior to 2003, Kaupthing had been an unrated investment bank, but as the bank merged with the Icelandic retail bank, Búnadarbanki slands ("the agricultural bank") it received a long-term deposit and debt A3 credit rating from Moody's. Later it was upgraded to A2 by Moody's to *"reflect ... the bank's successful execution of the merger of the two predecessor entities in May 2003, resulting in a well diversified and dominant market player with healthy financial fundamentals."* After the acquisition of Danish FIH Erhvervsbanks, where consolidated assets approximately doubled, the bank was upgraded to A1 to *"reflect ... the bank's leading position in its domestic market in Iceland, the fact that it is one of the country's largest institutions, and its healthy financial fundamentals."* In 2005, Kaupthing acquired the London-based investment bank Singer & Friedlander. Moody's A1 rating reflected the strong likelihood of state support in the event of systemic shock, with the BFSR remaining unchanged at A2. In fact, the stand-alone rating was downgraded to A3 in the second half of 2006.

In February 2007, Moody's (2007a,c) incorporated additional financial support into its bank ratings trough its joint-default analysis (JDA). The Icelandic banks were thus temporarily upgraded to Aaa. A refinement of its bank rating methodology in April 2008 modified ratings to Aa3 after heavy criticism of the JDA. Each of the banks thus "only" received a three-notch uplift in its debt/deposit ratings from its stand-alone credit rating. Moody's justification for the new Aa3 rating of the banks was explained in its publication on the Icelandic banking system outlook. To quote Moody's (2008a): *Each bank individually accounts for at least 25% of the system. We believe that the default of any one of these three banks would pose a substantial risk to the Icelandic economy, the consequences of which would be far greater than the cost of rescuing a failing*

Figure 24: **Kaupthing's credit rating**



Kaupthing's credit rating partly reflected sovereign support factors. Moody's stand-alone credit rating (BFSR/BCA) was below the senior unsecured rating. Data observations are monthly. Moody's bank financial strength rating (BFSR) is translated to a baseline credit assessment (BCA). Source: Bloomberg and Moody's.

bank. Therefore, in Moody's judgment, there is a very high probability that the Icelandic authorities would support each of the rated banks in a period of financial distress. Hence, the Icelandic banks were rated as if the sovereign was able to bail them out in a worst case scenario. We return to the sovereign support issue in the penultimate section.

The rating agencies were not alone in giving a positive review of Icelandic banks. In November 2007, Baldursson and Portes (2007) issued a report, again sponsored by the Iceland Chamber of Commerce, which was even more optimistic than the credit rating agencies. In their assessment: *"The banks have negligible exposure to the US subprime market, structured finance products, and related financial vehicles that have hit many financial institutions hard recently. Most fundamental, the banks exploit strong competitive advantage, arising from their entrepreneurial management, flat management structures, and unusual business models. Yet in spite of their strong performance, Icelandic banks have lower ratings than their Nordic peers, and a much higher risk premium is being placed on their debt during the present turmoil. We see no justification for this in their risk exposure. This suggests that either the markets are not fully aware of their situation or markets place a country premium on the banks."* In the next section we will take a look at the financial markets' view on the Icelandic banks relative to their credit ratings.

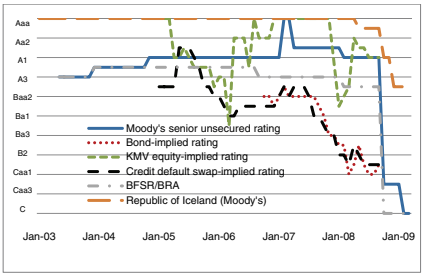
4.4 Low Market-implied Credit Rating

Was the market better than credit ratings at capturing the risks of the Icelandic banking system? The answer depends on whether we consider equity, bond or CDS markets' assessment. Equity-implied credit ratings, based on the performance of the equity using Moody's KMV expected default frequency measure, were not factoring in immediate financial distress for the Icelandic banks in 2008 (see Kaupthing's implied rating in Figure 25).[12] As previously noted, the banks' market capitalisation was an unreliable indicator

[12]See Moody's (2010) on market implied credit ratings.

of the true valuation. In fact, the Special Investigation Commission (2010) documents manipulation of stock values.

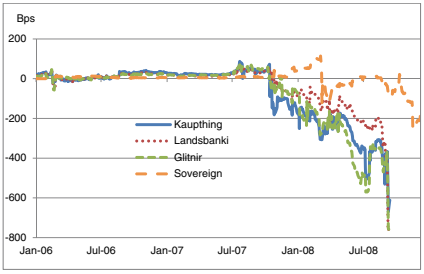
Figure 25: **Kaupthing's market-implied credit rating**



Kaupthing's CDS-implied credit rating was lower than the official rating. Moody's CDS-implied ratings are derived from five-year CDS quotes. For further information please Moody's (2010). Data observations are monthly. Source: Bloomberg and Moody's.

It was more difficult for the banks to influence the CDS market directly. CDS-implied ratings, ie, ratings implied from CDS spreads, were much lower than senior unsecured ratings and ratings based on equity prices. Since CDS spreads tend to move in tandem with credit spreads on bonds, it is not surprising that the bond-implied rating was similar to the CDS-implied rating. The interesting observation is that worries about the asset quality of Icelandic banks and doubts on the sovereign support spurred a demand for credit protection. Hedge-fund speculation may also have contributed to a further widening of the CDS spreads. Furthermore, as seen in Figure 26, the term structures of CDS spreads for the three major banks started to invert in the autumn of 2007: a typical sign that the market is worried that the issuer may face financial distress. In summary, the CDS markets and the ratings derived from CDS spreads were the perhaps the clearest early warning signals of the banking crisis.

Figure 26: **Term structures of CDS spreads**

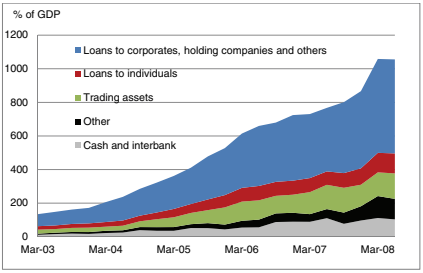


Term structure is measured as the five-year senior CDS spread minus the one-year senior CDS spread. Source: CMA DataVision/Bloomberg.

5. The Banks' Asset Quality

In this section we take a closer look at the banks' asset composition and quality. In summary, several factors contributed to the decline in asset quality. The rapid expansion of the banking book, which covers loans to the corporate sector and individuals, in itself indicated a deteriorating asset quality. In addition, many Icelandic customers had loans denominated in foreign currency and they were therefore vulnerable to a depreciation of the Icelandic krna. The corporate loan book was of course sensitive to a downturn in the Icelandic and international economy, but the banks were particularly sensitive to such a downturn because they were also heavily exposed to listed and unlisted domestic equities. Finally, the banks had weak corporate governance and a high concentration of risk in their loan portfolios. Below, we take a closer look at the composition of the banks' assets shown in Figure 27.

Figure 27: **The three Icelandic banks' assets**



Composition of the three largest banks' assets. Loans to corporations and holding companies were the largest item on the banks' balance sheets. Further items include loans to individuals, trading assets and cash and interbank loans. The item "other" measures all other assets not included in the aforementioned categories. Source: Bloomberg and interim accounts.

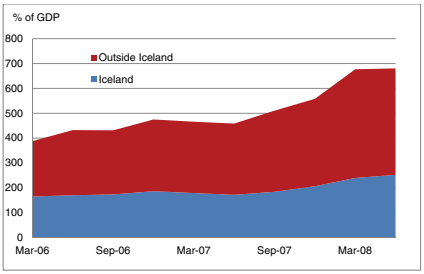
5.1 Loans to the Corporate Sector rising sharply

The biggest item on the banks' balance sheet was corporate loans, whose share of total lending was approximately 83% in 2007-8. The banks' large volume of loans to the corporate sector was in part driven by the reliance on the simplest approach to assessing the risk-weighted assets in the banking book (the so-called "standardised approach" in the Basel II framework) rather than the development of their own internal rating-based models (IRBs). In the standardised approach, each group of customers has a fixed capital charge per unit of exposure in the calculations of risk-weighted assets (20% to 150% depending on the credit assessment). A well-known weakness in this framework is that banks have an incentive to exploit the risk weights and acquire the riskiest corporate assets. This seems to have been the case in Iceland. An example is the Icelandic banks'

acquisition and leveraged finance (ALF) portfolios. The banks were rather open about their exposures, with Glitnir noting in its official securities note document: *we have exposure to credit risk related to acquisition finance loans, which typically involve higher degrees of leverage than general corporate borrowing and make these borrowers more exposed to increases in interest rates and downturns in the economy.* Glitnir reported that the leveraged loan portfolio accounted for approximately 9.2% of its total loan portfolio as of Q2 2008.

For Kaupthing, the ALF portfolio was reported to represent 17% of its customers' loans at the end of Q2 2008. Before the onset of the global financial crisis, the Icelandic banks expanded into new markets where there was already fierce competition. The banks saw the expansion outside of Iceland as a way to diversify their loan portfolios and improve their credit ratings. In Figure 28 we see that around two-thirds of the banks' loans were to outside of Iceland in 2008. The competition for loans to customers, however, prohibited the Icelandic banks, which faced a larger credit spread, from charging a higher credit-risk premium than their global competitors. To quote the chief economist of Kaupthing, Jónsson (2009): *the three Icelandic banks could pass the premium on to their domestic clients, but that option did not exist with foreign clients, who might be lost to banks of other nations.*

Figure 28: **Loans within Iceland and outside**



Icelandic bank loans were split between approximately one-third inside Iceland and two-third outside of Iceland. Source: Consolidated balance sheets.

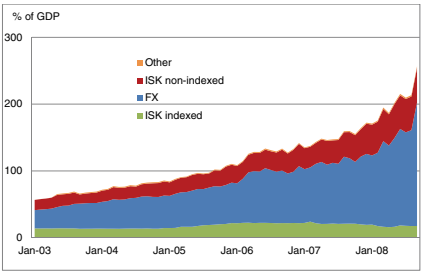
The Icelandic banks' relatively strong liquidity positions subsequent to the mini crisis in 2006 made the banks better prepared for the onset of global financial crisis in mid-2007 than many other international banks. In fact, the Icelandic banks saw the global financial crisis as a way to capture market shares from their competitors. This explains why the Icelandic banks continued to expand their balance sheets even as the global crisis started in mid-2007 (Figure 27). In August 2007, Kaupthing also announced its intention to acquire the Dutch merchant bank NIBC, which would have increased Kaupthing's balance sheet by two-thirds.[13] In fact, lending to foreign parties increased by more than 100%

[13]Nevertheless, the announcement backfired, with a sharp widening in CDS spreads on the bank to

of Iceland's GDP within a year. In the words of the Special Investigation Commission (2010): *The increase was so substantial that it can be assumed that many of these new clients had turned to the Icelandic banks after other banks were beginning to slow their lending, and that these clients had thus been rejected by other banks. The Icelandic banks thus lent substantial amounts while experiencing considerable liquidity problems at the same time.*

In Iceland, the banking system extended its total lending to the domestic corporate sector to more than 170% of GDP by year-end 2007 (Figure 29). In particular, lending to holding companies grew rapidly in the second half of 2007. The banks were also lending for stock purchases and often took domestic stocks as collateral.[14] Loans collateralised with equities increased the banks' exposure to (indirect) market liquidity risk in case the borrower was unable to fulfil the loan contract. As the crisis struck in Iceland, the collateral sales related to contractual margin calls increased and this resulted in a downward pressure on equity prices. The Special Investigation Commission (2010) documents that these margin calls were abandoned, as the banks were reluctant to realise credit losses on the loan portfolio and start a fire sale in the domestic equity market.

Figure 29: **The banks' lending to companies and holding companies in Iceland**



These loans were primarily denominated or indexed to foreign exchange rates. Source: The Central Bank of Iceland.

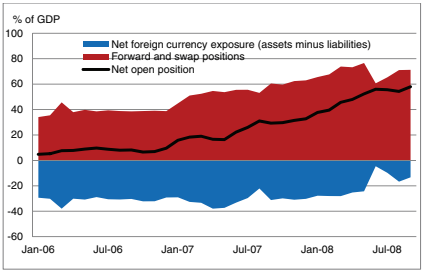
The double-digit interest rates from early 2006 in Iceland (and a stable currency) increased the incentive for the Icelandic companies to finance themselves in foreign low-interest-rate currencies. Approximately 70-75% of bank loans to corporations were foreign exchange linked, which was an important indirect credit risk for the Icelandic banks. The banks were fully hedged against currency risk but their customers were left with open foreign-currency exposure. The banks had fewer assets than liabilities denominated in

800-1,000 basis points. In January 2008, Kaupthing made a statement that the proposed acquisition of NIBC was abandoned. Ironically, NIBC had accepted losses due to exposure to subprime mortgages, whereas Kaupthing had not accepted upcoming losses on its loan portfolio.

[14] According to the Central Bank of Iceland (2008) around 13% of the parent banks' total lending to customers was against share collateral at the end of 2007. At year-end 2007, 39% of the shares used as collateral for loans were listed on the OMX Exchange in Iceland (and valued at nearly 17% of the total year-end market value).

foreign currency, which implied a short (spot) position in foreign exchange market (Figure 30). Without hedging, a depreciation of the domestic currency would deteriorate the banks' capital adequacy ratios. However, the banks hedged themselves against such a depreciation with a long foreign currency position through derivatives (currency swaps, etc). In fact, the banks not only were protected against a depreciation of the Icelandic króna, but they also used derivatives to increase their open long foreign exchange position in order to gain on a depreciation of the króna.[15] The net positive foreign exchange balance was around 40% of GDP at year-end 2007, partly reflecting the fact that the banks' customers had short foreign exchange positions.

Figure 30: **The banks' spot and forward positions**



The banks had fewer assets than liabilities denominated in foreign currency (equivalent to a short foreign exchange position). However, the banks established a long foreign exchange position through forward and currency swaps. Hence, their overall net open position was long foreign exchange. Source: The Central Bank of Iceland.

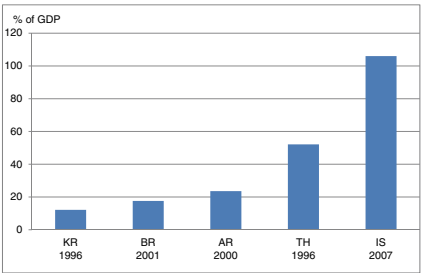
A part of the Icelandic corporate sector's foreign exchange risk was naturally hedged, but the majority of the companies were still dependent on króna earnings to repay the debt and interest rate payments in foreign currency. In the event of a sharp depreciation of the domestic currency, it could easily result in loan losses on the asset side of the banks if the underlying borrower was unable to repay the larger foreign-exchange-denominated debt. In Iceland, the foreign-currency-indexed debt of the corporate sector was substantially higher than in other systemic banking and currency crises (Figure 31). With the sharp depreciation of the Icelandic currency in 2008, the majority of the firms in Iceland were technically bankrupt. This was also the case in Thailand in the late 1990s.

5.2 Loans to the household sector in Iceland

Loans to individuals in Iceland constituted a smaller part of the banks' balance sheets. The three banks entered the Icelandic mortgage market in Q3 2004, when they started competing aggressively with the state-supported HF Fund (which used to be the dominant player in the retail mortgage sector). This competition set the foundations for an

[15] In fact, "hedging" gains were a primary driver behind the banks' reported profits in 2008.

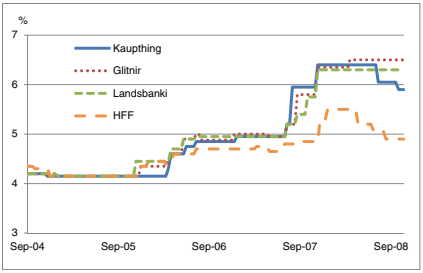
Figure 31: **Foreign-currency denominated debt of the corporate sector**



Foreign-currency-denominated (or indexed) debt of the corporate sector in countries facing financial crises. The data was collected prior to the systemic banking crisis. KR, Republic of Korea; BR, Brazil; AR, Argentina; TH, Thailand; IS, Iceland. Source: Rosenberg et al (2005) and the Central Bank of Iceland.

underpricing of risk, since the banks would never be able to offer competitive interest against a state-sponsored institution over an extended period of time (the HF Fund's interest rate set the lower bound, as seen in Figure 32). The banks gained a competitive edge against the government guarantee by granting more liberal criteria for mortgages, eg, attractive loan-to-value ratios (OECD 2009). This resulted in households refinancing their mortgages and switching to the banks. Hence, the HF Fund's lending relative to GDP fell sharply (Figure 33).

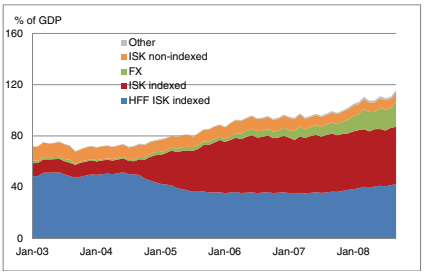
Figure 32: **Real interest rates on indexed housing loans**



Real interest rates on inflation-indexed housing loans set by the three largest banks and the Housing Financing Fund. The state-supported HF Fund's interest rate set the lower bound for interest rates in Iceland. Source: The Central Bank of Iceland.

As the HF Fund offered domestic currency loans only (indexed to the consumer price index), the banks later promoted low-interest foreign-currency loans. This resulted in a sharply increasing share of foreign-currency-indexed loans to households (around 15% of GDP in 2008). As with corporate loans, the foreign-currency lending was an indirect credit risk for the banks, as few households would have a natural hedge against a sharp depreciation of the domestic exchange rate. The banks' lending to the Icelandic household

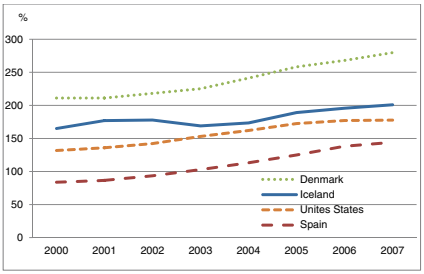
Figure 33: **Figure 33 Domestic banks and HF Fund lending to households**



Deposit money banks' lending by category: non-inflation indexed, inflation indexed, indexed to the foreign exchange rate and others. The HF Fund provided only inflation-indexed loans. Source: The Central Bank of Iceland.

sector reached slightly more than 100% of GDP or 200% of disposable income by year-end 2007, as seen in Figures 33 and 34. It is a rather large amount, but it was partly mitigated by relatively modest loan-to-value ratios. It suggests that the fall in Icelandic house prices in 2007-8 was not the primary culprit of the banking crisis in Iceland, since there were relatively stringent loan-to-value ratios on mortgage loans to the household sector (see also Table 1).[16]

Figure 34: **Household debt as a percentage of disposable income**



Household debt as a percentage of disposable income (before interest payments) Source: OECD.

5.3 The Banks' Trading Assets were larger than those of their Peers

In the period 2003-8, the three banks' trading portfolios accounted for 15-16% of total assets on average (Figure 27). The main part of the marketable securities was in the

[16]Nonetheless, with a 90% loan to-value on a marginal mortgage, the bank naturally starts to lose money when prices fall by more than 10% (if margin calls are impossible, eg, due to a very high debt service). As of June 2009, the Central Bank of Iceland (2009b) assessed that only around 2.5% of homeowners had both a negative equity position and a heavy debt service.

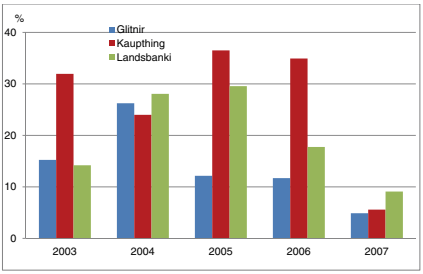
Table 1: **Loan-to-value ratio of mortgage loans**

The banks' reported loan-to-value ratios of mortgage loans were moderate going into the crisis (based on parent company data). This indicated that the banks had a cushion before they would start to lose money. Source: The Icelandic Financial Supervisory Authority and the Central Bank of Iceland.

LTV ratio	Year-end 2006	Year-end 2007
0-50	20	34
50-70	22	25
70-90	34	23
90-100	8	5
100+	8	4
Unknown	8	9

form of bonds, whereas the equity holdings (both listed and unlisted equity exposures) accounted for approximately 2-3% of total assets. According to the IFRS, changes in market value of trading assets are required to be reflected in the income statement on a mark-to-market basis. In the years of rising stock markets (2003 to mid-2007), the strong profits of the bank were buoyed from trading income (Figure 35). However, when the price of risky assets fell after the onset of the global financial crisis in mid-2007, the strong income from long trading positions was clearly not sustainable.

Figure 35: **Trading income as a percentage of operating income**



It is clear that the banks' trading income was a large fraction of operating income. Source: Moody's.

5.4 Poor Corporate Governance and Leveraged Bank Owners

The primary worries regarding the Icelandic banks were the large extent of related party lending, their large exposures to single customers and the opaque nature of their cross-ownership structures. This was noted by several investment banks in 2006 and onwards. The findings were repeated in an International Monetary Fund (2008a) study: *Icelandic banks have a relatively high concentration of exposure to large borrowers and connected parties, with the top 20 borrowers representing between 250 percent and 300 percent of*

Tier I capital. In addition, it was common knowledge that the controlling shares in the banks were owned by highly leveraged interconnected companies and they were sensitive to a fall in share prices. After the collapse of the banking system, the Special Investigation Commission (2010) revealed that the lending to related parties in interim accounts was grossly understated in financial statements. In fact, each of the banks had total lending to related parties exceeding the maximum of 25% of capital stated in EU regulations on large risk exposures. The banks circumvented the rule by using a very narrow definition of connected risk to related parties. In addition, many of the banks' customers had large loans from several banks, which resulted in a concentration of risk in the system. For instance, the three banks' total lending to Baugur Group at the highest level constituted 53% of the three banks' equity base. The commission also found that *The operations of the banks were in many ways characterised by their maximising the benefit of majority shareholders, who held the reins in the banks, rather than by running reliable banks with the interests of all shareholders in mind and to show due responsibility towards creditors.*

After the collapse of the Icelandic banks, a document was leaked which provided a snapshot of Kaupthing's pre-crisis loan book of large exposures. We have aggregated the data in Figure 36 according to the internal risk ratings scale based on an individual assessment of customers. The bank's rating scale is to some extent related to the official rating agencies' but with the bank's internal assessment of the probability of default that within 12 months the customer will be unable to meet his financial obligation.[17] According to the bank's internal assessment, the asset quality of the large exposures was predominantly non-investment grade. This seems to largely contradict a statement by Kaupthing in September 2008 that there are "signs of an improved loan portfolio despite the substantial growth of the portfolio since 2003" under the headline "sound asset quality".[18] The loan book revealed very dubious lending and governance practices. There were loans given to holding companies and individuals with low or no collateral, or loans to entities with the only purpose of buying stocks in Kaupthing. For example, Kaupthing's loans to companies related to Exista, which was the biggest shareholder with a 23% stake, amounted to more than 25% of Kaupthing's capital.

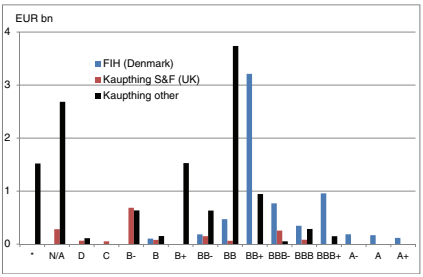
6 How did the Banks get Funding after 2006?

It is remarkable that the Icelandic banks managed to continue their aggressive growth despite the mini funding crisis in early 2006. We now show how they were able to fund themselves up to the collapse of the banking system. Figure 37 shows the funding sources divided into broad categories from January 2003 to June 2008. The banks' most

[17]Bond ratings are based on expected long-term risk of default and thus are not intended to change over the business cycle. The subjective rating scale can take collateral as well as covenants into account and can be adjusted rapidly.

[18]See "Kaupthing Bank Company Profile, September 2008" at http://www.kaupthing.com/lisalib/getfile.aspx?itemid=17423.

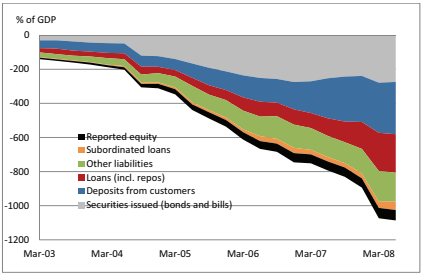
Figure 36: **Kaupthing's large exposure distribution**



The distribution of Kaupthing's subjective credit ratings based on exposures larger than 0.045 billion (as of September 25, 2008).The figure shows the parent company and the two subsidiaries, FIH Erhvervsbanks and Kaupthing Singer & Friedlander. "N/A" indicates the data was not available and the asterisk indicates that the loan taker is on a special list without a need for a credit rating. Source: http:// wikileaks.org/.

important funding source was issuances of commercial paper and bonds. The second most important funding source was foreign wholesale and retail deposits. A third source of funding was from bilateral and syndicated loans as well as access to money market lines from relationship banks. These include short-term collateralised loans from central banks and investment banks. We now take a closer look at these funding sources and discuss the role played by the government and central bank in securing this funding.

Figure 37: **The three banks' liabilities**



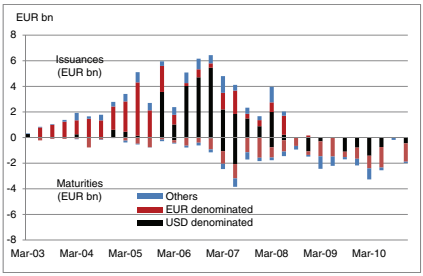
Aggregation of the Icelandic banks funding sources. The banks' primary funding source was issuances of commercial paper and bonds. The second most important funding source was foreign wholesale and retail deposits. Third in line were loans. The item "other liabilities" measures all other liabilities not included in the previous categories. Source: Bloomberg and interim accounts.

6.1 Unsecured Securities as the Primary Funding Source

Leading up to the mini crisis in 2006, the Icelandic banks borrowed heavily in foreign security markets at low credit spreads in order to finance their asset growth. Initially,

the Icelandic banks focused on unsecured bond issuances under their Euro Medium Term Notes programmes (Figure 38). The bonds typically had a maturity of three to five years. The Icelandic banks' debt had high credit ratings and could therefore easily enter the balance sheets of international banks and other institutional investors who also saw Icelandic risk as means of diversifying their portfolios.

Figure 38: **Bond issuances and maturities in different currencies**



Issuances are above the horizontal axis and the associated maturities are below the axis.
Source: Bloomberg and own calculations.

After the mini crisis of early 2006, the Icelandic banks seemed unable to access European debt securities markets and they shifted to the US debt securities markets. The opening in the US was primarily caused by a strong demand for cash collateralised debt obligations (CDOs) with Icelandic bank securities as the underlying assets. These securities were attractive to use as collateral in CDOs, as they offered higher yields than other credit institutions with similar ratings. The Icelandic banks were also used as reference securities in synthetic CDOs, and the selling of credit protection caused by this may have contributed to a narrowing of CDS spreads on the banks. According to Bloomberg (2008), relying on Standard & Poor's documentation, the three Icelandic banks were included in 376 CDOs worldwide and another 297 CDOs had made bets on two of the three banks as of October 2008. After mid-2007, a part of the general widening of CDS spreads on the Icelandic banks was likely to have been caused by buying of protection to hedge existing CDOs. During the mini crisis in 2006, the banks also returned to issuances in króna. In order to repay liabilities in foreign currency, the banks thus relied on a liquid functioning foreign exchange spot or swap market.

Finally, implicit sovereign support through the silent acceptance of the growing banking system had calmed the senior bond investors. The common understanding among investors is best summarised by the investment bank, Merrill Lynch (2006):[19] *"in the event of a systemic crisis, we would be expecting the Treasury to support the banks [] such*

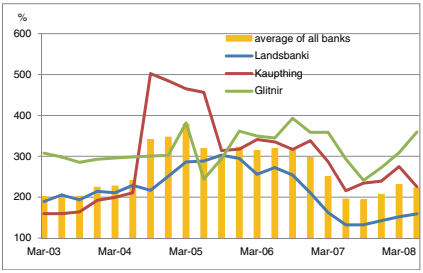
[19]Several financial analysts also referred to liquidity support by the Nordic central banks in the so-called Memorandum of Understanding (MoU) dated June 2003. The MoU makes clear that the central banks will not intervene to prop up an insolvent bank, but a bank facing liquidity problems could be offered support from the group.

is the dependence of the banks on external funding that we would expect some provision to ensure that shorter term, senior obligations at the very least continued to be serviced in an orderly fashion." The Icelandic banks are likely to have found it impossible to rollover their liabilities if government officials had explicitly dismissed the implicit guarantee on the banks' liabilities.

6.2 Deposit Finance outside of Iceland

We now turn to the banks' funding through foreign deposits. Before the onset of the mini crisis of 2006, deposits constituted a relatively low proportion of the banks' total liabilities (around 20%) and the average ratio of loans to deposits was around 3. This implied a very high dependency on market funding relative to their Nordic peers. On the back of the mini crisis, the rating agencies encouraged the banks to increase their deposit base, since it was considered to be a more reliable funding source than bond financing. Deposits of ordinary Icelanders were never going to be enough to fund the banks. The integration of financial markets in the European Economic Area (EEA),[20] however, enabled the Icelandic banks to expand rapidly in the European market. Icelandic banks could easily establish subsidiaries and branches in the EEA, based on the principles of home country control and mutual recognition. Deposits in subsidiaries and branches abroad became an important funding base in 2007 and early 2008. As a result, the ratio of deposits to total liabilities rose to around 30% and the average ratio of loans to deposits fell to around 2 (Figures 37 and 39). In 2006, some of the banks' foreign subsidiaries already offered so-called wholesale deposits (often deposits based on specific agreement between intermediaries, including interest rates and duration). Landsbanki also offered accounts through their branches, as seen in Figure 40.

Figure 39: **Loan-to-deposit ratios**

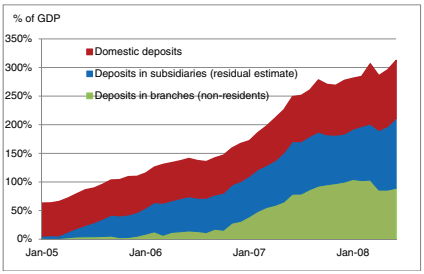


It can clearly be seen that the Icelandic banks were providing more loans than their deposits base. Source: Bloomberg.

In October 2006, Landsbanki launched Internet-based retail deposit accounts through their UK branch, paying higher interest rates than many competitors were offering. The

[20]The 27 EU countries as well as Switzerland, Norway and Iceland.

Figure 40: **Deposits in the DMBs**



The composition of deposits from January 2005 to June 2008. Deposits in subsidiaries are calculated as the difference between total deposits according to interim accounts and deposits in branches according to data from the Central Bank of Iceland. Source: The Central Bank of Iceland and the authors' calculations.

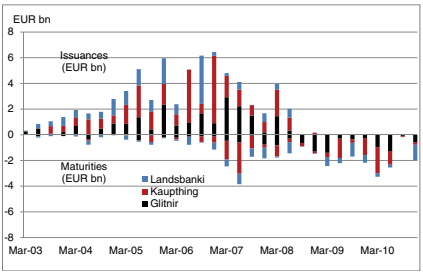
accounts were named IceSave. EU/EEA rules stipulate that branches are a part of the parent company (located in Iceland) and operations should be supervised by the (Icelandic) supervisory authority. Furthermore, the UK Financial Services Authority was to supervise the liquidity management and was authorised to intervene in the branch. A branch was an Icelandic legal entity and deposits were thus covered by the Icelandic Depositors and Investors' Guarantee Fund up to 20,887 to each depositor (or 20,000 according to the European Deposit Guarantee Directive).[21] The Icelandic insurance scheme only had assets amounting to around 0.5% of deposits in October 2008, and it had insufficient funds to cover even domestic deposits in the case that one of the three banks failed. This can be said of other countries with large banks (relative to GDP) as well, however. But the foreign deposits in branches represented a large foreign currency potential liability of the sovereign, which could have been avoided if regulators had demanded a transfer of the deposits of the branch to a UK subsidiary. We return to the sovereign's contingent liabilities in the penultimate section. The deposit accounts were marketed in the UK and later in the Netherlands with reference to the systemic importance of Landsbanki in Iceland, the Republic of Iceland's Aaa rating as well as the deposit insurance backed by Icelandic authorities.[22] IceSave was named a "clear genius" by the management of Landsbanki, as it was a cheap way to get funding when the funding cost on new senior debt issuances was rising (as reflected in the CDS spread on the bank). In Figure 41 we see that Landsbanki lowered its debt issuance since the bank was so successful in gathering deposits.

In November 2007 Kaupthing also launched an Internet-based savings account through

[21] It was less desirable for the Landsbanki to transfer IceSave deposit accounts from the branch to its subsidiary, Heritable Bank, since the UK rules on large exposures placed considerable limitations on the transfer of funds to other parts of the banking group, including to Iceland (Special Investigation Commission 2010). The Dutch rules of transfer were less restrictive.

[22] See an official letter by Landsbanki to its employees at http://blog.eyjan.is/helgavala/files/2009/07/staff_letter_150208_-_final.PDF.

Figure 41: **Bond issuances and maturities for the three banks**



Issuances are above the horizontal axis and the associated maturities are below the axis.
Source: Bloomberg and authors' calculations.

Kaupthing Edge, deposit accounts offering relatively high interest rates. Kaupthing's stand-alone subsidiary in the UK, Kaupthing Singer & Friedlander, was an independent foreign legal entity under the supervision of the UK FSA and depositors were covered by the UK deposit guarantee scheme (the Financial Services Compensation Scheme).[23] In June 2008, Glitnir also opened a retail account under the name "Save & Save". Landsbanki, with its high deposit ratios, was considered less risky by the market, since insured depositors have few incentives to fear the safety of their deposit (at least as long as the insurance is credible). However, the relatively strong funding position of Landsbanki changed over the period February to April 2008 with negative coverage of the Icelandic banks in the UK press. It resulted in an outflow of wholesale and, to a lesser extent, retail deposits in the UK branch. It was close to causing the failure of Landsbanki in early 2008. Nonetheless, the return of retail deposits was later used to repay the outflow of wholesale deposits (Special Investigation Committee 2010).[24] Landsbanki thus was surviving on the back of insured deposits.

6.3 Short-term Collateralised Loan and the Collapse of the Exchange Rate

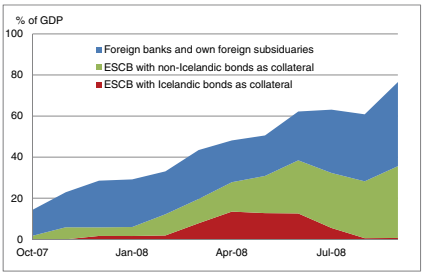
The banks' external maturity profile shortened substantially after the onset of the global financial crisis. Repurchase agreements ("repos") or collateralised loans turned into an important short-term funding source. In September 2008, collateralised loans from outside Iceland amounted to at least 70% of Iceland's GDP. As seen in Figure 42, repo transactions with non-central banks (for example, Royal Bank of Scotland) accounted for

[23]Kaupthing also offered Edge through its branch in Germany. However, the majority of the Edge accounts were offered through subsidiaries.

[24]The sluggish reaction of retail depositors is similar to the Northern Rock case, as documented by Shin (2009): "The Northern Rock depositor run, although dramatic on television, was an event in the aftermath of the liquidity crisis at Northern Rock, rather than the event that triggered its liquidity crisis. Indeed, the irony of the images of Northern Rock's retail customers standing in line to withdraw deposits is that retail deposit funding is perhaps the most stable form of funding available."

the main part of the collateralised loans.[25] The securities that were secured against the loans were typically the banks' foreign bonds and Icelandic securities.

Figure 42: **The three banks' collateralised loans outside Iceland**



Data for the three banks' collateralised loans with foreign banks and their own foreign subsidiaries as well as at the European System of Central Banks (ESCB).The data covers the period from October 31, 2007, to September 30, 2008 and was disclosed after the collapse of the banking system. Data on Landsbanki's collateralised loans made through the UK is not available. Source: Special Investigation Commission.

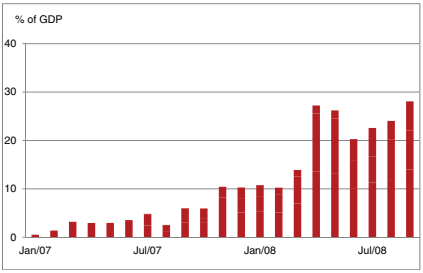
Central banks provide (last resort) liquidity facilities against eligibility collateral to banks with capital above the statutory minimum requirements. Bagehot's (1873) famous dictum states that *"to avert panic, central banks should lend early and freely (without limit), to solvent firms, against good collateral, and at 'high rates'."* Obviously, solvency turned out to be a problem, but central banks also accepted dubious collateral. The Icelandic banks owned subsidiaries in Luxembourg and thus had access to collateralised loans through the Central Bank of Luxembourg (CBL) from the European System of Central Banks (ESCB). In the latter part of 2008, the CBL was a major provider of liquidity to the Icelandic banks, with the banks achieving close to 40% of GDP in collateralised loans through the CBL. Central bank rules prevent banks from posting their own debt as collateral, but during 2008 the three banks circumvented this by posting each other's bonds as collateral at the CBL. This procedure is popularly referred to as issuing "love letters". At the end of July 2008, the CBL prohibited this way of funding with reference to the strong interconnection among the Icelandic banks. This reduction is clearly seen in Figure 42.

Fortunately for the banks, the "love letters" were more readily accepted at the Central Bank of Iceland (CBI). In 2008, the Icelandic banks issued debt to the savings bank, Icebank, which then used the debt as collateral at the CBI. Figure 43 shows the rapid growth in the banks' holdings of bonds issued by other Icelandic banks and Figure 44

[25] Collateralised loans explain a large part of the increase in short-term external loans seen in Figure 16. They include securities to repos with Kaupthing's subsidiary, Singer & Friedlander (KSF). The parent company directed repos through KSF and achieved funding. In early October 2008 these transactions were seen by the UK FSA as a way for the parent company to reach the deposits of Kaupthing Edge (Special Investigation Commission 2010).

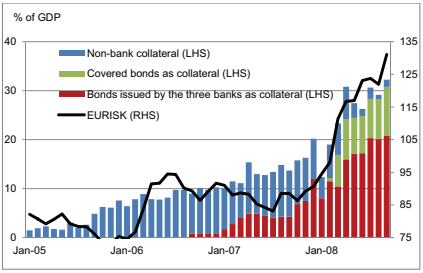
demonstrates that these bonds were used to a large extent as collateral at the CBI. Collateralised loans at the CBI amounted to around 20% of GDP. Kaupthing and Glitnir also issued covered bonds used for collateralised loans at the CBI.

Figure 43: **The banks' holdings of other Icelandic banks' bonds**



It is clear that the Icelandic banks were buying their own and other Icelandic banks' bonds in 2007 and 2008. Source: The Central Bank of Iceland.

Figure 44: **Collateralised loans at the CBI and the exchange rate**



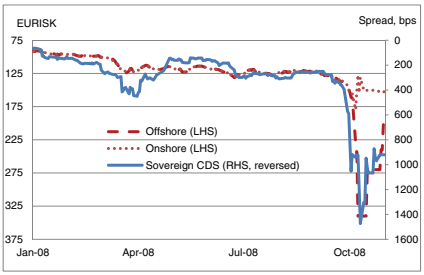
The Icelandic banks collateralised loans at the Central Bank of Iceland from January 2005 to September 2008.The CBI accepted bonds issued by the three banks. A rise in EURISK is an appreciation of the euro against the (onshore) Icelandic króna. Source: Central Bank of Iceland and the Special Investigation Commission.

The CBI's domestic liquidity provision made the upcoming crisis worse by contributing to a collapse of the exchange rate. The CBI only provided liquidity in Icelandic króna, whereas the CBL provided liquidity in euro, in compliance with rules on liquidity. Since the Icelandic banks primarily needed foreign currency, they exchanged the króna into foreign exchange in the spot or currency swap markets. In Figure 30, we see that the banks constantly raised their short positions against the domestic currency. The one-way flow in the currency market was exacerbated by currency carry traders liquidating their existing positions.[26] Figure 45 shows the simultaneous sharp rise in sovereign credit risk

[26]The malfunctioning foreign exchange swap market resulted in the low FX swap-implied króna yields and lowered the attraction of the currency carry trade implemented through FX swaps.

and the drop in the exchange rate. It was followed by a further sharp drop in the off-shore exchange rate after the implementation of exchange rate controls in October 2008.

Figure 45: **The Icelandic exchange rate**



Icelandic onshore and offshore exchange rates are given in addition to the credit default swap on the Republic of Iceland. A rise in EURISK is an appreciation of the euro against the króna. The rise in credit risk co-moved with a depreciation of the króna. Source: Reuters and the Central Bank of Iceland.

In 2008, the CBI's rules for the credit standards of eligible collateral were broadly similar to the rules in the ESCB, stating that unsecured bonds and bills were required to have a minimum long-term rating of "A-" by Standard & Poor's or Fitch Ratings or of "A3" by Moody's as well as having securities trading on a regulated market in the EEA. However, the credit agencies' ratings of the Icelandic banks reflected the high probability of sovereign support to the banking system. The CBI might reasonably, as a minimum, have based its liquidity facilities against eligible collateral on an assessment of a bank's stand-alone financial strength credit rating and/or supplemented by market implied credit ratings. According to Moody's stand-alone BFSR or CDS-implied credit ratings, the Icelandic banks were not qualified for collateralised lending in February 2008.

6.4 The sovereign's Inability to help the Banking Sector

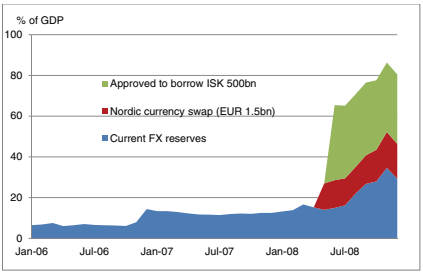
All access to funding of the banks was facilitated by or even depended on implicit or explicit sovereign support. Throughout the expansion of the banking system, official statements indeed indicated a willingness to support the three largest banks. In fact, the country's prime minister, Geir Haarde, was very proud of the banking sector and actually wanted it to expand further. In his words (Haarde 2008):[27] *"The financial sector has become one of the most important sectors in the country. I see it as very important that it will be in a position to continue its growth ... The Treasury is in a strong position and*

[27]Even after the Icelandic government stepped in to rescue Glitnir, an economic advisor to the prime minister, Tryggvi Herbertsson, said in an interview with the BBC (British Broadcasting Corporation 2009): *"It's obvious that the banking system in Iceland is very large compared to the economy, but still we think we can maintain the problem, you know, because the balance sheet of the bank is after all very good." To the question "If one of them did get into difficulties, despite what you say, could you afford to rescue it?" he responded " Definitely we would come to the rescue of the bank, definitely".*

can therefore borrow sizeable amounts if necessary. There is no doubt that the Treasury and the Central Bank could provide assistance if a serious situation were to emerge in the banking system." However, Iceland clearly faced a huge mismatch between the foreign currency roll-over risk of the banking sector and the sovereign's ability to provide foreign currency. The banking sector's foreign currency liabilities far exceeded Iceland's fiscal capacity.

After the onset on the global credit crisis in mid-2007, the appetite for Icelandic bonds declined sharply and the bonds were issued with higher yields. The main worry was the total bond refinancing need in 2008 and the following years. In 2009 alone, it accounted for 100% GDP and 35 billion in foreign bonds needed refinancing through 2012, corresponding to more than 300% of GDP. Glitnir had the largest rollover risk among the banks in Q4 2008 and Q1 2009 (Figure 41). The significant fall in the banks' new bond issuances combined with the fast pace of lending magnified the medium-term refinancing risks. The banks were gambling that the funding markets would open up again as they had done after the mini crisis of early 2006.

Figure 46: **Potential foreign exchange reserves (without IMF funding)**

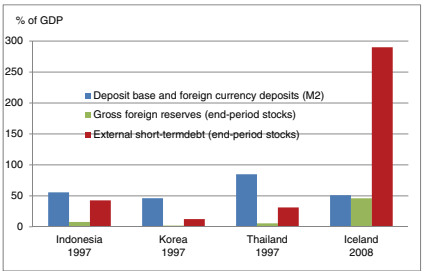


Iceland's foreign exchange reserves and potential funding in foreign currency. In June 2008, the government's debt management office was allowed to borrow up to IKr500 billion to bolster the foreign currency reserves. However, they were unable to borrow at attractive credit spreads. Source: Bloomberg.

The banks' short-term gross external debt rose from around 190% of GDP in Q4 2007 to around 290% of GDP in Q3 2008. In 2008, it reflected deposits in overseas foreign branches at around 117% of the GDP and loans (including repurchase agreements) at 173% of the GDP. The short-term debt was extremely high relative to Iceland's foreign currency reserves, which amounted to around 30% of GDP, as seen in Figure 46.[28] In May 2008, the Central Bank of Iceland entered a currency swap agreement of 1.5 billion with the Central Banks of Denmark, Sweden and Norway which increased the sovereign's potential foreign exchange reserves to around 50% of GDP. A large gap has often occurred in countries prior to systemic banking and currency crises between the short-term external

[28]With the bankruptcy of Landsbanki, the minimum reimbursement limited the potential bill to the Icelandic deposit insurance scheme; the bill was "only" around 4 billion, or 40% of GDP.

Figure 47: **The gap between external short-term debt and foreign currency reserves**



The gross foreign reserve, the external short-term debt and the M2 money supply are shown for Indonesia, Korea, Thailand and Iceland in the year of the systemic banking crisis. Gross foreign exchange reserves are net of forwards and swaps for Thailand. Source: Allen et al (2002) and the Central Bank of Iceland.

debt and foreign exchange reserves. But, as seen from Figure 47, Iceland's "external gap" was enormous. The CBI's foreign currency reserves were far too low to provide liquidity directly in foreign currency and it was clearly not a credible lender of last resort in foreign currency. In reality, the Icelandic banking system was "doomed", as the CBI's requests for currency swaps from the European Central Bank, Bank of England and the US Federal Reserve were rejected.

7. Concluding Remarks

There are many features of the Icelandic banking system leading up to the collapse that are very similar to previous banking crises. The warning signals that have preceded banking crises in the past (Reinhart and Rogoff 2009) were present in Iceland as well. As we have shown, some were more extreme than in any other previous banking crises when measured against the size of the Icelandic economy. It is, however, astonishing that the build-up of the banking system could reach such proportions given the fact that in 2006 the system was already under heavy pressure from markets. Some investors had already then questioned both the business models of Icelandic banks and the huge imbalances in the Icelandic economy. There were several factors that made the continued build-up possible. First, sovereign support, in terms of both promised government support and central bank liquidity provision against dubious collateral, played a key role. Second, the supervision of banks in Iceland was extremely weak and did not react to questionable business practices that the authorities could have detected at the time. These practices, for example, meant that real leverage was much higher than reported. Third, credit ratings were too high, in part because the agencies overestimated the value of the sovereign support and because they relied on accounting reports, in which assets and profitability were inflated because of inadequate loan loss provisioning. Investors, as in many

other cases in the 2007-9 financial crisis, failed to question the high ratings, even when market indicators pointed to much weaker credit quality. High ratings and investors' overreliance on ratings secured access to financing from foreign lenders, in part indirectly from securitisation of Icelandic bank debt through the CDO markets. In defence of the rating agencies, sovereign support has played a key role in saving hundreds of banks in other countries, many of which also had very large risks in the banking system compared to GDP. Also, rating agencies maintain that they are not in the business of verifying accounting reports and other information which passes the regulatory review and due diligence procedures. Iceland is a textbook example of the high risk for government of providing guarantees and not being prepared for extreme events. Sovereign support may help to alleviate a systemic banking crisis, but regulatory forbearance to keep systemically important institutions afloat can have severe consequences as well.

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Conclusion

We show that sovereign credit risk depends critically on fragility in the banking sector in advanced economies. This has been noted previously but little empirical research has been done on the importance of bank fundamentals on sovereign credit risk in a dynamic setting. Sovereign CDS spreads are decomposed into bank and public sector contributions based on a panel econometric analysis of balance sheet variables. We find that fragility in the banking sector has been an important driver of sovereign credit risk especially since 2008 and add additional insights into Acharya, Drechsler, and Schnabl (2011). Longstaff, Pan, Pedersen, and Singleton (2011) find that sovereign risk is primarily driven by global risk premium factors but their econometric analysis exclude bank fundamentals which we argue are important factors for understanding the dynamics of sovereign credit risk in most countries. There exists aggregated balance sheet variables of a national banking system which represent determinants of bank credit risk and contingent liabilities of the government. Traditional public debt variables - such as debt-to-GDP - also influence the dynamics of sovereign credit risk but less so than commonly thought in the literature.

Financial linkages across borders are also priced in the CDS markets beyond what can be explained by exposure to both global and country-specific factors. Financial linkages are measured using BIS consolidated banking statistics and these statistics are combined with CDS spreads to construct a risk-weighted foreign exposure measure for banking systems in 17 countries. We also construct a measure which takes into account the entire asset side of banking systems by combining the information on foreign exposures with information on the relative size and riskiness of exposures to domestic government bonds and to other domestic residents. This measure also helps explaining bank CDS premia. While the first measure is relevant for proving that cross-border financial exposures are reflected in CDS spreads, the second measure is a better candidate for detecting riskiness of a banking system when the risk arises both from exposure to foreign and to domestic factors.

The insights from the two first articles should be combined to get a better understanding of the dynamics of bank and sovereign CDS spreads. The final article is a case study on the banking crisis in Iceland. Investors in Iceland, as in many other cases in the 2007-9 financial crisis, failed to question the high ratings, even when market indicators pointed to much weaker credit quality. High ratings and investors' overreliance on ratings secured Icelandic banks access to financing from foreign lenders, in part indirectly from securitisation of Icelandic bank debt through the CDO markets. Iceland is a textbook example of the high risk for government of providing guarantees and not being prepared for extreme events. Sovereign support may help to alleviate a systemic banking crisis, but regulatory forbearance to keep systemically important institutions afloat can have severe consequences as well.

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