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PhD Dissertation

Macrofinancial Linkages and Crises in Small Open Economies

DEPARTMENT OF ECONOMICS AND BUSINESS ECONOMICS
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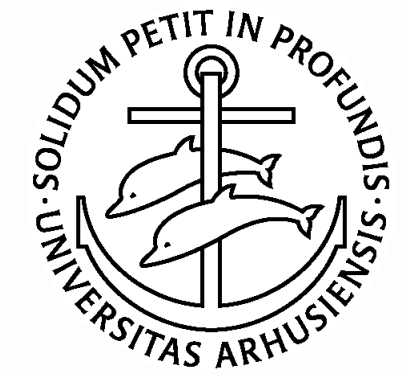

Aarhus BSS, Aarhus University
Department of Economics and Business Economics

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For my children and endless source of inspiration,
Magnús, Ari and Valdís

Preface

This dissertation is the result of my PhD studies at the Department of Economics and Business Economics at Aarhus University, as well as my research activities at the Central Bank of Iceland. I am grateful to both of these institutions for providing excellent research facilities and an enjoyable working environment.

I would like to thank a number of people that have in one way or another participated in my journey towards handing in my dissertation, but I will have to suffice with naming a few. First and foremost, I would like to thank Thórarinn G. Pétursson, Chief Economist and Director of Economics and Monetary Policy at the Central Bank of Iceland, for his inspiration, encouragement, cooperation, and friendship for the last ten years. I also want to thank my supervisor Torben M. Andersen for a pleasant and productive collaboration throughout my PhD studies. Special thanks also go to my colleagues, Karen Áslaug Vignisdóttir, Kristófer Gunnlaugsson, and Bjarni G. Einarsson, for their cooperation on some of the chapters in this dissertation.

During the summer of 2014, I was fortunate to visit Norges Bank to work on my dissertation, and attain valuable insight into their modelling and research activities. I want thank Norges Bank for their kind hospitality, especially Leif, Kjetil, and Martin, and also thank the Central Bank of Iceland for making this visit possible.

At the Department of Economics and Business Economics, Aarhus University, I want to thank my fellow PhD students, special thanks go to Niels, Malene, Laurant, Anne, Anders L, Juan Carlos, Mark, Rune, Anders B, and Kenneth.

Finally, and most importantly, I owe an enormous amount of gratitude to my family and friends. I would never have achieved this without the endless love and support from my three children – Magnús, Ari, and Valdís – and my wife, Anna Margrét.

Tjörvi Ólafsson
Reykjavík, January 2016.

Updated preface

The pre-defence meeting was held on 11 April 2016. I would like to thank the assessment committee consisting of Professor Gunnar Bårdsen, NTNU Trondheim, Associate Professor, Michael Bergman, University of Copenhagen, and Professor Martin Paldam, Aarhus University (chair), for their careful readings of the dissertation, and for constructive and insightful comments and suggestions. Some of the suggestions have been incorporated in the present version of the dissertation, in particular in the last chapter, which has benefitted considerably from further model development.

Tjörvi Ólafsson
Reykjavík, August 2016.

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"Does the existence of uncontrolled financial intermediaries vitiate monetary control?"
James Tobin and William C. Brainard (1963).

Summary

Macrofinancial linkages, i.e. the multifaceted interactions between the real economy and the financial sector, are the pivotal point of interest in this dissertation. As a result, the importance of balance sheets are a reoccurring theme throughout the dissertation, in particular the balance sheets of financial institutions which size and composition provide important insight into their role in fuelling financial boom-bust cycles and crises. Economists, such as James Tobin, who experienced the Great Depression, were well aware of the macroeconomic importance of banks, but many of the lessons of the Great Depression were all but forgotten when the recent global financial crisis struck (Gertler, 1988, Brunnermeier et al., 2013). The aim of this dissertation is to contribute to the rapidly growing post-crisis literature where the lessons of the past are uncovered and new insight provided into the complex linkages between the financial sector and the real economy, with special focus on such interactions in small open economies.

The dissertation consists of five chapters where macrofinancial linkages and crises are analysed using different empirical and theoretical approaches. The first chapter, *Weathering the financial storm: The importance of fundamentals and flexibility*, is co-authored with Thórarinn G. Pétursson (Central Bank of Iceland). The chapter provides a cross-country empirical analysis of the recent global financial crisis.[1] The goal is to try to identify which factors were important in determining the macroeconomic impact of the global crisis, and why some countries experienced a systemic banking and currency crises while others escaped more lightly. We do this by identifying a broad set of potential pre-crisis explanatory variables in a cross-section of forty-six medium-to-high income countries, framed within four possible channels through which the crisis spread out from financial markets through the real economy all over the world: a financial channel, a trade channel, a macro channel and an institutional channel. We find an especially important role for both the macro and financial channels. Thus, the key factors in escaping relatively unscathed seem to have been to maintain sound macroeconomic conditions, i.e. avoid allowing large economic imbalances to build up, and not allowing the banking system to become too large relative to the economy. Exchange rate flexibility also seemed to have helped to reduce the real economy impact and expedite the recovery, but increased the risk of a currency crisis at the same time.

The second chapter, *The long history of financial boom-bust cycles in Iceland - Part I: Financial crises*, is co-authored with Bjarni G. Einarsson, Kristófer Gunnlaugsson, and Thórarinn G. Pétursson (Central Bank of Iceland).[2] The chapter provides an empirical analysis of several financial crises over a period spanning almost one and a half century within a single small open economy. For this purpose, we construct a dataset that includes macroeconomic

[1] A shorter version of this chapter has been published as a book chapter in Beblavý, M., D. Cobham and L. Ódor (2011). *The Euro Area and the Financial Crisis*. Cambridge: Cambridge University Press, 23-58.
[2] This chapter has been published as a Central Bank of Iceland *Working Paper*, no. 68.

variables that reflect the structure of the economy and financial variables that are rarely found in the literature on financial crises due to lack of data availability over sufficiently long periods. This reflects, for instance, data capturing the funding liquidity position of the domestic banking system and its varying degree of reliance on cross-border funding. We identify over twenty instances of financial crises of different types. Recognising that different types of financial crises tend to come in clusters, we also construct a single "multiple financial crisis indicator" using a non-parametric common cycle algorithm. This allows us to identify six major financial crises occurring every fifteen years with each lasting almost four years on average. We analyse the main properties of these crisis episodes and the development of key macroeconomic and financial variables in the run-up to these crises and in the period when they unfold. We find that macrofinancial imbalances played an important role in most of the serious crises, most notably in the last one. However, no single measure provides a robust early-warning signal across all crisis episodes. Our results also suggest an important role of contagion from global financial crises in most of these episodes, with five of the six episodes coinciding with a global financial crisis of some type.

The third chapter, *The long history of financial boom-bust cycles in Iceland – Part II: Financial cycles*, is co-authored with the same authors as the previous one.[3] The chapter analyses the financial cycle in Iceland over a period spanning more than a century. The financial cycle is a promising instrument to expose the role of financial factors in driving macroeconomic dynamics. To capture the financial cycle, Borio (2014) argues that the most parsimonious representation of the cycle is in terms of the interaction between credit and property prices, although other variables may provide useful complementary information. We measure the financial cycle as the low-frequency cyclical co-movement of a set of financial variables including both prices and quantities, conceptually similar to the standard approach for defining the business cycle. We use a broader collection of variables than just credit and house prices to attain additional insight and to expose potentially important small open economy features of the financial cycle and its interaction with the domestic economy. To make this operational, we aggregate the medium-term cycles in our financial variables using a principal component approach. Our findings suggest that indeed there exists a well-defined financial cycle in Iceland that has gradually become more prominent, in particular with increased liberalisation and deepening of the domestic financial system. We find that this financial cycle has played a key role in the country's macroeconomic developments and its financial crises. Furthermore, our results show that the aggregate financial cycle provides a marked improvement over the capacity of individual financial and macroeconomic variables to signal ensuing financial crises, highlighting the importance of the interaction of different financial variables in amplifying financial imbalances. We also find that Iceland is no island in the vast ocean of global high finance, uncovering extremely strong spillover effects from the global financial cycle (proxied by our estimate of the US financial cycle).

[3] This chapter has been published as a Central Bank of Iceland *Working Paper*, no. 72, and is forthcoming in *Revisiting Macro-Financial Linkages: Looking Back and Looking Ahead*, proceeding of the 2016 Bangko Sentral ng Pilipinas International Research Conference 20-21 September 2016. Manilla: Bangko Sentral ng Pilipinas.

Our results are very much in the spirit of the findings of recent papers on the importance of the financial cycle in other industrial countries, such as Claessens et al. (2011, 2012), Drehmann et al. (2012), and Aikman et al. (2015). Our study adds to this growing literature by adding yet another country to the sample of countries studied, a country that has been exposed to numerous financial crises of various types over a period spanning over a century. But also by showing how more detailed data on bank balance sheets can provide further insights into the analysis of the financial cycle and by highlighting important small open economy features of the cycle and its interactions with the domestic economy, including the importance of contagion from the global financial cycle. We conclude the paper with a first attempt at exploring some of the policy questions that our findings raise.

The fourth chapter, *Households' position in the financial crisis in Iceland: Analysis based on a nationwide household-level database*, is co-authored with Karen Áslaug Vignisdóttir (Central Bank of Iceland). The chapter provides an empirical analysis of a single sector's financial position in the run-up to and aftermath of the recent financial crisis using unique micro data.[4] Household debt played a pivotal role in the global financial crisis (cf. Mian and Sufi, 2014) and Icelandic households were among the hardest hit. This chapter aims to portray how the state of households' finances evolved in the period from January 2007 to December 2010. We do this by designing and collecting an extraordinary detailed micro database with information covering nearly all individual loans and households within the country and then utilising the information to build profiles for debt service, outstanding balances, disposable income, living expenses, and housing wealth enabling us to capture the key dynamics of the crisis. Hence our database contains detailed information on each individual loan and household for an entire country's population of indebted households at a time of unexpected adverse shocks in the form of a banking system collapse and a currency crisis of exceptional magnitude.

The main focus of our analysis is to assess how the share of indebted households in financial distress evolved and how it was affected by debt restructuring measures and court decisions. We also analyse the share of indebted homeowners in negative housing equity and those in the highly vulnerable situation of being in distress and negative housing equity simultaneously. An important benefit of our analysis is that it allows us to uncover a more complete account of both the build-up of households' balance sheet weaknesses, the devastating consequences of adverse shocks, and the mitigating effects of debt relief measures.

In the final chapter, *Cross-border credit intermediation and domestic liquidity provision in a small open economy*, a model is developed for a small open economy with a sophisticated credit market set-up where global and domestic liquidity is intermediated to the corporate sector through two financial intermediation processes. On the one hand, investment banks intermediate cross-border credit through interlinked debt contracts to entrepreneurs and, on the other hand, commercial banks intermediate domestic savings to liquidity constrained final good producers. Both processes are needed to facilitate the use and development of key inputs in aggregate production. The economic analysis of the model served to illuminate in a qualitative

[4] This chapter is a short version of an extended Central Bank of Iceland *Working Paper*, no. 59.

manner how the interconnectedness within the financial system and the macrofinancial linkages transmit shocks within the financial sector and across the real economy. This reflects that the richness of the credit market framework allows the model to qualitatively produce procyclical investment bank leverage dynamics, global liquidity spillovers, domestic money market pressures, and multifaceted macrofinancial linkages through which shocks propagate across the two financial intermediation processes, affecting interest rate spreads and balance sheets, as well as the real economy through investment and working capital channels. Hence, the model provides a richer framework than many other financial friction models, including Bernanke et al. (1999) and Hirakata et al. (2009). Empirical motivation for modelling interactions between cross-border and domestic credit developments is also provided in the chapter by utilising banking statistics from the Bank of International Settlements for a sample of fifty countries.

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"Does the existence of uncontrolled financial intermediaries vitiate monetary control?"
James Tobin and William C. Brainard (1963).

Danish Summary (dansk resumé)

Makro-finansielle koblinger (e. macrofinancial linkages), dvs. de mangefacetterede interaktioner mellem den reelle økonomi og den finansielle sektor, er midtpunktet i denne ph.d.-afhandling. Derfor er betydningen af balancer et gennemgående tema i afhandlingen, særligt finansielle institutioners' balancer, hvis omfang og sammensætning giver et væsentligt indblik i deres rolle i forhold til at drive finansielle høj- og lavkonjunktur samt kriser. Økonomer, som James Tobin, der oplevede Depressionen, var godt bevidste om bankernes makroøkonomiske betydning, men mange af Depressionens erfaringer var så godt som glemte, da den sidste globale finansielle krise ramte (Gertler, 1988, Brunnermeier m.fl., 2013). Afhandlingens formål er at bidrage til den hurtigt voksende mængde af litteratur, vedrørende den sidste finansielle krise, hvor fortidens erfaringer bliver afsløret og der gives ny indsigt i de komplekse koblinger mellem den finansielle sektor og den reelle økonomi. Afhandlingen har særligt fokus på disse interaktioner i små åbne økonomier.

Denne ph.d.-afhandling består af fem kapitler, hvor makro-finansielle koblinger og kriser er analyseret ved brug af forskellige empiriske og teoretiske tilgange. Første kapitel, *Weathering the financial storm: The importance of fundamentals and flexibility*, er skrevet i samarbejde med Thórarinn G. Pétursson (Central Bank of Iceland). Kapitlet indeholder en empirisk analyse af den sidste globale finansielle krise for et sæt af lande.[5] Formålet er at forsøge at identificere de faktorer, som havde stor betydning for den globale krises makroøkonomiske påvirkning, samt at forklare, hvorfor nogle lande oplevede en systemisk bankkrise samt valutakrise, mens andre slap lettere fra krisen. Vi identificerer et bredt sæt potentielt forklarende faktorer for 46 medium- til høj-indkomst lande, og dem rammer vi ind i fire forskellige kanaler, som tydeliggør, hvordan krisen spredte sig fra de finansielle markeder, gennem den reelle økonomi og over hele verden. Dvs. en finansiel kanal, en handelskanal, en makrokanal og en institutionel kanal. Vores resultat er, at både den makroøkonomiske og den finansielle kanal spillede en vigtig rolle. Dvs. at de afgørende faktorer for at slippe nogenlunde udenom krisen ser ud til at have været, at beholde sunde makroøkonomiske tilstande (undgå at lade for store økonomiske ubalancer opbygges) samt at undgå at lade banksystemet blive for omfattende i forhold til økonomien. Fleksibilitet i valutakursregimet ser også ud til at have reduceret påvirkningen på den reelle økonomi, men også forøget risikoen for at en valutakurskrise kan opstå.

Andet kapitel, *The long history of financial boom-bust cycles in Iceland - Part I: Financial crises*, er skrevet i samarbejde med Bjarni G. Einarsson, Kristófer Gunnlaugsson og

[5] En kortere version af dette kapitel har allerede været udgivet i bogen Beblavý, M., D. Cobham og L. Ódor (2011). *The Euro Area and the Financial Crisis*. Cambridge: Cambridge University Press, 23-58.

Thórarinn G. Pétursson (Central Bank of Iceland).[6] Kapitlet indeholder en empirisk analyse af adskillige finansielle kriser i en lille åben økonomi over en periode, som dækker næsten halvandet århundrede. Vi sammensætter et datasæt, der indeholder makroøkonomiske variabler, som reflekterer økonomiens struktur, og finansielle variabler, som er sjældne indenfor litteraturen om finansielle kriser på grund af begrænset data tilgængelighed over tilstrækkelige lange perioder. Her henvises fx til variabler, som fanger finansiering positionen for det indlandske banksystem og dets varierende brug af finansiering på tværs af grænser. Vi identificerer over tyve tilfælde af forskellige slags finansielle kriser. I lyset af at der er en stærk tendens til, at finansielle kriser kommer i flok, konstruerer vi en enkel "mangfoldig finansiel krise indikator" ved brug af en ikke-parametrisk fælles konjunktur algoritme (e. non-parametric common cycle algorithm). Dermed kan vi identificere seks mangfoldige finansielle kriser, som gennemsnitligt opstår med femten års mellemrum og varer i fire år. Vi analyserer disse krise-episoders vigtigste egenskaber samt udviklingen i nogle vigtige makroøkomiske og finansielle variabler, både under optakten til kriserne og da de udspiller sig. Vores resultat er, at makro-finansielle ubalancer har spillet en vigtig rolle i de fleste seriøse kriser, særligt i den sidste. Dog er det ikke muligt for en enkel variabel at give et tydeligt advarselssignal for alle episodene. Vores resultater giver også udtryk for stærk afsmitning fra globale finansielle kriser i de fleste af disse episoder, da de i fem ud af seks tilfælde falder sammen med en global krise af en eller anden art.

Tredje kapitel, *The long history of financial boom-bust cycles in Iceland - Part I: Financial cycles*, er skrevet med de samme medforfattere.[7] Kapitlet analyserer finansielle konjunktursvingninger (e. financial cycles) i Island over en periode, som dækker over et århundrede. Den finansielle konjunktursvingning er et lovende værktøj til at afsløre den rolle, som finansielle faktorer spiller i den makroøkonomiske dynamik. Borio (2014) argumenterer for, at den enkleste måde at registrere den finansielle konjunktursvingning på, er ved interaktionen mellem kredit og ejendomspriser, selv om andre variabler kan indeholde komplementerende informationer. Vi måler den finansielle konjunktursvingning med de lavfrekvente sammenfaldende konjunktursvingninger i et sæt af finansielle variabler, som indeholder både priser og kvantiteter, på lignende måde som den normale strategi for at måle økonomiske konjunktursvingninger. Vi bruger et bredere sæt af variabler end kun kredit og boligpriser for at opnå yderligere indblik og for at afsløre potentielle træk i de finansielle konjunktursvingninger, som er særligt betydningsfulde for små åbne økonomier og deres interaktioner med den indenlandske reele økonomi. For at udføre denne strategi i praksis, samler vi de mellem-lange konjunktursvingninger i vores finansielle variabler ved brug af en "principal component analyse". Vores resultater tyder på, at der faktisk eksisterer en vel defineret finansiel konjunktursvingning i Island, som gradvis er blevet mere fremtrædende, særligt efter liberaliseringen og videreudviklingen af det indenlandske finansielle system. Vores resultater viser, at den finansielle konjunktursvingning har spillet en afgørende rolle i landets

[6] Dette kapitel er udkommet som Central Bank of Iceland *Working Paper* nr. 68.

[7] Dette kapitel er udkommet som Central Bank of Iceland *Working Paper* nr. 72 og udkommer i 2017 i *Revisiting Macro-Financial Linkages: Looking Back and Looking Ahead*, proceeding of the 2016 Bangko Sentral ng Pilipinas International Research Conference 20-21 September 2016. Manilla: Bangko Sentral ng Pilipinas

makroøkonomiske udvikling og dets finansielle kriser. Desuden viser vores resultater, at den samlede finansielle konjunktursvingning i langt højere grad end de enkelte variabler kan sende et varsel om kommende finansielle kriser. Det viser, hvor vigtig interaktionen mellem forskellige finansielle variabler er, i at forstærke finansielle ubalancer. Vores analyse viser også tydeligt, at Island ikke er en ø i det globale, finansielle verdenshav, da vores resultater afslører særdeles stærk afsmitning fra den globale, finansielle konjunktursvingning (hvor vi bruger vores estimation af den amerikanske finansielle konjunktursvingning som en stedfortræder (e. proxy) for den globale version).

Vores resultater er i overenstemmelse med resultater i en række undersøgelser af betydningen af den finansielle konjunktursvingning i andre avancerede lande, fx Claessens m.fl. (2011, 2012), Drehmann m.fl. (2012) og Aikman m.fl. (2015). Vores undersøgelse bidrager til denne voksende litteratur ved at tilføje endnu et land og faktisk et land, som har været udsat for en række finansielle kriser over en periode, der dækker over et århundrede. Vores bidrag er også med til at vise, hvordan mere detaljerede informationer om bankerners balancer kan byde på yderligere indblik i en analyse af den finansielle konjunktursvingning, samt at gøre opmærksom på faktorer, som er særligt betydningsfulde for små åbne økonomier. Det dækker både over interaktionen mellem den finansielle konjunktursvingning og den indenlandske økonomi, og hvor vigtig afsmitning fra den globale, finansielle konjunktursvingning er. Vi afslutter med et første forsøg på at undersøge nogle af de implikationer, som vores resultater har for udførelsen af den økonomiske politik.

Fjerde kapitel, *Households' position in the financial crisis in Iceland: Analysis based on a nationwide household-level database*, er skrevet i samarbejde med Karen Áslaug Vignisdóttir (Central Bank of Iceland). Kapitlet indeholder en empirisk analyse af udviklingen i husholdningernes finansielle position under optakten til og udfoldelsen af den sidste finansielle krise. Undersøgelsen bygger på et enestående mikrodatasæt.[8] Husholdningernes gæld spillede en vigtig rolle i den sidste globale, finansielle krise (Mian og Sufi, 2014), og islandske husholdninger var særdeles hårdt ramt. Kapitlets formål er at vise, hvordan husholdningernes finansielle position udviklede sig i perioden fra januar 2007 til december 2010. Dette gør vi ved at designe og samle et særdeles detaljeret mikro-datasæt, som indeholder informationer om næsten alle enkelte lån og husholdninger i landet, og bruge det til at opbygge profiler for gældsbetjening, udestående gæld, disponibel indkomst, nødvendige udgifter, samt boligværdi, som betyder, at vi er i stand til at registrere den vigtigste dynamik i krisen. Dvs., at vores datasæt indeholder detaljeret information om hvert enkelt lån og husholdning (med gæld) for en hel nation, på et tidspunkt hvor et uventet chok kom i form af et systemisk bankkrak og en særdeles dyb valutakurskrise.

I vores analyse fokuserer vi på at vurdere udviklingen i andelen af husholdninger med gæld, som er i finansiel nød (e. financial distress), og hvordan de blev påvirket af gældsomstrukturering og domstolsafgørelser. Vi analyserer også andelen af husejere med gæld og negativ friværdi, samt den særdeles sårbare andel af husejere, som samtidig er i finansiel nød og har negativ friværdi. En vigtig fordel er, at vores analyse gør os i stand til at afsløre på

[8] Dette kapitel er en forkortet version af Central Bank of Iceland Working Paper (No. 59).

en mere omfattende måde, hvordan husholdningernes økonomiske sårbarhed blev opbygget, hvordan de voldsomme påvirkninger af krisen kom frem, og hvor effektive gældomstruktureringen var med til at dæmpe krisen påvirkninger.

I det sidste kapitel, *Cross-border credit intermediation and domestic liquidity provision in a small open economy*, udvikles der en model for en lille åben økonomi med et avanceret kreditmarked hvor global og indenlandsk likviditet er formidlet til virksomheder igennem to financielle formidlingsprocesser. På den ene side, formidler investeringsbanker kredit på tværs af lande via relaterede kreditkontrakter til iværksættere, og på den anden side formidler kommercielle banker indenlandsk opsparing til likviditetsbegrænsede producenter af den endelige vare. Begge processer er nødvendige for at facilitere brugen og udviklingen af nøgle input i produktionen. Den økonomiske analyse af modellen viser på en kvalitativ måde, hvordan relationer indenfor det finansielle system og makro-finansielle koblinger transmitterer chock i det finansielle system og over i den reelle økonomi. Dette afspejler, at den omfangsrige tilgang til kreditmarkedet i modellen gør den i stand til, på en kvalitiativ måde, at fremkalde en procyklisk gældsatsning (e. leverage) hos investeringsbankerne, effekter af ændringer i de globale likviditetsomstændigheder, pres på indenlandske pengemarkeder, og mangefacetterede makro-finansielle koblinger, som chock transmitteres igennem indenfor de to finansielle formidlingsprocesser (via ændringer i rentespændinger og balancer) og over i den reelle økonomi (via investerings- og arbejdskapitalkanaler). Dermed byder modellen på en rigere ramme end mange andre modeller med finansielle imperfektioner, inklusiv Bernanke m.fl. (1999) og Hirakata m.fl. (2009). Desuden fremlægges der en empirisk motivation for at modellere interaktioner mellem kreditformidling på tværs af grænser og indenlandsk kreditgivning. Her bruges der bankstatistik fra Bank of International Settlements fra 50 lande.

CHAPTER 1

WEATHERING THE FINANCIAL STORM

The importance of fundamentals and flexibility[9]

[9] A shorter version of this chapter has been published as a book chapter in Beblavý, M., D. Cobham and L. Ódor (2011). *The Euro Area and the Financial Crisis*. Cambridge: Cambridge University Press, 23-58.

Weathering the financial storm: The importance of fundamentals and flexibility[10]

Thorvardur Tjörvi Ólafsson
Central Bank of Iceland and Aarhus University

Thórarinn G. Pétursson
Central Bank of Iceland

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Abstract

The recent global financial tsunami has had economic consequences that have not been witnessed since the Great Depression. But while some countries suffered a particularly large contraction in economic activity on top of a system-wide banking and currency collapse, others came off relatively lightly. In this paper, we attempt to explain this cross-country variation in post-crisis experience, using a wide variety of pre-crisis explanatory variables in a sample of 46 medium-to-high income countries. We find that domestic macroeconomic imbalances and vulnerabilities were crucial for determining the incidence and severity of the crisis. In particular, we find that the pre-crisis rate of inflation captures factors which are important in explaining the post-crisis experience. Our results also suggest an important role for financial factors. In particular, we find that large banking systems tended to be associated with a deeper and more protracted consumption contraction and a higher risk of a systemic banking or currency crisis. Our results suggest that greater exchange rate flexibility coincided with a smaller and shorter contraction, but at the same time increased the risk of a banking and currency crisis. Countries with exchange rate pegs outside EMU were hit particularly hard, while inflation targeting seemed to mitigate the crisis. Finally, we find some evidence suggesting a role for international real linkages and institutional factors. Our key results are robust to various alterations in the empirical setup and we are able to explain a significant share of the cross-country variation in the depth and duration of the crisis and provide quite sharp predictions of the incidence of banking and currency crises. This suggests that country-specific initial conditions played an important role in determining the economic impact of the crisis and, in particular, that countries with sound fundamentals and flexible economic frameworks were better able to weather the financial storm.

Keywords: Global financial crisis, real economy impact, banking and currency crisis, initial conditions, cross-country analysis

JEL classification: F30, F31, F32, F41, G01

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1. Introduction

The recent global financial tsunami has had economic consequences that have not been witnessed since the Great Depression. But while some countries suffered a particularly large contraction in economic activity on top of a system-wide banking and currency collapse, others came off relatively lightly. This paper aims to explain this difference in cross-country experience by means of a non-structural econometric analysis using a variety of potential pre-crisis explanatory variables in a cross-section of 46 medium-to-high income countries. The severity of the macroeconomic impact is measured in terms of depth and duration of the contraction in both output and consumption. Potential pre-crisis explanatory variables are chosen to reflect propagation channels for the global crisis typically mentioned in the literature, i.e. a financial channel, a trade channel, a macro channel and an institutional channel, although we offer some new variables that have not been included in such analyses before as far as we know. As another contribution to the analysis of the current crisis, we also use cross-country probit regressions to identify the main determinants of the probability of a domestic systemic banking or currency crises during the current crisis.

Our results suggest that the macro channel played a prominent role, as domestic macroeconomic imbalances and vulnerabilities are found crucial for determining the incidence and severity of the crisis. An especially important pre-crisis macroeconomic indicator, which seems to capture factors that are important in explaining the extent of the crisis along many different dimensions, is the rate of inflation in the run up to the crisis. We also find evidence suggesting the importance of financial factors. In particular, we find that large banking systems tended to be associated with a deeper and more protracted consumption contraction and a higher risk of a systemic banking or currency crisis. Our results suggest that greater exchange rate flexibility coincided with a smaller and shorter contraction, but at the same time increased the risk of a banking and currency crisis. We also find that countries with exchange rate pegs outside the European Monetary Union (EMU) were hit particularly hard, while inflation targeting seemed to mitigate the crisis. Finally, we find some evidence suggesting a role for international real linkages and institutional factors.

Several recent papers attempt to explain the cross-country variation in the impact of the global crisis. For example, the findings in Berkmen et al. (2009) suggest that private sector leverage, credit growth, exchange rate flexibility, trade composition, and the fiscal position are important in explaining the cross-country variation in output growth forecast revisions. Lane and Milesi-Ferretti (2010) show that current account deficits, credit and output growth rates, and exposure to trade and production of traded goods are all important predictors for the impact of the crisis on post-crisis output and domestic demand (including consumption) growth rates. Other papers are more sceptical about the importance of initial conditions. Using output growth, stock price and exchange rate changes and revisions to country's credit ratings as crisis indicators, Rose and Spiegel (2009a, b) find that initial conditions have limited predictive power. Only pre-crisis asset price changes and current account deficits are found to be robust crisis predictors, while they find weaker evidence for a role of pre-crisis credit growth. Claessens et al. (2010) are also somewhat sceptical concerning the importance of initial conditions, although they find that credit growth, mortgage debt, asset price appreciation,

current account deficits and trade openness can predict the severity of the output contraction and the post-crisis developments of a financial stress index.

Our results, however, give us reason to be more optimistic on the predictive power of initial conditions in the current crisis, both in terms of explaining a significant share of the cross-country variation in the depth and duration of the crisis and in providing quite sharp predictions of the incidence of banking and currency crises. This therefore suggests that country-specific initial conditions played an important role in determining the economic impact of the crisis and, in particular, that countries with sound fundamentals and flexible economic frameworks were better able to weather the financial storm. We find that these results are robust to various alterations in the empirical setup.

The remainder of the paper is organised as follows. Section 2 discusses the country sample, our crisis measures and the potential explanatory variables used in the analysis. Section 3 presents the empirical results, both with regard to the real economy effects of the crisis and the probability of a banking and currency crisis. Results from some sensitivity analyses are also reported. The section ends with an interpretation of the key results from the paper. Section 4 concludes.

2. The data

2.1. The country sample

This section describes the country sample analysed in this paper. Since the incidence of the crisis and occurrences of domestic banking and currency crises was mainly notable in higher-income countries, the focus is on countries in the upper half of the income spectrum. Thus, the aim is to include countries of similar income levels and size as OECD member countries. Hence, countries with PPP adjusted per capita GDP lower than the poorest OECD member country (Turkey) and PPP adjusted GDP level lower than the smallest OECD member country (Iceland) are excluded.[11] This gives a sample of 64 countries in total from the 227 countries recorded in the *CIA World Factbook* for the period 2006-2008. After eliminating countries with missing data, we are left with 46 countries, i.e. all the current 33 OECD member countries, plus Bulgaria, Croatia, Cyprus, Estonia, Hong Kong, Latvia, Lithuania, Malta, Romania, Russia, South Africa, Taiwan and Thailand.

Thus, the analysis includes all the 27 EU member countries, 6 other European countries and 13 countries outside of Europe. There are 27 industrial countries and 19 emerging market economies, of which 12 are in Central and Eastern Europe. Finally, the analysis includes 7 very small open economies, i.e. countries with populations below 2.5 million.

The sample also includes countries with a wide array of monetary policy frameworks. Thus, there are the 16 EMU countries, 4 countries pegging their currency to the euro within the ERM2 framework and 4 other unilateral exchange rate pegs. There are also 22 countries with a

[11] There is, however, one exception: Malta is included although its GDP level falls just short of Iceland's level, in order to add one observation of a very small, open economy.

floating exchange rate, of which 19 follow an explicit inflation targeting (IT) regime.[12] The analysis therefore includes a country sample with a wide range of monetary frameworks. Table 1 gives an overview of the sample.

Table 1. Country sample

Australia	France	Lithuania	Slovakia
Austria	Germany	Luxembourg	Slovenia
Belgium	Greece	Malta	Spain
Bulgaria	Hong Kong	Mexico	Sweden
Canada	Hungary	Netherlands	Switzerland
Chile	Iceland	New Zealand	Taiwan
Croatia	Ireland	Norway	Thailand
Cyprus	Israel	Poland	Turkey
Czech Republic	Italy	Portugal	United Kingdom
Denmark	Japan	Romania	United States
Estonia	Korea	Russia	
Finland	Latvia	South Africa	

Different country groups

Industrial countries
Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Taiwan, United Kingdom, United States

Emerging market economies
Bulgaria, Chile, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Mexico, Poland, Romania, Russia, South Africa, Slovakia, Slovenia, Thailand, Turkey

Central and Eastern European countries
Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Russia, Slovakia, Slovenia

Very small open economies
Cyprus, Estonia, Iceland, Latvia, Luxembourg, Malta, Slovenia

Inflation targeting countries
Australia, Canada, Chile, Czech Republic, Hungary, Iceland, Israel, Korea, Mexico, New Zealand, Norway, Poland, Romania, South Africa, Sweden, Switzerland, Thailand, Turkey, United Kingdom

Unilateral exchange rate pegs
Bulgaria, Croatia, Denmark, Estonia, Hong Kong, Latvia, Lithuania, Russia,

2.2. Crisis indicators

There is no single, optimal way to measure economic losses due to financial crises and the results from this paper and the others quoted in the Introduction clearly show the need to look at many different crisis indicators. Various measures have therefore been put forward in the literature. Some focus on the fiscal costs of crises (e.g. Hoelscher et al., 2003), which captures the transfer of income due to crisis resolution policies rather than the extent of economic costs of the crisis. While most papers focus on various measures of output losses, this paper also focuses on consumption losses, which we think is important as it is clear that a special feature

[12] Information on monetary regimes is based on the latest IMF de facto classification of exchange rate regimes and monetary policy frameworks from 23 February 2009 (using data from 31 April 2008), but updating the framework in Slovakia to reflect its EMU membership from January 2009.

of this crisis is the unusually prominent role played by the highly indebted household sector in propagating and amplifying the financial shock, with an exceptionally large consumption contraction occurring in many countries. We also focus on the duration of the crisis with the aim to analyse whether the same factors explain the depth and duration of the crisis or whether different factors play a role in explaining the cross-country variation in the speed of recovery.

A common approach to measure the impact of crises on activity is to construct a counterfactual path in the absence of a crisis and measure the loss as the actual deviation from the constructed trend (see e.g. IMF, 1998, Bordo et al., 2001, and Laeven and Valencia, 2008). This approach may overstate both the depth and the duration of the economic impact for countries were the run-up to the crisis is characterised by booms that make activity levels along the constructed trend unsustainable and therefore unattainable even in the absence of a crisis. Furthermore, countries are often heading for recessions before the crisis erupts without an unsustainable boom taking place and in those cases, comparisons of actual activity levels with simple trends may exaggerate the degree of losses due to the crisis (see Hoggarth et al., 2002).

Instead of constructing a counterfactual path for output or consumption in the absence of crisis, we therefore attempt to measure the depth of output (consumption) contraction as the log-difference of seasonally adjusted GDP (consumption) level between peak in the period from 2007Q1 to 2008Q4 and the level in 2009Q4 (our final data observation).[13] Our approach has the advantage of avoiding the need to construct a counterfactual path for GDP or consumption in absence of the crisis. Possible disadvantages are that the peak level in the run up to the crisis can in some cases represent an unsustainable level with an adjustment being unavoidable with or without a financial crisis taking place. Hence, our measure may overstate the economic loss due to the crisis in such cases but on the other hand, we are not extrapolating the growth level in the run up to the crisis which is likely to lead to an even further overstatement. In addition, the analysis ends in 2009Q4 which means that the full impact of the crisis may yet to be fully realised in some of the countries included. Our approach is similar to Cecchetti et al. (2009), who measure the depth of contractions following crises as the peak to trough decline in GDP where the peak is the highest GDP level within one year either side of the crisis date.

Duration of output (consumption) contractions is measured as the number of quarters with negative quarter-on-quarter growth in seasonally adjusted GDP (consumption) from 2008Q3 to 2009Q4. The starting point is chosen to capture the effects of the global crisis once it entered panic mode in September 2008 so as to avoid capturing normal business cycle adjustments unrelated to the crisis. Of course, it can be argued that tighter financial conditions due to the emerging global crisis from mid-2007 played a part in reinforcing the downturn in activity and bringing some advanced economies into recession at an earlier stage but we choose to focus our duration analysis on the impact of the crisis once it entered panic mode in late 2008.[14]

[13] Other measures were also considered, for example the difference between the 2007Q1-2008Q4 peak and the trough in 2008Q4-2009Q4 as well as the difference of the level in 2008Q3 and trough in 2008Q4-2009Q4. The results were very similar (with correlation between the measures all above 0.9).

[14] We also considered other measures of duration with similar results. Two examples were the number of quarters below peak and the number of quarters before two consecutive quarters of positive quarter-on-quarter growth,

We also want to analyse the cross-country variation in the probability of a banking and currency crisis. The incidence of a systemic banking crises is based on an updated version of the database in Laeven and Valencia (2008), generously provided by the authors, in addition to our own elaboration. They categorise 10 countries from our country sample to have experienced a systemic banking crisis during the global crisis: Austria, Belgium, Denmark, Germany, Iceland, Ireland, Luxemburg, the Netherlands, the UK and the US. We add Latvia, Russia and Switzerland (which Laeven and Valencia had as borderline cases at the time of our correspondence) to the list based on significant stress in the banking sectors of these countries and the extent of policy interventions. Hence, there are 13 incidences of systemic banking crises in our country sample.

The definition of currency crises also follows Laeven and Valancia's (2008) using BIS's nominal effective exchange rate indices (see also Frankel and Rose, 1996). We categorise a country as having experienced a currency crisis if the annual average of the nominal effective exchange rate depreciated by 30% or more in 2008-2009 and if this depreciation is also at least a 10 percentage points increase in the rate of depreciation compared to the two year period before. Given this definition, only two countries experienced a currency crisis between 2008 and 2009, Iceland and Korea, and therefore only Iceland experienced a twin crisis (see the Appendix for more detail).[15]

2.3. Potential pre-crisis explanatory variables

We use a range of variables to analyse which factors played a role in determining the depth and duration of the contraction in activity, on one hand, and the probability of banking and currency crisis, on the other. In a broad sense, they can be categorised into four general channels from which the crisis was transmitted throughout the world economy: a financial channel (reflecting factors such as financial structure, development and cross-country linkages), a trade channel (reflecting factors such as trade penetration, trade structure and business cycle synchronisation), a macro channel (reflecting macroeconomic volatility and imbalances), and a channel reflecting institutional factors. To avoid possible endogeneity problems, all of our explanatory variables are measured at pre-crisis values, with most dated in 2006 or 2007 or values obtained from time series data with a cut-off point in 2007 or earlier. These variables and their motivation are further discussed in the following. A detailed list of variable definitions and sources can be found in the Appendix.

Economic structure

The first set of explanatory variables includes two measures of economic size and development, i.e. the PPP-adjusted US dollar value of GDP and the corresponding per capita measure of GDP.

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respectively. The correlation between these two measures, on the one hand, and the measure chosen on the other, is very high (above 0.8) for both output and consumption contractions.

[15] The Icelandic króna depreciated by roughly 48% in total between 2007 and 2009, while the Korean Won fell by 30%. Expanding the criteria to other countries with large depreciations in both 2008 and 2009, would next include Pound Sterling (22% depreciation between 2007 and 2009) and the Romanian lei (19% depreciation between 2007 and 2009). We decided however to stick to the stricter criteria as we find no supporting evidence suggesting that a currency crisis occurred in the UK during 2008-9.

The motivation of including these measures is to capture and control for the effects of size and development on the economic impact of the crisis and the probability of a banking and currency crisis.

The global crisis originated in the advanced economies and spread throughout the globe (see, for example, Claessens et al., 2010), and the evidence in Lane and Milesi-Ferretti (2010) suggests that the advanced economies were hit hardest by the crisis. This is different from many previous crises in the last few decades and reflects the advanced-economy nature of the current crisis. In fact, the experience from previous crises with regard to difference in output contraction in developed countries compared to their less developed counterparts is ambiguous, although large consumption contractions are more frequently observed in the latter group. The frequency of banking and currency crises seems however remarkably similar in developed and developing countries (see Reinhart and Rogoff, 2009, Hoggarth et al., 2002, Dell'Ariccia et al., 2008, and Barro and Ursúa, 2008). To capture these effects, we include per capita GDP. But including per capita income can also serve as a proxy for other economic and institutional factors that are probably positively correlated with greater ability to absorb and respond to adverse shocks. However, as noted by Rose and Spiegel (2009a), this greater perceived ability to respond to crises may lead to greater moral hazard problems, thus leaving richer countries just as vulnerable as their less developed counterparts.

The crisis has also generally been observed as a crisis were smaller countries, which make up a significant share of the country sample used here, have taken a particularly big hit (see the discussion in Rose and Spiegel, 2009a). Many of these small countries had experienced large build-up of imbalances and were also heavily exposed to the collapse of international trade and activity and tightening financial conditions that followed the financial crisis than larger economies. The smaller countries are probably also less able to absorb shocks than the larger ones. Including economic size is meant to capture these effects.

Financial structure and development

As a second set of explanatory variables we include three different measures of financial structure and development. It is often argued that the level of financial sophistication reached during the years prior to the crisis, if not triggering the crisis, at least served to exacerbate it and propagate it around different financial markets and around the world through rising moral hazard problems, opaque and complicated financial instruments and the inability of financial regulators to effectively regulate the financial system.[16] At the same time, deeper financial markets can be more able to absorb shocks and support the recovery from a crisis than thin markets with few financial instruments for hedging risk that may even disappear completely during crisis periods. The question of sign of these effects is therefore ultimately an empirical one.

The first variable we include measures financial deepening, using the ratio of broad money (M2) to GDP, a standard measure of development of financial markets and hence their ability to absorb and diversify risk. A higher degree of financial development could be expected

[16] See, for example, the discussions in Rose and Spiegel (2009a) and the references therein.

to be negatively related to the size and duration of the contraction following the crisis. However, if this measure merely reflects the ability of domestic agents to increase their leverage and hence contribute to greater imbalances through asset price bubbles and unsustainable balance sheets expansion, it could instead indicate greater vulnerability to the crisis and have a positive relation to the size of the crisis' economic impact (cf. Dell'Ariccia et al., 2008, and Claessens et al., 2010).

The second variable measures the size of the domestic banking system as the ratio of total assets of the five largest banks to GDP.[17] Large banking systems, with significant cross-border operations, may have served to exacerbate the transmission of the global crisis to the domestic economy (cf. Davis, 2008, and Claessens et al., 2010). They may also stretch the ability of domestic regulators to deal with such large and complex banking systems and the fiscal resources to support the system in times of need.[18] They may also exacerbate the risk of regulative capture and the moral hazard problem related to the too-big-to-fail problem (cf. Demirguc-Kunt and Serven, 2009). Large banking systems with significant cross-border operations are also more vulnerable to a liquidity crisis, such as happened in the current crisis as the host country's lender-of-last resort abilities were in many cases restricted to the domestic currency of which only a small share of the banking system's assets and liabilities are denominated in (cf. Buiter and Sibert, 2008). Finally, a relatively large banking system can also reflect excessive domestic credit expansion which is likely to contribute to the size of the crisis' economic impact. The size of the banking system may also at the same time reflect the type of financial intermediation prevalent in the economy, i.e. whether bank lending or financial markets are most important for financial intermediation. A higher share of direct lending via credit markets may have been beneficial in the current crisis, for example if bank lending has been more affected than direct financing through the bond market.

Finally, as a third measure of financial development and structure, we use the ratio of stock market capitalisation to GDP. The stock market plays an important role in corporate funding in many economies and is often considered a vital indicator for a country's economic strength.[19] Deep stock markets could be expected to provide an important mean for channelling funds to medium-sized and large firms with productive investment opportunities in a time of crisis and cushion against bank credit retrenchment, in addition to allowing banks to raise new equity in an environment of rapidly deteriorating asset values. However, this is not necessarily

[17] The results were robust to whether the three, four or five of the largest banks were used. We also tried using the largest domestically-owned banks listed in The Banker's *Top 1000 World Bank* list (although the coverage was not as comprehensive as the one we use), which might be more closely related to the probability of banking crisis than our measure, e.g. due to sovereign's contingent liabilities from supporting domestically-owned banks. However, the effects on our results were only minor. An alternative source would be the BIS's consolidated banking statistics for national banking systems but that covers only half of our country sample.

[18] Due to data limitations, we could not include detailed banking system data often mentioned in the discussion as having played a role in the current crisis, such as such as banking interconnectedness, cross-currency funding needs, and currency and maturity mismatches present in banking systems in the run up to the crisis. Another potentially important pre-crisis condition missing due to data limitations is data on interbank turnover, which could capture the serious market disruption that occurred in many countries and differentiate more clearly between different types of market structures that could have played a role in the propagation of the crisis.

[19] Understandably, stock markets play a large role in market-based economies and therefore also reflect the type of financial system in each country.

true in a severe crisis. Declining equity prices can undermine corporate net worth, collateral values and limit their access to credit even further, decelerating investment and activity. Issuance of bank stock can also be problematic in practice in an environment of extensive counterparty risk and asset value uncertainty. Furthermore, high stock market capitalisation can also reflect asset price bubbles and therefore be an indicator of vulnerability rather than financial development (cf. Rose and Spiegel, 2009a, b).

International real linkages

The financial crisis literature stresses the importance of international trade as a key channel of crisis contagion. With the global recession causing a sharp decline in global demand, the spill-over effects can be expected to be greater in countries with closer ties to the global economy (cf. Rose and Spiegel, 2009b, and Levchenko et al., 2009). We therefore add as a third set of explanatory variables five different measures of macroeconomic exposure to external shocks through trade linkages.

To capture the effects of trade intensity, we use a standard measure of trade openness, i.e. the ratio of the sum of exports and imports of goods and services to GDP. As a complimentary measure of these global real linkages, we also add a proxy for the link between the domestic and global business cycles, i.e. the contemporaneous correlation between the domestic and global output gaps, measured as de-trended output (using a Hodrick-Prescott filter).[20] Furthermore, with the global recession dominated by a large contraction in demand for manufacturing goods across the globe, it can also be argued that countries whose exports are dominated by manufacturing goods were hit particularly hard by the crisis. To capture this compositional aspect, we therefore also include as a third variable the share of manufacturing goods in total merchandise exports.

The final two variables capture the possible effects of trade patterns on the transmission of the global shock to the domestic economy through the trade channel. Countries that export only a narrow range of goods or have trade concentrated on few markets may be expected to be more vulnerable to the global crisis than countries who export a broad menu of goods to many markets. These effects are captured by two indices on trade diversification and trade concentration. The first index measures how a country's exports differ from that of the average country. A country with a narrow export base will have a high value of this index. The second index measures the degree of market concentration in trade. A country with exports concentrated on few markets will have a high value of this index.

[20] Note that the simple correlation may overstate the co-movement for the large economies as they represent a significant part of the world output measure used here. To adjust for this, an alternative measure of world output excluding the largest economies individually was constructed (using constant US dollar price data obtained from Eurostat). Hence, to calculate the US correlation, US output was compared to world output excluding the US. A similar adjustment was made for the other five large economies (France, Germany, Italy, Japan, and the UK). This led to a significant reduction in the correlation for Japan, the UK and the US, but had no effect on the measured correlation for the other three countries.

International financial linkages

The fourth set of explanatory variables proxies the extent of financial linkages with the global economy. These variables are included to capture the extent of countries' linkages with the international financial system as the crisis rapidly spread from the main financial centres to other countries across the globe (cf. Davis, 2008, and Rose and Spiegel, 2009b). It can be expected that closer financial links enhanced the spill-over of the financial shock to domestic financial systems. But at the same time, it can also be argued that stronger ties to the global financial system can facilitate a more rapid recovery from the crisis through greater access to global finance once the crisis hit.

To capture the extent of financial exposure to the global economy we use a general measure of financial openness, given as the ratio of the sum of foreign assets and liabilities to GDP, which is commonly used in the literature, cf. Kose et al. (2009). A high ratio implies stronger financial links with the international economy and therefore greater exposure to disruptions in credit markets and international asset price reversals.[21] But as pointed out by Lane and Milesi-Ferretti (2010), a high ratio also reflects a more internationally diversified asset portfolio and can therefore also reflect some valuable diversification in the event of instability in the domestic financial system. The question whether a large international balance sheet is associated with a greater or lesser exposure to the global crisis is therefore ultimately an empirical one.

Closely related is a measure of the extent of capital inflows, given as the ratio of foreign direct investment (FDI) inflows to GDP. The reversibility of capital flows and the risk of sudden stop crises is a recurrent theme in the literature and the idea behind this variable is to capture the vulnerability of countries' risk to reversal due to the global crisis which could increase the economic impact. We follow Forbes and Chinn (2004) and use FDI inflows as a measure of vulnerability to capital inflows reversal. FDI inflows may, however, not be the type of inflows most sensitive to such abrupt reversals but data limitations prevented us from using other measures such as foreign portfolio flows and foreign bank loans, which may be more important drivers of capital flow reversals (see e.g. Tong and Wei, 2009). This view has though been questioned, with Dooley et al. (1994) finding a high level of FDI to be associated with high variability in capital flows and Frankel and Rose (1996) finding currency crashes to be related to episodes where FDI inflows dry up.

The final financial linkages variable is meant to capture the possible positive effects of global financial ties through a 'global security net' and is given as an indicator variable for access to the US Federal Reserve extraordinary US dollar liquidity swap facilities in the autumn of 2008. The Fed provided US dollar liquidity to a selection of central banks to ease pressure that occurred in US dollar short-term wholesale funding markets (McGuire and von Peter, 2009, and Allen and Moessner, 2010).[22] Thus, the indicator variable takes the value of one if the

[21] This ignores the importance of the structure of external assets and liabilities, e.g. the share of equity versus short-term debt in liabilities and the degree of risk in foreign asset holdings.

[22] Swap lines were set up with the European Central Bank and Swiss National Bank in December 2007. These lines were expanded considerably following Lehman Brother's collapse and similar swap lines were set up with the central banks of Japan, UK, Canada, Australia, Sweden, Norway, Denmark, New Zealand, Brazil, Mexico,

domestic central bank had access to this liquidity program in the autumn of 2008 and zero otherwise.[23]

Underlying economic volatility

The fifth set of variables includes three measures of underlying economic volatility. In general, greater economic volatility can reflect frequent or large shocks, or poor success in dealing with shocks, e.g. due to weak institutions and lack of credibility. Greater underlying volatility could therefore be expected to make countries more vulnerable to the global crisis. But greater volatility in some macroeconomic variables can also capture greater flexibility which can foster a swift adjustment to shocks and support a more rapid recovery.

To capture these different dimensions of the link between crisis vulnerability and economic volatility, we first include a variable measuring business cycle volatility using the standard deviation of the output gap (using Hodrick-Prescott de-trended output) for quarterly data over the period from 1985 to 2007.

The second variable is the volatility of the nominal exchange rate, measured as the standard deviation of quarterly nominal effective exchange rates in the period from 1994 to 2007. A more volatile exchange rate can reflect a number of factors, e.g. underlying instability in the economy, high and volatile inflation and monetary policy's lack of credibility and transparency (e.g. Kuttner and Posen, 2000). But a more volatile exchange rate can also reflect greater exchange rate flexibility that can help mitigate economic shocks such as the recent global crisis through improved competitiveness of the domestic economy due to depreciation of the domestic currency.[24]

But not all currency movements serve to facilitate economic adjustment. As a final variable capturing underlying economic volatility, we therefore also add a measure of the non-fundamental part of exchange rate volatility. This measure is obtained from Pétursson (2010), which uses the standard monetary model of exchange rate determination to estimate the lower bound of the variance of a time-varying exchange rate risk premium within a rational-expectations signal extraction approach. The idea behind including this variable is that the more volatile the exchange rate risk premium is, the more vulnerable the economy is to the financial crisis.

Economic imbalances and vulnerabilities

The sixth set of initial conditions includes variables capturing macroeconomic conditions just before the crisis hit. The idea is that the larger the macroeconomic imbalances, the more

Korea and Singapore. These facilities were terminated in early 2010 but some were reintroduced in May 2010 when funding pressures emerged again.

[23] The use of this indicator variable in our analysis may be problematic in the sense that the introduction of swap lines between central banks was part of the crisis response of monetary authorities. Any effects of this variable can therefore reflect a reverse causality instead of being a truly exogenous regressor.

[24] This shock-absorber role of a flexible exchange rate can be limited in practice however if currency mismatches are widespread as non-financial private sector or public sector balance sheets will be dealt a heavy blow by the depreciation, causing widespread repayment problems and write-downs of banks' assets. Data limitations prevent us from including these currency mismatches in the analysis.

vulnerable the economy is to adverse changes in financial and economic conditions. This is a well known characteristic of financial crises. Barajas et al. (2009) show for example that large macroeconomic imbalances tend to increase the probability of a crisis. They also find that the larger the imbalances, the longer the contraction following the crisis tends to be.

As a first measure of macroeconomic imbalances, we include the rate of inflation in 2007. Inflation control is likely to reflect the quality of policy institutions and the extent of demand pressures within each country, both of which can be expected to influence how vulnerable countries are to a global financial crisis and the possibility for policy makers to use monetary stimulus measures to cushion against adverse shocks. Thus, we expect countries with low inflation and better anchored inflation expectations to have greater scope to ease monetary policy more aggressively and be more effective in transforming lower policy rates into lower medium and long-term real rates than countries that were also dealing with inflationary problems by the time the crisis hit.

The second variable we include to capture macroeconomic imbalances is the current account balance as a share of GDP. Countries running current account deficits are more reliant on foreign financing and are therefore more exposed to a sudden stop of capital inflows, which is a frequent characteristic of financial crises (cf. Claessens et al., 2009). The ensuing balance of payment adjustment usually takes the form of rapidly declining domestic demand and currency depreciation. Larger deficits are likely to require larger adjustments in domestic demand and the exchange rate which can, if large enough, lead to a currency and banking crises through the depreciation's effect on domestic balance sheets (cf. Fratzscher, 2009).

Third, we include a variable capturing financial leverage of domestic balance sheets. In general terms, leverage refers to the degree to which assets are funded by debt and is therefore a useful indicator of balance sheet vulnerabilities. Excessive increase in leverage is also typically related to credit and asset price bubbles. At the time the bubbles burst and the crisis hits, private sector balance sheets are therefore particularly exposed to collapsing asset prices and refinancing risks and households and firms need to rapidly unwind their balance sheets which further exacerbates the slowdown of economic activity (see, for example, Rose and Spiegel, 2009a, b, and Claessens et al., 2010). Various leverage measures have been used in the literature, such as the debt-to-equity ratio and the debt-to-assets ratio. However, due to data limitations we follow Berkmen et al. (2009) and measure leverage with the ratio of domestic credit to domestic deposits. This compares total credit to a relatively liquid and limited form of assets but can nevertheless be expected to reflect the degree of balance sheet vulnerability and therefore how fragile countries are to tighter financial conditions and declining asset prices brought upon by the global crisis.

Fourth, we include two variables capturing the underlying vulnerability of the fiscal authority, i.e. fiscal balances and government debt (both measured as a ratio to GDP). These two variables should capture both the ability of the fiscal authority to respond to the crisis through a fiscal stimulus and the transmission of the crisis through the risk premium on government debt with possible repercussions on funding and debt sustainability. Higher debt levels and larger deficits are therefore expected to make countries more vulnerable to the crisis and limit their ability to mitigate its real effects. If debt sustainability is questioned due to high

debt levels or large refinancing needs and causes considerable increase in risk premia, the government may have to introduce strict fiscal austerity measures that will further increase the contraction in domestic demand in the short run.

The final measure introduced to capture macroeconomic imbalances and vulnerabilities is central bank foreign reserves as a ratio to GDP. Low levels of reserves prior to the crisis may suggest limited capability of the monetary authority to support the domestic currency in a situation where the currency comes under pressure, as often occurs in times of financial stress. Limited reserves also reflect restricted ability to provide foreign currency liquidity support to the domestic banking system in times of financial panic as occurred during the US dollar liquidity shortage as previously discussed. Thus, countries with relatively low reserves can be expected to be hit harder by the crisis as their local currency and banking system come under more strain (cf. Fratzscher, 2009, and Obstfeld et al., 2009).[25]

Institutional factors

One can expect countries with stronger institutions to be better able to cope with crisis situations and in general to deliver a more stable macroeconomic environment (cf. Acemoglu et al., 2003), which may also make countries less vulnerable to the crisis as discussed above. The seventh set of initial conditions therefore includes ten variables capturing different institutional aspects.

First, we include four different measures of institutional quality: two separate proxies of governance quality from the World Bank, i.e. one measure of government efficiency and another of regulatory quality; a proxy for the quality of the legal system from the Fraser Institute's Economic Freedom of the World Index; and an index of central bank independence from Fry et al. (2000). We expect countries with a stronger governance structure and a sounder legal system to be more able to reduce the probability of imbalances building up, e.g. through reducing the risk of regulative capture. Greater central bank autonomy can also be argued to reduce the risk of crises by better insulating monetary policy from political pressures and therefore reducing the time-inconsistency problem and supporting firmer anchoring of inflation expectations.

Second, we include four measures of flexibility of markets, based on the Fraser Institute's Economic Freedom of the World Index: indices of regulatory burden in credit and labour markets, respectively, a measure of regulatory burden in overall business transactions, and a summary index of overall economic freedom (the EFW-index). Here, the idea is that greater flexibility and less regulatory burden may help economies recover faster from a crisis. But at the same time, it is often argued that one of the key drivers in the current crisis was 'too much' freedom and lax supervision of private sector behaviour. The possible effects of these institutional features are therefore not necessarily clear a priori.

Finally, we include two indicator variables capturing past crisis experience, i.e. whether countries have experienced systemic banking or currency crises in the previous 30 years. It is

[25] The size of foreign reserves was to a certain extent made less important for countries with access to international swap lines. Of the main international centres, the euro area, the UK, Switzerland and Australia would have depleted a substantial fraction of their foreign currency reserves if they would have had to provide foreign currency liquidity out of their reserves without the use of central bank swap lines according to Allen and Moessner (2010).

often argued that countries that have experienced such crises in the past tend to learn from earlier mistakes and avoid allowing such vulnerabilities to build up again. Past crises experience should therefore reduce the negative effects of the current one. However, it can also be argued that recurring crises reflect weak institutions and lack of credibility, which takes a long time to recuperate. Hence, past crises experience can make countries more vulnerable to rapid loss of confidence once a new crisis hits. The links between past crises experience and the current financial crisis are therefore not obvious.

Monetary and exchange rate regimes

Although no exchange rate peg has been dismantled in the current global crisis, such a collapse has marked many crises in the last two decades, and was often linked to severe banking, corporate or sovereign debt crises. Many commentators have also argued that the exchange rate regime played a key role in the current crisis. Thus, some have argued that euro-membership was crucial in preventing a complete collapse in Ireland, Malta and some of the Southern European countries, while others have argued that the flexible exchange rate regime played a key role in the banking collapse and large contraction in activity experienced in Iceland. Others have, however, highlighted the benefit of a flexible exchange rate for supporting the post-crisis recovery. At the same time, some have argued that the strong focus on inflation control that comes with the inflation targeting regime played an important detrimental role in the build up of vulnerabilities in the run up to the financial crisis in some of the inflation targeting countries, with Iceland a particular case in point.

As a final set of initial conditions, we therefore include indicator variables capturing different monetary and exchange rate regimes within the country sample. The aim of including these regime variables is to analyse to what extent different monetary regimes played a role in the crisis and whether any particular regime reduced or added to the impact of the crisis, after controlling for the initial conditions discussed above.[26] As discussed in the previous section, the country sample includes 16 countries that have a common monetary policy and currency through EMU membership. In addition, there are 8 countries following some type of a unilateral exchange rate peg, either through a currency board or other softer forms of a fixed exchange rate regime. Finally, there are 22 countries with a floating exchange rate, of which 19 follow an explicit IT framework and the others broadly following a framework similar to IT.

2.4. Descriptive statistics

Before turning to the formal analysis of the key determinants of the economic impact from the global crisis, it can be useful to look for patterns in the data that may suggest what to expect from a more formal analysis. Table 2 therefore reports average values for all the variables analysed in the paper for the whole country sample and for various interesting country groups.

[26] For example, Berkmen et al. (2009) find evidence that countries with exchange rate pegs experienced a more severe contraction than countries with more flexible exchange rate regimes. Against this, the results in Coulibaly (2009) indicate that countries within currency unions are less likely to experience a currency crisis.

Table 2. Average values for different country groups

	ALL	IND	EME	CEA	VSOE	EMU	IT	PEG
Depth of output contraction	0.055	0.040	0.076	0.098	0.119	0.051	0.036	0.114
Depth of consump. contract.	0.044	0.011	0.090	**0.125**	0.138	0.016	0.025	**0.162**
Dur. of output contraction	3.739	3.741	3.737	3.583	**4.857**	3.938	3.368	4.250
Dur. of consump. contract.	3.109	2.741	3.632	4.000	3.857	3.000	2.684	**4.625**
Frequency of banking crisis	0.283	0.407	0.105	0.167	0.429	0.375	0.158	0.375
Frequency of currency crisis	0.043	0.074	0.000	0.000	0.143	0.000	0.105	0.000
GDP level	991	1,394	418	347	**30**	681	638	386
GDP per capita	30.0	**38.7**	**17.7**	**19.2**	34.0	35.5	27.1	23.1
Financial deepening	0.933	1.143	0.633	**0.484**	1.509	1.217	0.655	0.879
Size of banking system	2.247	2.949	1.249	**0.635**	4.338	3.180	2.041	1.391
Stock market capitalisation	1.164	1.401	0.828	**0.478**	1.481	1.108	1.143	1.252
Trade openness	0.863	0.764	1.004	1.027	1.112	0.948	0.691	1.190
Output correlation	0.447	0.524	0.337	0.346	0.465	**0.584**	0.383	0.329
Manufacturing exports share	0.666	0.685	0.639	0.682	0.653	**0.770**	0.577	0.592
Trade diversification	0.478	0.458	0.508	0.480	0.570	0.442	0.511	0.511
Trade concentration	0.166	0.156	0.181	0.153	0.229	0.143	0.188	0.171
Financial openness	10.545	15.117	4.047	2.116	42.907	22.834	3.680	5.229
Capital inflows	0.059	0.040	0.087	0.081	0.038	0.043	0.054	0.122
Access to US$ liquidity	0.609	**0.852**	**0.263**	**0.167**	0.571	**1.000**	0.474	**0.125**
Output volatility	0.020	**0.015**	**0.026**	**0.028**	0.023	**0.015**	0.021	**0.028**
Exchange rate variability	0.031	**0.021**	0.044	0.043	**0.019**	**0.014**	0.039	0.045
Exchange rate noise	0.137	**0.097**	**0.209**	0.211	0.177	0.101	0.155	0.203
Inflation rate	0.034	**0.022**	**0.050**	**0.056**	0.044	**0.024**	0.034	0.058
Current account balance	-0.030	0.006	**-0.082**	**-0.101**	-0.124	-0.030	-0.015	-0.085
Size of foreign reserves	0.173	0.110	0.263	0.213	0.311	0.131	0.135	0.300
Financial leverage	1.494	1.607	1.332	1.399	1.842	1.464	1.512	1.662
Fiscal balance	0.010	0.018	0.000	-0.007	0.018	0.000	0.018	0.021
Government debt	0.461	0.555	**0.327**	**0.269**	0.272	0.578	0.415	**0.166**
Government effectiveness	1.176	**1.601**	**0.571**	**0.491**	1.260	1.284	1.215	0.797
Regulatory quality	1.167	**1.448**	**0.767**	**0.781**	1.345	1.324	1.104	1.010
Legal structure	7.299	**7.930**	**6.403**	**6.244**	7.493	7.494	7.285	6.912
Central bank independence	0.831	0.822	0.843	0.858	0.807	0.845	0.806	0.835
Credit market regulation	8.879	8.895	8.855	8.892	9.300	8.766	8.884	9.228
Labour market regulation	5.976	6.085	5.821	5.921	5.994	5.403	6.213	6.212
Business regulation	6.853	**7.460**	**5.991**	**5.964**	6.752	6.824	6.989	6.526
Economic freedom index	7.402	7.648	**7.052**	**6.974**	7.400	7.383	7.403	7.321
Past banking crisis	0.522	0.296	**0.842**	**1.000**	0.429	0.250	0.632	0.750
Past currency crisis	0.435	0.333	0.579	0.500	0.429	0.313	0.526	0.625

The values for the current and past banking and currency crisis and access to US$ liquidity report the average number of countries in each group which experienced a banking and currency crisis. All variables are measured in percentages, except the duration of the output and consumption contractions (in quarters), the GDP level and per capita (in billions and thousand of US dollars respectively), trade diversification, trade concentration and central bank independence (indices between 0 and 1), government effectiveness and regulatory quality (indices between -2.5 and 2.5) and credit market regulation, labour market regulations, business regulation and the economic freedom index (indices between 0 and 10). 'All' denotes the whole country sample, 'IND' denotes the 27 industrial countries, 'EME' denotes the 19 emerging market economies, 'CEA' denotes the 12 central and eastern European countries, 'VSOE' denotes the 7 very small open economies, 'EMU' denotes the 16 EMU countries, 'IT' denotes the 19 inflation targeting countries, and 'PEG' denotes the 8 countries with unilateral exchange rate pegs. Bolded (underlined) numbers denote significant difference between individual group averages and the whole sample average, allowing for different sample variances (a Satterthwaite-Welch *t*-test) using a 5% (10%) critical value.

First, looking at the whole country sample, Table 2 shows that the average output loss in the crisis was 5.5%, whereas the average consumption loss was slightly smaller or 4.4%.[27] This indicates that output contraction in the global crisis during our sample period was less than the 6.3% average for a severe recession in the period 1960-2007 in the 21 OECD country sample analysed in Claessens et al. (2009). The consumption contraction is, on the other hand, much larger in the current crisis than the 1.2% average they report. This large consumption contraction is therefore a key characteristic of the recent global crisis and underlines the importance of looking beyond measures of output losses. The average duration of the contraction period for the whole country sample ranges from roughly 3 quarters for consumption to closer to 4 quarters for output. The average frequency of a systemic banking crisis was 28%, while a currency crisis only occurred in 4% of the sample.[28]

Looking at different country groups, it appears that despite greater incidence of banking system crises, the contraction in economic activity was smaller in the industrial countries than in the less developed countries. This might at first glance seem at conflict with the previous claim that this crisis, unlike most previous financial crises, has hit more developed countries harder than less developed countries. This, however, simply reflects the choice of including only medium-to-high income countries in the analysis. The table also shows that very small open economies and countries with unilateral exchange rate pegs were hit particularly hard. Overall, these descriptive statistics suggest that countries whose real economy suffered the most had significant macroeconomic imbalances prior to the crisis, were highly leveraged, and had less flexible exchange rates, whereas countries which had the greatest banking and currency crises incidences tend to be those who had large and integrated financial systems and large macroeconomic imbalances prior to the crisis. The next section takes a more formal view on these possible links.

3. Empirical results

In this section, we move on to a more formal analysis of the relevance of different initial conditions in explaining the depth and duration of the output and consumption contraction, using cross-country regressions, and the probability of a systemic banking and currency crisis, using cross-country probit regressions. The two following sections report the main results, while Section 3.3 reports some sensitivity analysis. The economic interpretation of the main results is relegated to Section 3.4.

Note that the explanatory variables predate the crisis and the analysis is therefore an attempt to identify what factors were important in predicting the depth and duration of the contraction and whether countries experienced banking or currency crisis or both. Furthermore,

[27] The variation in consumption loss across the country sample is however much larger than the variation in output loss: the standard deviation of consumption loss equals 8.7% while the standard deviation of output loss equals 5.8%.

[28] The real economy crisis indicators are positively correlated, but not overwhelmingly so. The correlations range from 0.39 between the duration of output and consumption loss to 0.78 between the depth of output and consumption loss. The correlations between the banking and currency crises incidences and the correlations of those indicators with the real economy indicators are all well below 0.3.

with the large number of potential explanatory variables included in this study and limited guidance from theory on exactly what factors to include, we necessarily had to undertake some experimentation before arriving at the preferred baseline specifications presented. Thus, all the potential variables were tested but only those found to be statistically significant at conventional levels are retained.

3.1. The real economy effects of the crisis

Tables 3-6 present the main results, i.e. the preferred baseline specifications and the marginal contributions of additional dummy variables for different monetary and exchange rate regimes.

Table 3. Regression results for the depth of the output contraction

	Specification				
	(1)	(2)	(3)	(4)	(5)
Constant	-0.093 (0.002) [0.001]	-0.096 (0.001) [0.001]	-0.086 (0.002) [0.001]	-0.089 (0.002) [0.001]	-0.084 (0.004) [0.002]
Output correlation	0.066 (0.030) [0.023]	0.063 (0.048) [0.021]	0.055 (0.055) [0.042]	0.069 (0.023) [0.016]	0.060 (0.050) [0.044]
Output volatility	2.981 (0.001) [0.002]	3.016 (0.001) [0.001]	2.941 (0.001) [0.001]	2.754 (0.002) [0.003]	2.909 (0.001) [0.002]
Exchange rate variability	-0.905 (0.002) [0.013]	-0.872 (0.003) [0.019]	-0.700 (0.012) [0.047]	-0.866 (0.002) [0.012]	-0.794 (0.007) [0.025]
Inflation rate	1.562 (0.000) [0.002]	1.553 (0.000) [0.002]	1.406 (0.000) [0.002]	1.453 (0.000) [0.003]	1.463 (0.000) [0.003]
Financial leverage	0.023 (0.012) [0.001]	0.024 (0.012) [0.001]	0.028 (0.002) [0.004]	0.022 (0.017) [0.011]	0.025 (0.008) [0.002]
EMU dummy		0.005 (0.661) [0.617]			
Inflation targeting dummy			-0.025 (0.014) [0.022]		
Exchange rate peg dummy				0.019 (0.200) [0.263]	
Floating exchange rate dummy					-0.014 (0.200) [0.148]
R^2	0.726	0.728	0.766	0.738	0.738
Standard error	0.032	0.033	0.030	0.032	0.032

Numbers in parenthesis are *p*-values based on conventional standard errors, while numbers in brackets are *p*-values based on robust (White) standard errors.

As the tables show, we are able to explain up to three-quarters of the cross-country variation in output and consumption loss with a limited set of pre-crisis indicators. Thus, we immediately

obtain the important result that initial conditions have mattered in this crisis, unlike the conclusions drawn by Claessens et al. (2010) and Rose and Spiegel (2009a, b).[29]

Table 4. Regression results for the depth of the consumption contraction

	Specification				
	(1)	(2)	(3)	(4)	(5)
Constant	-0.089	-0.081	-0.081	-0.083	-0.077
	(0.000)	(0.002)	(0.000)	(0.000)	(0.001)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.002]
Size of banking system	0.013	0.013	0.013	0.013	0.013
	(0.004)	(0.003)	(0.002)	(0.001)	(0.004)
	[0.000]	[0.000]	[0.003]	[0.002]	[0.006]
Inflation rate	2.368	2.291	2.403	1.811	2.320
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
	[0.001]	[0.001]	[0.000]	[0.001]	[0.000]
Current account balance	-0.248	-0.261	-0.219	-0.240	-0.222
	(0.009)	(0.007)	(0.017)	(0.003)	(0.017)
	[0.032]	[0.031]	[0.046]	[0.019]	[0.047]
Past banking crisis	0.033	0.029	0.040	0.031	0.039
	(0.094)	(0.148)	(0.039)	(0.064)	(0.046)
	[0.018]	[0.033]	[0.005]	[0.011]	[0.008]
EMU dummy		-0.014			
		(0.415)			
		[0.190]			
Inflation targeting dummy			-0.032		
			(0.034)		
			[0.040]		
Exchange rate peg dummy				0.078	
				(0.000)	
				[0.002]	
Floating exchange rate dummy					-0.027
					(0.081)
					[0.099]
R^2	0.704	0.708	0.735	0.794	0.726
Standard error	0.050	0.050	0.048	0.042	0.049

Numbers in parenthesis are *p*-values based on conventional standard errors, while numbers in brackets are *p*-values based on robust (White) standard errors.

The depth of the contraction

The macro channel seems to have played a particularly important role in determining the depth of the real economy contraction during the current crisis, both through macroeconomic volatility and macroeconomic imbalances in the run up to the crisis. This is especially true for inflation which seems to capture factors that were crucial in determining how large the contraction in output and consumption turned out to be. The baseline results (Specification 1 in Tables 3 and 4) suggest that a 1 percentage point higher inflation prior to the crisis coincided with 1.6 percentage point deeper contraction in output and a 2.4 percentage point deeper

[29] As the tables show, we are only able to explain one-third to half of the cross-country variation in crisis duration. That we are able to explain less of the country variation in crisis duration than crisis depth probably reflects the fact that the variation in duration across countries is smaller than the variation in depth. Again, this may reflect the fact that the crisis is still being played out in some countries and greater variation in the duration of the crisis can be expected once the crisis is fully completed.

contraction in consumption, respectively. The baseline results also suggest that output volatility had a sizeable effect, with a 1 percentage point higher standard deviation in the output gap coinciding with a 3 percentage point larger output contraction. There are also effects from private sector leverage, with a 10 percentage point higher leverage relative to GDP coinciding with a 0.2 percentage point deeper contraction in output. However, a more flexible exchange rate seems to have contributed to a smaller output contraction: a 1 percentage point higher standard deviation of the effective nominal exchange rate coincided with a 0.9 percentage point smaller contraction in output. The macro channel also had an effect on the consumption contraction through the current account balance, with the baseline results in Table 4 implying that a 10 percentage point better current account position leading to the crisis coincided with a 2.5 percentage point smaller consumption contraction.

There is also a role for the trade and financial channels in determining the extent of the output and consumption contractions. Thus, closer ties to the world economy, through a 0.1 higher correlation of the domestic and world business cycle, coincided with a 0.7 percentage point deeper output contraction, while countries with bigger banking systems tended to have a larger consumption contraction: a country with a banking system that was 1 GDP larger than the average country tended to have a 1.3 percentage point larger contraction in consumption. In addition, we find that countries which experienced a systemic banking crisis in the past tended to have a 3.3 percentage point larger consumption contraction compared to countries which have not experienced such a crisis in the past 30 years.

Finally, our results suggest that countries with some kind of unilateral exchange rate pegs were hit particularly hard by the crisis, while we find no significant additional effects for the EMU countries. Countries with floating exchange rates came out better, in particular if they also had a formal inflation target. Thus, countries outside EMU with an exchange rate peg experienced an almost 8 percentage point larger contraction in consumption compared to other countries, while countries with an inflation target tended to have a 2.5 percentage point smaller contraction in output and 3.2 percentage point smaller contraction in consumption.

The duration of the contraction

We also find that the macro channel played a key role in determining the length of the crisis (Specification 1 in Tables 5 and 6). Again, we find that higher inflation in the run up to the crisis is reflected in a more protracted economic impact, with a 1 percentage point higher inflation coinciding with a roughly 0.3 quarters longer contraction in output and 0.5 quarters contraction in consumption, respectively. Higher government debt prior to the crisis also seems to have coincided with a longer output contraction: a 10 percentage point higher debt ratio coincided with a 0.1 quarter longer output contraction. Just as with the depth of the crisis, we find that greater exchange rate variability tended to coincide with a more rapid recovery: a 1 percentage point higher standard deviation in the nominal exchange rate coincided with a 0.3 quarters shorter output contraction and a 0.2 quarters shorter consumption contraction.

Table 5. Regression results for the duration of output contraction

	Specification				
	(1)	(2)	(3)	(4)	(5)
Constant	2.465 (0.000) [0.001]	2.548 (0.000) [0.001]	2.598 (0.000) [0.001]	2.477 (0.000) [0.001]	2.432 (0.002) [0.004]
Trade openness	-0.719 (0.040) [0.048]	-0.740 (0.034) [0.013]	-0.749 (0.037) [0.023]	-0.794 (0.024) [0.014]	-0.717 (0.044) [0.025]
Financial openness	0.030 (0.000) [0.000]	0.033 (0.000) [0.000]	0.029 (0.000) [0.000]	0.029 (0.000) [0.000]	0.030 (0.001) [0.000]
Capital inflows	7.220 (0.002) [0.001]	7.812 (0.001) [0.000]	7.144 (0.003) [0.000]	6.932 (0.003) [0.000]	7.288 (0.003) [0.001]
Exchange rate variability	-26.148 (0.001) [0.001]	-30.116 (0.000) [0.000]	-25.069 (0.002) [0.000]	-25.895 (0.001) [0.000]	-26.507 (0.001) [0.000]
Inflation rate	30.110 (0.001) [0.001]	30.825 (0.001) [0.000]	28.886 (0.002) [0.001]	26.172 (0.005) [0.003]	30.412 (0.002) [0.000]
Government debt	1.382 (0.014) [0.002]	1.587 (0.007) [0.003]	1.313 (0.025) [0.020]	1.561 (0.007) [0.004]	1.389 (0.016) [0.013]
Past currency crisis	0.730 (0.039) [0.061]	0.793 (0.026) [0.036]	0.737 (0.040) [0.061]	0.726 (0.037) [0.061]	0.735 (0.042) [0.055]
EMU dummy		-0.457 (0.205) [0.156]			
Inflation targeting dummy			-0.124 (0.701) [0.682]		
Exchange rate peg dummy				0.649 (0.151) [0.146]	
Floating exchange rate dummy					0.040 (0.905) [0.898]
R^2	0.494	0.515	0.495	0.521	0.494
Standard error	0.930	0.922	0.941	0.916	0.942

Numbers in parenthesis are *p*-values based on conventional standard errors, while numbers in brackets are *p*-values based on robust (White) standard errors.

We also find some role for the financial channel in determining the length of the output contraction. Thus, the more financially open countries tended to experience a somewhat longer contraction, although the effects are quite small. For example, increasing our measure of financial openness by 1 GDP lengthens the output contraction by 0.03 quarters. There are also negative effects from the extent of capital inflows: increasing the ratio of capital inflows to GDP by 10 percentage points, coincides with a 0.7 quarters longer output contraction. However, we find that countries more open to trade experienced a shorter output contraction: increasing the share of trade to GDP by 10 percentage points reduces the duration of the output contraction by 0.1 quarter. The results also indicate that countries which have experienced a currency crisis

in the past tended to have a 0.7 quarters longer output contraction than countries which had not experienced such a crisis in the past 30 years.

Finally, we find no additional effects from the monetary and exchange rate regime dummies, except that countries with unilateral exchange rate pegs experienced a 1 quarter longer consumption contraction than countries with floating exchange rates or peg within EMU.

Table 6. Regression results for the duration of consumption contraction

	Specification				
	(1)	(2)	(3)	(4)	(5)
Constant	2.195 (0.000) [0.000]	2.187 (0.000) [0.000]	2.371 (0.000) [0.000]	2.271 (0.000) [0.000]	2.443 (0.000) [0.000]
Exchange rate variability	-20.742 (0.022) [0.012]	-20.643 (0.035) [0.017]	-16.695 (0.074) [0.033]	-19.857 (0.024) [0.018]	-15.916 (0.093) [0.044]
Inflation rate	46.381 (0.000) [0.000]	46.391 (0.000) [0.000]	43.983 (0.000) [0.000]	37.925 (0.001) [0.000]	42.350 (0.000) [0.000]
EMU dummy		0.012 (0.977) [0.977]			
Inflation targeting dummy			-0.535 (0.175) [0.127]		
Exchange rate peg dummy				1.038 (0.058) [0.017]	
Floating exchange rate dummy					-0.547 (0.168) [0.120]
R^2	0.358	0.358	0.386	0.411	0.386
Standard error	1.237	1.252	1.224	1.198	1.223

Numbers in parenthesis are *p*-values based on conventional standard errors, while numbers in brackets are *p*-values based on robust (White) standard errors.

3.2. The probability of a banking and currency crisis

To estimate the probability of a systemic banking or a currency crisis, we estimate a multivariate ordered probit model. Tables 7-9 report the results for a banking, currency and twin crisis, respectively.[30] Since probit coefficients are difficult to interpret, we also report the marginal effects measured as a one-unit change in the regressors on the probability of a crisis, evaluated

[30] For the banking and currency crisis specifications, the indicator variable takes on the value 1 if a banking (currency) crisis occurs and 0 otherwise. For the twin crisis specification the indicator variable takes on the value 0 if neither a banking nor currency crisis occurs, one if either a banking or currency crisis occurs and 2 if a twin crisis occurs. We also tried separating the banking and currency crisis incidence in the crisis indicator (thus allowing four mutually exclusive outcomes: no crisis, a banking crisis, a currency crisis and a twin crisis). The results obtained are very similar to those reported. In particular, the same variables remain significant in both specifications.

at the mean of the data.[31] However, for binary regressors, we report the effect of a change from 0 to 1 on the probability of a crisis. For the twin crisis specification, we only report the marginal effects on the probability of a banking or currency crisis, as the marginal effects on the probability of a twin crisis were extremely small, with twin crises found to be highly unlikely in this data set. The marginal effects on the probability of no crisis were therefore practically identical (but with opposite signs) to the marginal effects of either a banking or currency crisis. The tables also report some diagnostic statistics, including the success of correctly predicting a crisis (using a cut-off point of 50%) and a measure of improvement over a simple constant-probability model (a probit model which only includes a constant).

Before proceeding to individual results, it is important to note that the estimation results for the currency crisis incidences need to be interpreted with some caution as the frequency of such crises is very low in the country sample (two currency crises and one twin crisis). These results should therefore be thought more of as indicative. This is much less of a problem for the estimation of a banking crisis, where there are 13 crisis observations (28% of the sample).

Determinants of a banking crisis

The variables that significantly predict a systemic banking crisis are reported in Table 7. First, higher GDP per capita is found to have coincided with a higher probability of a banking crisis. This finding simply reflects the fact that a higher frequency of banking failures in the current financial crisis is found among higher income countries and therefore has no obvious structural implication. More interestingly, a larger banking system prior to the crisis is found to have coincided with higher probability of banking crisis. The marginal effect in the baseline specification (Specification 1) suggests that a 10 percentage point increase in the share of banking system assets to GDP increased the probability of a banking crisis by 1 percentage point. Higher pre-crisis inflation is also associated with a higher probability of a banking crisis. The baseline specification suggests that a 1 percentage point higher inflation in the run up to the crisis raised the probability of a banking crisis by 12 percentage points. Finally, a higher level of foreign reserves relative to GDP is found to decrease the probability of a banking crisis, with the marginal effects suggesting that a 10 percentage point higher ratio of reserves to GDP reduced the probability of a banking crisis by almost 5 percentage points.

The table also reports the effects of adding dummy variables for different monetary regimes. The dummy variables for EMU membership and countries with unilateral exchange rate pegs are not found to be significant, but the dummy variables for IT countries and floating exchange rate countries are found significant at the 5% critical level. The results suggest that the probability of a banking crisis was 8 percentage points lower for the IT countries than for non-IT countries, other things equal, while the probability was almost 6 percentage points lower for the floating exchange rate countries in general. Note also that the original regressors remain highly significant although that the marginal effects decline somewhat when the regime dummies are added.

[31] Thus, for single-digit percentages the unit change measures a rise of 1 percentage point, while for double-digit or higher percentages the unit change measures a rise of 10 percentage points. For GDP per capita the unit change measures a rise of 1 thousand US dollars.

Table 7. Probit estimates of the likelihood of a banking crisis

	Specification				
	(1)	(2)	(3)	(4)	(5)
Constant	-18.358 (0.002)	-22.200 (0.002)	-30.500 (0.003)	-19.932 (0.009)	-30.594 (0.007)
log of GDP per capita	4.050 [2.25] (0.006)	4.895 [2.14] (0.005)	6.972 [0.66] (0.003)	4.526 [1.31] (0.019)	7.213 [0.74] (0.013)
Size of banking system	0.645 [0.98] (0.001)	0.694 [0.83] (0.000)	1.108 [0.29] (0.019)	0.604 [0.48] (0.000)	0.802 [0.23] (0.001)
Inflation rate	81.585 [12.41] (0.001)	96.780 [11.63] (0.001)	133.488 [3.46] (0.009)	78.020 [6.19] (0.007)	126.755 [3.58] (0.004)
Size of foreign reserves	-3.214 [-4.89] (0.053)	-2.770 [-3.33] (0.083)	-4.772 [-1.24] (0.017)	-6.001 [-4.76] (0.065)	-4.501 [-1.27] (0.016)
EMU dummy		0.586 [8.18] (0.414)			
Inflation targeting dummy			-2.276 [-8.10] (0.018)		
Exchange rate peg dummy				1.684 [32.39] (0.126)	
Floating exchange rate dummy					-1.538 [-5.78] (0.047)
Log-likelihood	-11.706	-11.437	-8.592	-10.491	-10.031
Pseudo R^2	0.573	0.582	0.686	0.617	0.634
Cases correct	37	39	41	41	39
Percent gain	0.308	0.462	0.615	0.615	0.462

Numbers in brackets are marginal effects of a one-unit change in the explanatory variables on the probability of a banking crisis (× 100 to convert into percentages), evaluated at the mean of the data, except when reporting the marginal effects for the dummy variables, in which case the numbers are the effects of a change from 0 to 1 on the probability of a banking crisis. Numbers in parenthesis are *p*-values based on robust (Hubert-White) standard errors. Cases correct show the number of cases predicted correctly by each model, using a cut-off point of 50%, while the percent gain shows the percent of incorrect cases predicted by a simple constant-probability specification corrected by each model.

Determinants of a currency crisis

Table 8 reports the variables that significantly predict a currency crisis. It should, however, be noted from the outset that with only two observations of currency crisis, these results by and large pick up the difference between Iceland and Korea, on one hand, and the whole country sample, on the other. Sweeping conclusions cannot therefore be drawn. That said, we again find that GDP per capita needs to be included as a control variable. A larger banking system is also found to have coincided with a higher probability of a currency crisis. There are also positive effects on the probability of a currency crisis from greater exchange rate flexibility and higher fiscal deficits prior to the crisis. However, better institutions, as reflected in greater central bank independence and fewer incidences of past banking crises are found to have coincided with a lower probability of a currency crisis in the current crisis. With the probability of currency crisis

extremely low, the marginal effects of changes in the explanatory variables are found to be very small, as shown in Table 8. Furthermore, note that we are not able to add the regime dummies as the maximum likelihood procedure breaks down with the probit model perfectly predicting the binary variable.

Table 8. Probit estimates of the likelihood of a currency crisis

	Parameter estimate	Marginal effect	*p*-value
Constant	-20.558	-	0.004
log of GDP per capita	5.471	2.10E-7	0.002
Size of banking system	1.040	1.10E-7	0.005
Exchange rate variability	62.843	6.63E-7	0.003
Fiscal balances	-40.440	-4.27E-7	0.005
Central bank independence	-13.353	-1.41E-7	0.016
Past banking crisis	7.402	0.89	0.003
Log-likelihood	-3.075		
Pseudo R^2	0.626		
Cases correct	45		
Percent gain	0.500		

The table reports the marginal effects of a one-unit change in the explanatory variables on the probability of a currency crisis (× 100 to convert into percentages), evaluated at the mean of the data, except when reporting the marginal effects for 'Past banking crisis', in which case the number is the effect of a change from 0 to 1 on the probability of a currency crisis. The *p*-values are based on robust (Hubert-White) standard errors. Cases correct show the number of cases predicted correctly by the model, using a cut-off point of 50%, while the percent gain shows the percent of incorrect cases predicted by a simple constant-probability specification corrected by the model.

Determinants of a twin crisis

Finally, Table 9 reports the significant variables predicting a twin crisis. As for the previous two crisis variables, GDP per capita is needed as a control variable. The size of the banking system and the level of inflation are also found to have positively coincided with a twin crisis, with similar marginal effects as found for the baseline specification on the probability of a banking crisis in Table 7. Greater exchange rate variability and higher fiscal deficits are also found to have coincided with higher probability of a currency crisis, similar to the findings in Table 8, with a 1 percentage point increase in these variables raising the probability of a banking or currency crisis by 6 and 3 percentage points, respectively. However, a 10 percentage point increase in financial deepening is found to have reduced the probability of a banking or currency crisis by roughly 1 percentage point. Finally, none of the regime dummies are found to be significant.

Table 9. Probit estimates of the likelihood of a banking, currency or twin crisis

	Specification				
	(1)	(2)	(3)	(4)	(5)
log of GDP per capita	5.490 [4.38] (0.000)	5.458 [4.40] (0.000)	5.696 [4.22] (0.001)	6.103 [4.12] (0.001)	5.822 [4.21] (0.003)
Financial deepening	-0.471 [-1.03] (0.023)	-0.463 [-1.02] (0.038)	-0.556 [-1.14] (0.055)	-0.633 [-1.17] (0.029)	-0.558 [-1.11] (0.059)
Size of banking system	0.545 [1.19] (0.002)	0.544 [1.20] (0.002)	0.554 [1.13] (0.006)	0.506 [0.94] (0.001)	0.542 [1.07] (0.006)
Exchange rate variability	29.566 [6.47] (0.017)	29.093 [6.43] (0.023)	31.827 [6.47] (0.014)	31.700 [5.87] (0.013)	32.462 [6.44] (0.017)
Inflation rate	56.909 [12.45] (0.014)	56.163 [12.41] (0.020)	56.876 [11.54] (0.023)	46.700 [8.65] (0.015)	56.964 [11.29] (0.032)
Fiscal balances	-14.814 [-3.24] (0.010)	-15.154 [-3.35] (0.006)	-14.233 [-2.89] (0.010)	-20.175 [-3.74] (0.008)	-14.995 [-2.97] (0.010)
Threshold level 1	22.633 (0.000)	22.447 (0.000)	23.188 (0.001)	24.449 (0.000)	23.560 (0.002)
Threshold level 2	27.539 (0.000)	27.319 (0.000)	28.100 (0.001)	28.860 (0.000)	28.515 (0.002)
EMU dummy		-0.097 [-2.11] (0.883)			
Inflation targeting dummy			-0.505 [-9.84] (0.495)		
Exchange rate peg dummy				1.291 [36.00] (0.151)	
Floating exchange rate dummy					-0.448 [-8.81] (0.527)
Log-likelihood	-14.185	-14.176	-13.831	-13.294	-13.907
Pseudo R^2	0.555	0.555	0.566	0.583	0.564
Cases correct	39	39	40	41	40
Percent gain	0.500	0.500	0.571	0.643	0.571

Numbers in brackets are marginal effects of a one-unit change in the explanatory variables on the probability of a banking or a currency crisis (× 100 to convert into percentages), evaluated at the mean of the data, except when reporting the marginal effects for the dummy variables, in which case the numbers are the effects of a change from 0 to 1 on the probability of a banking or a crisis. The marginal effects on the probability of a twin crisis are extremely small and therefore not reported. The marginal effects on the probability of no crisis are therefore practically the same as the marginal effects on the probability of either banking or currency crisis, but with reversed signs. Numbers in parenthesis are *p*-values based on robust (Hubert-White) standard errors. Cases correct show the number of cases predicted correctly by each model, using a cut-off point of 50%, while the percent gain shows the percent of incorrect cases predicted by a simple constant-probability specification corrected by each model.

Estimated banking and currency crisis probabilities

The probit models are quite successful in predicting the banking and currency crises correctly. The three baseline specifications (Specifications 1) predict the incidences correctly in 80-98% of the cases (using a cut-off point of 50%), sometimes with some improvements when the regime dummies are added. The baseline specifications also show a significant improvement over a simple constant-probability alternative, with the percentage gain ranging from 30-50%. The models are also generally able to make a sharp distinction between crisis and non-crisis countries: the crisis probabilities tend to lie above 90% or below 10% in 59-91% of the cases and above 80% and below 20% in 76-96% of the cases.

The banking crisis regression in Table 7 correctly predicts a banking crisis in Belgium, Iceland, Ireland, Latvia, Luxembourg, the Netherlands and Switzerland with close to 100% probability and in the UK with a slightly lower probability, or 70%. The model predicts a banking crisis in Austria and the US with just short of 50% probability, and assigns an even lower probability to a banking crisis in Denmark (34%), Russia, (23%) and Germany (18%). There are also a few cases of false warnings: the model predicts a banking crisis in Sweden with a 70% probability and a banking crisis in Estonia, Hungary and Norway with a probability just above 50%.[32] A somewhat smaller probability is assigned to a crisis in Spain, or 31%.[33] However, as Figure 3(a) shows, only four of the incorrect predictions are larger than two standard errors.

The currency crisis regression in Table 8 predicts a currency crisis in Iceland with a 93% probability, but fails to predict the currency crisis in Korea (only 15% probability). It also incorrectly assigns quite a high probability of a currency crisis in Israel (43%) and Bulgaria (23%) – but only the prediction errors for Korea and Israel are found to be significant at the 95% critical level (Figure 3(b)).

Finally, the probit specification for the twin crisis in Table 9 is better able to predict the banking crisis in Austria, Russia, the UK and the US than the banking crisis specification in Table 7 but seems less certain about the crisis in Latvia (Figure 4). For other countries, the crisis predictions are very similar to those from the banking crisis specification. Of the false banking crisis predictions, the high probabilities of a banking crisis in Hungary and Sweden remain, but the probabilities for Estonia, Norway and Spain decline substantially. Against this, the model incorrectly predicts a crisis in Bulgaria with a 54% probability. Furthermore, the false currency crisis in Israel has disappeared. Finally, the model predicts the twin crisis in Iceland correctly, with a 79% probability.

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[32] Allen and Moessner (2010) doubt that Sweden and Denmark could have provided effective support to their banks in the absence of swap lines from the Fed after the Lehman Brother's failure and from the ECB a little later as the necessary provision of foreign currency liquidity would have used up most of their reserves. Swedish banks in Estonia received support from their mother companies and the Swedish Riksbank set up swap lines with their Estonian counterpart. Hungary did turn to the IMF and the European Union for considerable support and the European Central Bank and Swiss National Bank set up swap facilities with the Hungarian central bank to provide commercial banks within the country with access to euro and Swiss franc liquidity.

[33] Problems among Spanish saving banks became clear in May 2010, outside of our sample period, when the Bank of Spain seized control of CajaSur and merger plans among the remaining *Cajas* intensified.

Table 10. Robustness analysis: adding different country group dummies

	Output loss equation	Consump-tion loss equation	Output duration equation	Consump-tion duration equation	Banking crisis equation	Twin crisis equation
OECD	-0.025	-0.014	-0.548	-0.360	1.125	0.164
	(0.167)	(0.261)	(0.165)	(0.230)	(0.390)	(0.834)
EU	-0.003	0.015	0.078	0.037	-0.160	-0.550
	(0.848)	(0.107)	(0.834)	(0.911)	(0.801)	(0.402)
EME	-0.013	-0.004	0.074	0.067	-5.912	-6.796
	(0.452)	(0.727)	(0.868)	(0.864)	(0.067)	(0.103)
CEA	0.046	0.011	0.235	-0.179	-3.657	-0.778
	(0.118)	(0.477)	(0.678)	(0.706)	(0.069)	(0.382)
VSOE	0.042	0.026	0.000	0.286	-4.014	0.525
	(0.190)	(0.060)	(0.976)	(0.467)	(0.006)	(0.431)
High income countries	-0.011	-0.000	-0.467	-0.584	-0.797	-2.093
	(0.216)	(0.985)	(0.181)	(0.181)	(0.317)	(0.031)
Mid-income countries	0.013	-0.004	0.361	0.350	-0.129	1.092
	(0.204)	(0.809)	(0.290)	(0.360)	(0.833)	(0.197)
Low income countries	-0.011	0.007	0.016	0.313	3.151	1.229
	(0.611)	(0.772)	(0.976)	(0.581)	(0.009)	(0.425)
Large countries	0.016	0.008	0.239	0.164	1.596	1.249
	(0.145)	(0.661)	(0.584)	(0.721)	(0.045)	(0.041)
Mid-sized countries	-0.027	-0.030	-0.298	-0.475	-0.926	-0.928
	(0.008)	(0.027)	(0.388)	(0.204)	(0.174)	(0.124)
Small countries	0.025	0.043	0.248	0.486	-1.152	-0.317
	(0.011)	(0.043)	(0.543)	(0.173)	(0.231)	(0.621)
Africa	-0.052	-0.065	-0.850	1.163	-	-3.330
	(0.000)	(0.011)	(0.000)	(0.000)		(0.005)
Asia	0.006	0.022	-0.152	0.258	-	3.427
	(0.789)	(0.165)	(0.777)	(0.598)		(0.024)
Europe	0.010	0.005	0.146	0.000	-0.010	-0.548
	(0.374)	(0.736)	(0.697)	(0.999)	(0.990)	(0.519)
Latin America	-0.018	-0.028	0.453	0.442	-	-4.191
	(0.249)	(0.542)	(0.142)	(0.522)		(0.001)
North America	-0.001	-0.003	-0.136	-0.383	0.745	-0.610
	(0.953)	(0.872)	(0.774)	(0.217)	(0.441)	(0.464)
Oceania	-0.012	-0.011	-0.232	-1.210	-	-7.567
	(0.434)	(0.617)	(0.864)	(0.296)		(0.000)

The table reports estimated parameters for country group dummy variables in each equation from Specification 1 in Tables 3-9, except for the probit model for currency crisis, where identification problems made it impossible to add country group dummies to the model specification. The country groups are explained in Table 2. 'High income countries' represents the upper GDP per capita quartile of the country sample, 'Mid-income countries' represents the two mid GDP per capita quartiles of the country sample, while 'Low income countries' represents the low GDP per capita quartile of the country sample. Different size groups are defined identically. Numbers in parenthesis are *p*-values based on robust standard errors.

3.3. Robustness tests

As a first robustness test, we try retaining the GDP level and GDP per capita as controls in all the baseline regressions in Tables 3-9, capturing the greater crisis impact in higher income countries and smaller countries, as discussed before. In all cases are these variables non-significant (except in the banking and currency crisis equations, were the significant GDP per capita variable is already included) and in no case does the inference on other explanatory variables change. With a relatively large number of small countries in our sample, it could also be the case that the small countries are given unduly large weights in the empirical findings, thus somewhat blurring how the global crisis spread from its epicentre in the US to other large countries. To test for the sensitivity of our results to a possible small-country bias we therefore re-estimate all the regressions using weighted least squares, with the log of GDP as a scaling variable. However, we find that our results are insensitive to this and in no case is the inference altered.

We also try adding different country group dummy variables to the baseline regressions, reported in Table 10. First, we add country dummy variables for OECD countries, EU countries, emerging market countries, the central and eastern European countries, and the very small open economies. As Table 10 shows, these dummy variables are found insignificant in almost all cases. Furthermore, the addition of these variables is not found to alter the statistical properties of the other explanatory variables.[34]

Next, we split the country group into income and size quartiles using GDP per capita and GDP levels, respectively, and add dummy variables defining different income and size groups to the baseline regressions. Table 10 reports the estimated coefficients on the dummy variables. The income and size dummies are found to be insignificant in almost all cases, and in all but two cases is the significance of the explanatory variables unaltered: the current account balance becomes insignificant in the consumption-loss equation when a country dummy for small countries is added and foreign reserves become insignificant in the banking-crisis equation when a country dummy for low income countries is added.

The final part of Table 10 adds continental dummies to the baseline regressions. The African dummy variable is found to be highly significant in all the regressions, but as South Africa is the only African country in the sample, this dummy variable simply serves as a dummy variable for that country. The other continental dummies are found to be insignificant in most other cases, and in all cases are the results from the baseline regressions unaffected.

As a final robustness test, we re-estimate all the baseline regressions dropping one observation at a time and check whether the explanatory variables continue to be significant. We find that they do in almost all cases. There are, however, four exceptions: dropping Hong Kong from the sample makes foreign reserves insignificant in the bank-crisis equation, dropping Luxembourg from the sample makes financial openness insignificant in the output-

[34] Following Lane and Milesi-Ferretti (2010), we also try adding a country group for small countries with large financial centres (defined as countries with financial openness ratio exceeding 800%), which have been hit particularly hard by this crisis. These 10 countries are Belgium, Cyprus, Hong Kong, Iceland, Ireland, Luxembourg, Malta, the Netherlands, Switzerland, and the UK. In no case is this dummy variable found significant, nor does it alter the inference on the other explanatory variables.

duration equation and financial deepening insignificant in the twin-crisis equation, and dropping Norway from the sample makes fiscal balances insignificant in the twin-crisis equation. We also do a similar sensitivity analysis for the regime dummies. The inference on the IT and exchange rate peg dummies is found to be robust to variations in the country sample, whereas the dummy variable for floating exchange rate countries become marginally insignificant in the consumption-loss equation in some cases, and three other cases give a *p*-value close to 0.2 (Russia, South Africa and Turkey). However, leaving out Iceland in the consumption-loss equation results in a highly significant dummy variable for floating exchange rate countries.

3.4. Interpreting the results

In this section we offer an interpretation of what we think are the key results of our paper. Before proceeding it should, however, be emphasised that this paper is not a general analysis of financial, banking or currency crises, but focuses only on the current crisis and its consequences. Therefore, some of the results found in this paper may be specific to this crisis and need not generalise to others. However, there are some interesting results worth highlighting that may be relevant to understanding not only this crisis but financial crises in general, and have some important policy implications.

One of the most striking results we obtain is how strong the effects of inflation just prior to the crisis seems to be, with the inflationary-effect generally the most significant effect of all the initial conditions. Thus, countries with higher inflation tended to experience a deeper and more protracted contraction, and were more vulnerable to the risk of a systemic banking and currency crises. We believe that this inflationary-effect captures the degree of macroeconomic imbalances in the run up to the crisis and policy constraints that countries faced in their response to the crisis. The scope for monetary policy easing and its transmission to the real economy is affected by current inflationary pressures and to what degree inflation expectations are sufficiently anchored. Countries with higher inflation in the run up to the crisis were therefore likely to be in a less favourable position to use monetary stimulus measures to counteract the economic impact of the global crisis than countries were inflation was already well anchored.[35]

Looking at other measures of economic imbalances and vulnerabilities, the general story emerges that the greater the macroeconomic imbalances in the run up to the crisis, the more painful it turned out to be. Higher private sector leverage, larger current account deficits,[36] more

[35] This finding on the importance of inflation may to a certain extent be interpreted as being at odds with the recent recommendation of the IMF's chief economist, Olivier Blanchard, and his co-authors (2010) who suggest that higher inflation targets, and therefore higher average inflation, makes crisis responses easier by increasing the room for lowering interest rates to counteract the crisis. Our results suggest that higher inflation in the run up to this crisis made it worse, not better, and these results seem robust to different crisis measures and various robustness checks. In particular, it is worth emphasising that they are not driven by few observations of extremely high inflation (the highest observed inflation in our sample is 10% and the average inflation rate across the country sample is 3.4%).

[36] Interestingly, we find that higher current account deficits tend to exacerbate the consumption contraction but have no effects on the output contraction. This seems logical as higher current account deficits call for an adjustment in domestic demand, with a net export adjustment (especially through import compression) reducing the effect on output.

output volatility, or lower foreign reserves all seemed to contribute in one way or another to a deeper contraction and increased risk of a systemic banking crisis. It is interesting to note that the level of foreign reserves did not have any significant effect on the probability of a currency crisis. Instead we find that lower reserves increased the risk of a banking crisis, which may reflect the interaction between very large banking systems and limited ability of the domestic monetary authority to provide foreign currency liquidity services, often pointed out as a major vulnerability during the current crisis. We note, however that the effect of reserves is not robust to the exclusion of Hong Kong from the country sample and that the interaction between access to central bank swap lines and actual reserve holdings can be difficult to control for.

We also find that the fiscal position played a role in this crisis. Thus, we find that greater government debt in the run up to the crisis coincided with a longer output contraction. This seems logical: the worse the debt position of the government, the less the fiscal space for supporting the recovery after the crisis hit. We also find that larger fiscal deficits prior to the crisis tended to increase the risk of a banking or currency crisis. Again, this seems logical: larger deficits tend to go hand in hand with higher risk premia which would presumably rise sharply once the crisis hit and exacerbate uncertainty that could eventually lead to panic and a full blown currency crisis. The significance of this effect depends, however, on the inclusion of Norway in the country sample.

Furthermore, we also find that the size of the banking system played an important role. First, we find that the larger the banking system, the larger the consumption contraction tended to be. This is consistent with the interpretation that once the crisis hit, governments needing to support large banking systems had less fiscal space to support domestic demand. It can also reflect increased households' dependence on credit for consumption financing in countries with larger banking systems. We also find that larger banking systems increased the probability of a banking and currency crises. However, our results suggest that a more developed financial system reduced the risk of a banking or currency crisis. This last finding, however, is not robust to excluding Luxembourg from the country sample.

We find mixed results on whether stronger ties to the global economy through trade and finance exacerbated the crisis or not. Thus, stronger trade and financial linkages coincided with a larger and longer output contraction, as the global financial panic and the sudden reversal of capital inflows and sharp contraction in global demand that followed hit those countries especially hard, which relied more heavily on these capital flows or were more open to trade. The significant effect of financial openness on the persistence of the output contraction is, however, very much driven by the extremely large external balance sheet of Luxembourg and excluding Luxembourg from the sample leaves this effect insignificant. Thus, any interpretation of a causal link between financial openness and exposure to the global crisis will need to take account of the sensitivity to this large outlier. The significance of capital inflows however remains when Luxembourg is excluded from the sample. At the same time, we find that countries more open to trade recovered faster from the crisis. This probably reflects the fact that these countries benefitted more by the relatively rapid reversal in global demand (especially in Asia) in 2009 than countries less open to trade.

We also find some mixed results on the role of exchange rate flexibility. While our results suggest that greater exchange rate flexibility reduced both the depth and the duration of the contraction, it increased the risk of a banking or currency crisis. Thus, exchange rate flexibility facilitated the economic adjustment to the crisis through greater relative price flexibility, but at the same time made countries more vulnerable to a banking or currency crisis. Flexibility was thus a double-edged sword in this sense. This is further corroborated by the effects of different unilateral exchange rate regime dummies: we find that countries with unilateral exchange rate pegs had a particularly large and protracted consumption contraction. This, however, only applies to countries with exchange rate pegs outside a monetary union: we find no evidence that EMU membership led to additional negative effects of the crisis comparable to the effects we find for the unilateral peg countries.[37] At the same time we find that countries with a formal inflation target (and sometimes floating exchange rates in general) tended to have a smaller contraction and were less likely to have a systemic banking crisis.[38]

We also find that countries that have experienced a banking or currency crisis in the past tended to have a deeper and longer consumption contraction and were more likely to suffer a currency crisis. No evidence is found that suggests that past crises experience reduced the probability of a banking system crisis in the current crisis. Thus, learning from past crises does not seem to have benefitted in the current crisis or, at least, seems to have been outweighed by the possible negative effects of past crises experience on credibility of current institutions to deal with the crisis. The importance of sound institutions is also suggested by our finding that greater central bank independence reduced the probability of a currency crisis. Other institutional factors are not found significant, however.

Our results indicate a non-significant role for some variables which have been widely discussed as having played an important role in determining the economic impact of the crisis. Especially, it is noteworthy that we find no role for access to the Fed's dollar liquidity facility for the likelihood of a systemic banking crisis. The establishment of central bank swap lines has been widely praised for having effectively relieved US dollar liquidity stresses in money and FX swap markets and hindering global financial instability from becoming much more serious (see e.g. Allen and Moessner, 2010). Our results should however not be interpreted as rejecting the importance of these international facilities as we cannot measure what the outcome would have been in their absence. We could also be overlooking the role played by the access to central bank swap lines in limiting the scale of a systemic banking crisis as our measurement of banking crises does not make any distinction between a banking crisis and a total banking system collapse. Neither do we find a role for our three measures of trade structure (the share of manufacturing exports, trade diversification and trade concentration), which might emerge if the country sample would be expanded to include more developing countries.

[37] Furthermore, we do not analyse possible effects from EMU membership on the probability of sovereign debt crisis. Effects from the turmoil in 2010 surrounding the sustainability of sovereign debt of countries within the euro area lie outside of our sample period.

[38] This is consistent with Carvalho Filho (2010), who also finds beneficial effects of inflation targeting during the current crisis.

While our finding that exchange rate flexibility seems to facilitate the real adjustment to the crisis while at the same time increasing the risk of currency crisis is plausible, a comment with respect to the apparent lack of separate effect of EMU membership is also in order. For example, it is important to keep in mind that the pre-crisis initial conditions are unlikely to be exogenous to the exchange rate regime in a given country. In addition, within a monetary union it is probable that a larger share of external debt and the current account deficit would be in domestic currency and thus less likely to be a source of vulnerability. Furthermore, it seems obvious that EMU membership protected countries against a currency crisis and may thus have helped mitigating the real impact of the crisis through that channel (cf. Cecchetti et al., 2009, who find that output losses tend to be much higher in currency crises episodes). Finally, as previously mentioned our measure of banking crises does not discriminate between the size of different banking crises in our sample. It could for example be argued that the large banking collapse in Iceland could have been contained to some extent had Iceland been a member of EMU, with stronger institutional support, for example through the greater ability of the ECB to provide liquidity support.

Finally, in terms of specific crisis episodes, we are able to predict quite accurately the extent of the crisis in some of the countries hit particularly hard (both in terms of the real economy impact and the banking and currency crisis incidences), such as Iceland, Ireland, and the three Baltic countries (see Figures 1-4). As can be seen in Figure 5, our statistical models suggest that the main reasons for the large and persistent contraction in output and consumption in the Baltic countries are the higher-than-average rate of inflation and, to a lesser extent, greater underlying economic volatility and higher current account deficits, whereas in Iceland and Ireland the main reasons were in addition to the inflationary-effect, the greater-than-average financial exposure of these two countries (larger capital inflows and higher private sector leverage in the case of Iceland, larger financial openness and limited exchange rate flexibility in the case of Ireland, and the very large banking systems in both countries).

However, some countries did worse than our statistical models predict. For example, our models predict a less protracted output contraction in Denmark and a smaller consumption loss in Russia, while assigning a relatively small probability of a banking crisis in either country. Our probit specifications also fail to spot the currency crisis in Korea.[39] At the same time, there are some countries that seem to have done better than predicted by our statistical models. For example, we find that the real economy impact in Australia and Poland was smaller than the initial conditions suggest and obtain quite a high probability of a banking crisis in Sweden which did not materialise.

[39] Given the relatively small real economy impact on Korea, this could suggest a problem in our definition of a currency crisis, which may incorrectly be signalling a currency crisis in Korea rather than suggesting a failure of our probit specification to spot the crisis.

4. Conclusions

The goal of this paper is to try to identify which factors were important in determining the macroeconomic impact of the recent global financial crisis, and why some countries experienced a systemic banking and currency crises while others escaped more lightly. We do this by identifying a broad set of potential pre-crisis explanatory variables in a cross-section of 46 medium-to-high income countries, framed within four possible channels through which the crisis spread out over from financial markets through the real economy all over the world: a financial channel, a trade channel, a macro channel and an institutional channel.

We find an important role for the macro channel in the propagation of the shock and the extent of the crisis, through various measures of pre-crisis macroeconomic imbalances and vulnerabilities. Thus, we find that countries that, in the run up to the crisis, had higher inflation, larger current account deficits, a more leveraged private sector, greater output volatility, or a poorer fiscal position tended to experience some combination of a deeper or more protracted contraction in output or consumption, and were more likely to experience a systemic banking or currency crisis.

We also find an important role for the financial channel. Thus, countries with relatively large banking systems or stronger global financial linkages tended to experience a deeper or longer contraction in output or consumption. In addition we find that large banking systems significantly increased the probability of a systemic banking or currency crisis.

Our results on the trade channel are mixed. While we find that countries with business cycles that were closely connected to the global business cycle experienced a deeper output contraction, we also find that the output contraction tended to be shorter in those countries that were more open to trade.

We also get mixed results for the role of exchange rate flexibility. We find that greater exchange rate flexibility coincided with a smaller and shorter contraction, while at the same time increasing the probability of a currency crisis or a combination of a systemic banking and currency crisis. We also find that countries with unilateral exchange rate pegs had a particularly large and protracted consumption contraction, while no comparable evidence is found for the EMU countries. This suggests that countries with exchange rate pegs outside a monetary union were particularly vulnerable in the current financial crisis. We also find that countries with a formal inflation target (and sometimes floating exchange rates in general) tended to have a smaller contraction and were less likely to have a systemic banking crisis.

Finally, we find that past experience of a systemic banking or currency crises had no beneficial effect during this crisis. In fact, our results suggest that past crises-countries tended to have a deeper and longer contraction and were more likely to suffer a currency crisis. We conclude that the possible positive learning effects from past crises is outweighed by loss of credibility resulting from past crises experience. We also find some tentative evidence suggesting the importance of institutional quality in that countries with more independent central banks were less likely to experience a currency crisis.

The policy implications of these results seem clear and perhaps uncontroversial. Thus, the key factors in escaping this global crisis relatively unscathed seem to have been to maintain sound macroeconomic conditions, i.e. avoid allowing large economic imbalances to build up,

and not allowing the banking system to get too large relative to the economy. Our results suggest that economies that achieved this were better able to absorb the financial shock and faster to recover from the crisis. Exchange rate flexibility also seemed to have helped reducing the real economy impact and expedite the recovery, but increased the risk of a currency crisis at the same time. Exchange rate flexibility, jointly with a formal inflation target, however, seemed to have helped reduce the risk of a systemic banking crisis. Although we find no significant effects of EMU membership, the fact that the additional negative effects of unilateral exchange rate pegs are not found in the case of the EMU countries suggests that fixed exchange rates through euro membership mitigated the negative effects of exchange rate pegs in the crisis. EMU membership can also have helped through preventing the occurrences of currency crises and reducing the size of possible banking crises within member countries.

Figure 1. Actual and fitted output and consumption contraction
(Specification 1 in Tables 3 and 4)

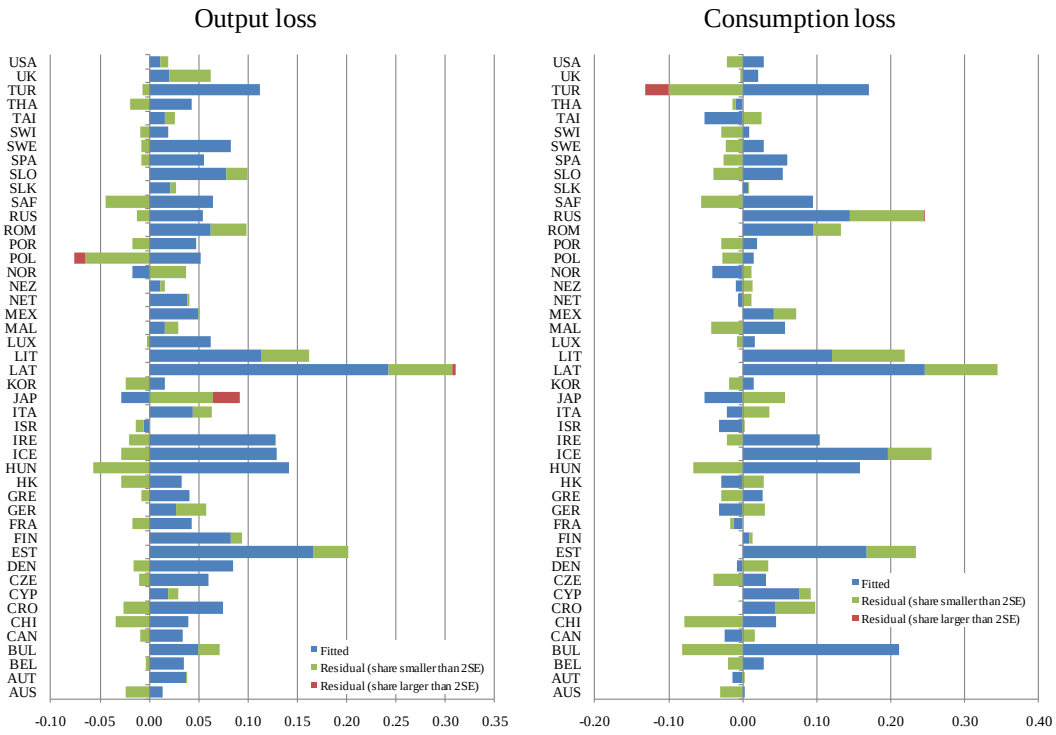


Figure 2. Actual and fitted output and consumption contraction duration
(Specification 1 in Tables 5 and 6)

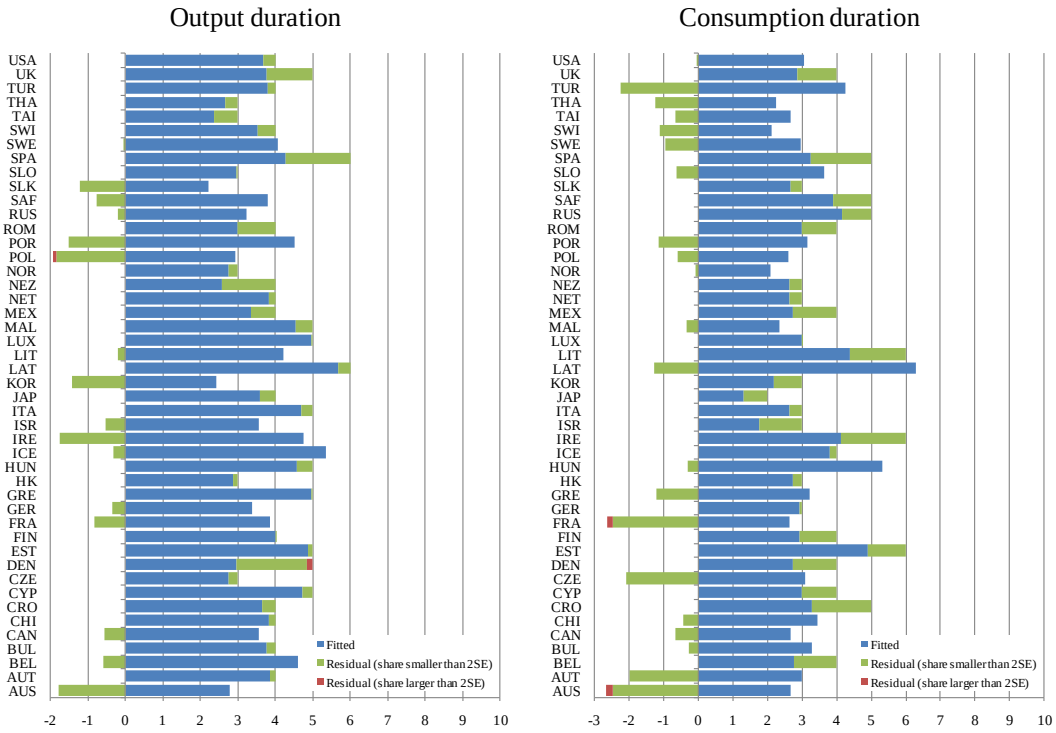


Figure 3. Actual and fitted banking and currency crisis
(Specification 1 in Tables 7 and 8)

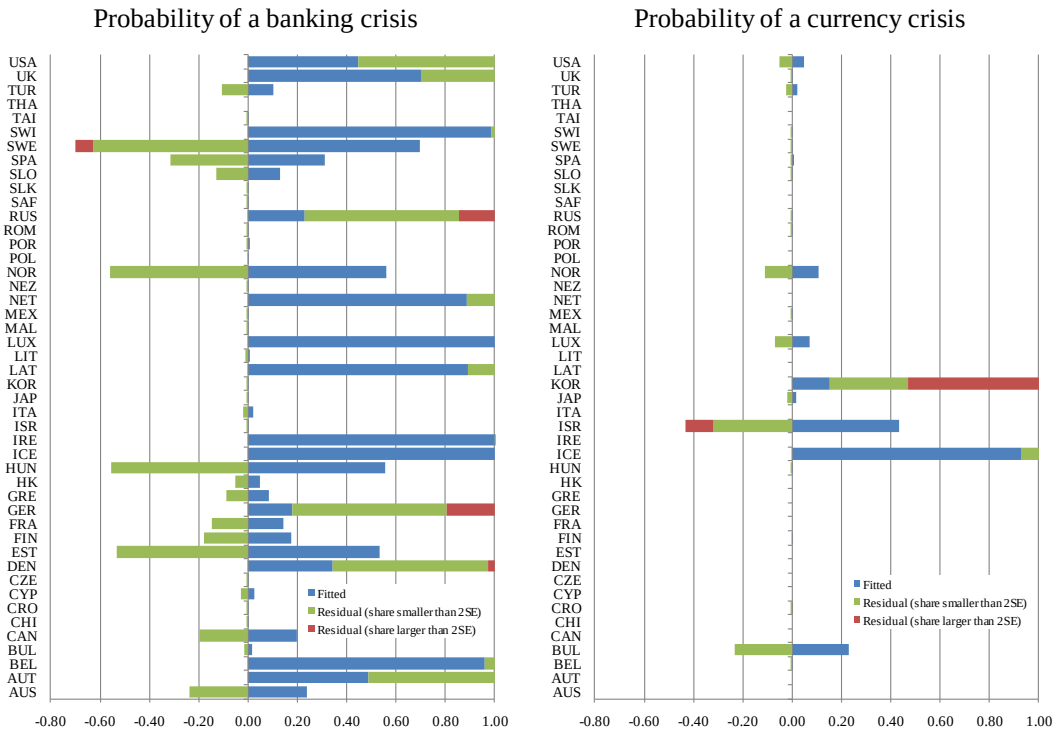


Figure 4. Actual and fitted banking and currency crisis

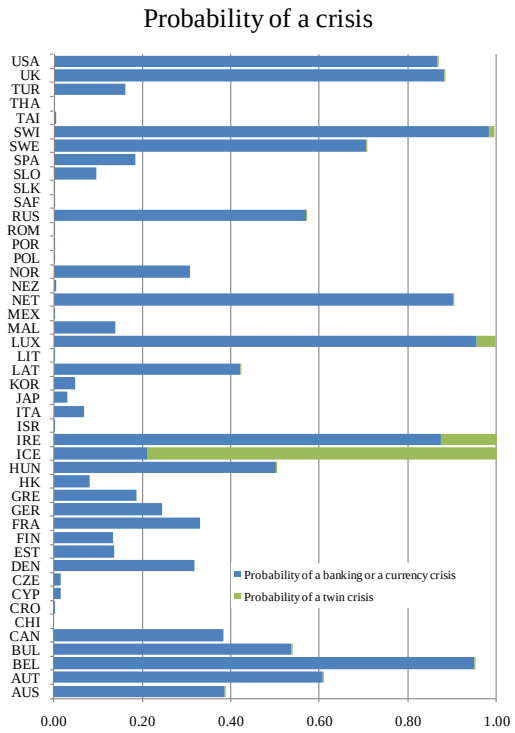
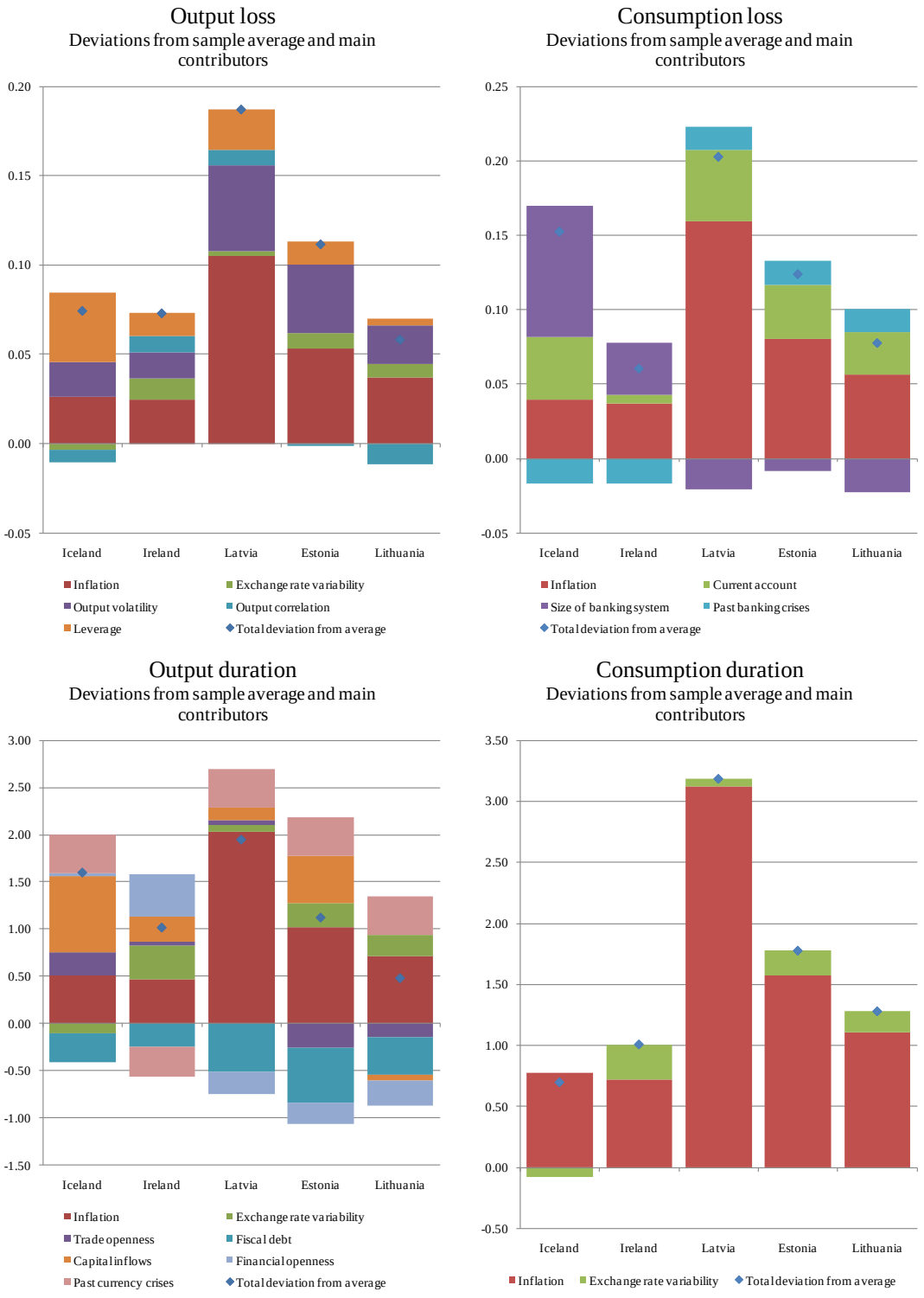


Figure 5. Baseline predictions of output and consumption losses and duration in selected countries (Contributions of explanatory variables to deviations from sample averages)



Appendix: The data

Table A1. Data definitions and sources

Variable	Description	Source
	Dependent variables	
Depth of output contraction	Log difference of seasonally adjusted GDP level from peak in 2007Q1-2008Q4 to 2009Q4	Eurostat, Reuters/EcoWin, local central banks and Global Insight
Depth of consumption contraction	Log difference of seasonally adjusted private consumption level from peak in 2007Q1-2008Q4 to 2009Q4	Eurostat, Reuters/EcoWin, local central banks and Global Insight
Duration of output contraction	Numbers of quarters with negative quarter-on-quarter growth in seasonally adjusted GDP from 2008Q3 to 2009Q4	Eurostat, Reuters/EcoWin, local central banks and Global Insight
Duration of consumption contraction	Numbers of quarters with negative quarter-on-quarter growth in seasonally adjusted private consumption from 2008Q3 to 2009Q4	Eurostat, Reuters/EcoWin, local central banks and Global Insight
Banking crisis	Indicator variable for a systemic banking crisis: defined as 1 if a country's corporate and financial sectors experience a large number of defaults and financial institutions and corporations face great difficulties repaying contracts on time leading to a rise in non-performing loans and an almost complete exhaustion of aggregate banking system capital and 0 otherwise	Laeven and Valencia (2008) updated database and authors own elaboration
Currency crisis	Indicator variable for a currency crisis: defined as 1 if the annual average of the nominal effective exchange rate depreciated by 30% or more in 2008-2009 and if this depreciation is also at least a 10 percentage points increase in the rate of depreciation compared to the two year period before and 0 otherwise	Effective exchange rates from the BIS database
	Economic structure	
GDP level	GDP level in 2008 (PPP adjusted billion US$)	CIA World Factbook (www.cia.gov/publications/factbook)
GDP per capita	GDP per capita in 2008 (PPP adjusted thousand US$)	CIA World Factbook (www.cia.gov/publications/factbook)

Table A1. Data definitions and sources (cont.)

Variable	Description	Source
	Financial structure and development	
Financial deepening	Broad money (M2) as a share of GDP in 2007	IMF/IFS and local central banks
Size of banking system	Total assets of the 5 largest banks in each country as a share of GDP in 2007	The Banker (2008) database
Stock market capitalisation	Market value of publicly traded stocks as a share of GDP in 2007	CIA World Factbook (www.cia.gov/publications/factbook)
	International real linkages	
Trade openness	Imports and exports as a share of GDP in 2007	IMF/IFS
Output correlation	Correlation of cyclical part of seasonally adjusted domestic GDP and world output 1985Q1-2007Q4 (or time period available, using the HP filter to generate trend GDP. For France, Germany, Italy, Japan, UK, and the US world output is measured using world output excluding each of these countries	Eurostat, Reuters/EcoWin, local central banks and Pétursson (2010)
Manufacturing exports share	Share of manufacturing exports (SITC 5 to 8, less 667 and 68) in total merchandise exports in 2006	UN/UNCTAD database (www.unctad.org/Handbook)
Trade diversification	A modified Finger-Kreinen index of trade similarities, measuring to what extent a country's trade structure in 2006 differs from that of the average country. Index ranging from 0 to 1, with higher numbers indicating a bigger difference from the world average	UN/UNCTAD database (www.unctad.org/Handbook)
Trade concentration	A Herfindahl-Hirschmann index measuring the degree of market concentration in country's trade in 2006. Index ranging from 0 to 1, with higher numbers indicating greater market concentration in trade	UN/UNCTAD database (www.unctad.org/Handbook)
	International financial linkages	
Financial openness	Sum of foreign assets and liabilities as a share of GDP in 2007	Lane and Milesi-Ferretti (2006); updated database
Capital inflows	FDI inward flows as share of GDP in 2007	UN/UNCTAD database (www.unctad.org/Handbook)
Access to US$ liquidity	Indicator variable for participation in the US Fed liquidity program in 2008: defined as 1 if a country participated in the liquidity program and 0 otherwise	McGuire and von Peter (2009)

Table A1. Data definitions and sources (cont.)

Variable	Description	Source
	Underlying economic volatility	
Output volatility	Standard deviation of cyclical component of seasonally adjusted GDP in 1985Q1-2007Q4 (or time period available, using the HP filter to generate trend GDP	Eurostat, Reuters/EcoWin and local central banks
Exchange rate variability	Standard deviation of quarterly changes in effective nominal exchange rates in 1994-2007	Effective exchange rates from the BIS database
Exchange rate noise	A measure of the standard deviation of the exchange rate risk premium, i.e. the present value of the rational expectations deviation from the uncovered interest rate parity condition in effective exchange rates. Estimated for the period 1990Q1-2005Q4 and available for all the countries except, Bulgaria, Croatia, Romania and Russia.	Pétursson (2010)
	Economic imbalances and vulnerabilities	
Inflation rate	Average consumer price inflation in 2007	Eurostat, Reuters/EcoWin and local central banks
Current account balance	Current account balance as a share of GDP in 2007	IMF/IFS
Size of foreign reserves	Foreign reserves as a share of GDP in 2007	IMF/IFS
Financial leverage	Ratio of domestic credit to domestic deposits in 2007	IMF/IFS
Fiscal balance	General government balance as a share of GDP in 2007	IMF/IFS, Eurostat, Reuters/EcoWin, local central banks and statistical offices
Government debt	General government debt as a share of GDP in 2007	IMF/IFS, Eurostat, Reuters/EcoWin, local central banks and statistical offices

Table A1. Data definitions and sources (cont.)

Variable	Description	Source
	Institutional factors	
Government effectiveness	A measure of government governance quality. Index from 2007 ranging from -2.5 to 2.5, with higher values indicating more effective governments	World Bank database (http://info.worldbank.org/governance/wgi/index.asp)
Regulatory quality	A measure of regulatory quality. Index from 2007 ranging from -2.5 to 2.5, with higher values indicating greater regulatory quality	World Bank database (http://info.worldbank.org/governance/wgi/index.asp)
Legal structure and security of property rights	A measure of quality of legal system covering judicial independence, impartiality of courts, protection of property rights, military interference in rule of law, integrity of legal system, legal enforcement of contracts and restrictions on sale of real property. Index from 2006, ranging from 0 to 10, with higher values indicating greater quality of legal system	Economic Freedom Network (http://www.freetheworld.com/2008/2008Dataset.xls)
Central bank independence	A measure of central bank overall independence. Index ranging from 0 to 1, with higher values indicating greater independence	Fry et al. (2000)
Credit market regulations	A measure of regulatory burden in the domestic credit market. Index from 2006 ranging from 0 to 10, with lower values indicating greater regulatory burden	Fraser Institute database on economic freedom (http://www.freetheworld.com/2008/2008Dataset.xls)
Labour market regulations	A measure of regulatory burden in the domestic labour market. Index from 2006 ranging from 0 to 10, with lower values indicating greater regulatory burden	Fraser Institute database on economic freedom (http://www.freetheworld.com/2008/2008Dataset.xls)
Business regulations	A measure of regulatory burden in general business activities. Index from 2006 ranging from 0 to 10, with lower values indicating greater regulatory burden	Fraser Institute database on economic freedom (http://www.freetheworld.com/2008/2008Dataset.xls)
Economic freedom index	Overall economic freedom index, weighing together sub-indices covering size of government, legal structure, access to sound money, freedom of international trade, and regulation of markets. Index from 2006 ranging from 0 to 10, with higher values indicating greater economic freedom	Fraser Institute database on economic freedom (http://www.freetheworld.com/2008/2008Dataset.xls)
Past banking crisis	Indicator variable for past banking crisis: defined as 1 if it has experienced a banking crisis in the past 30 years and 0 otherwise	Laeven and Valencia (2008)
Past currency crisis	Indicator variable for past currency crisis: defined as 1 if it has experienced a banking crisis in the past 30 years and 0 otherwise	Laeven and Valencia (2008)

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CHAPTER 2

THE LONG HISTORY OF FINANCIAL BOOM-BUST CYCLES IN ICELAND

Part I: Financial crises[40]

[40] This chapter has been published as a Central Bank of Iceland *Working Paper*, no. 68.

The long history of financial boom-bust cycles in Iceland

Part I: Financial crises*

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August 2015

Abstract

Iceland suffered a severe financial crisis in 2008 which can only be described as the perfect storm, with the currency falling by more than 50% and over 90% of the domestic financial system collapsing. What followed was a deep recession. This was not the first financial crisis experienced in Iceland, however. In fact, over a period spanning almost one and a half century (1875-2013), we identify over twenty instances of financial crises of different types. Recognising that crises tend to come in clusters, we identify six serious multiple financial crisis episodes occurring every fifteen years on average. These episodes seem to share many commonalities and the tragic but universal truth that "we've been there before" when it comes to financial crises really becomes all too clear. We find that these episodes usually involve a large collapse in domestic demand that in most cases serves as a trigger for the ensuing crisis. What typically follows is a currency crisis, sometimes coinciding with a sudden stop of capital inflows and an inflation crisis, and most often a banking crisis. In line with international evidence, we find that contractions coinciding with these large financial crises tend to be both deeper and longer than regular business cycle downturns. Although the crisis episodes share many common elements, each one of them is also different to some extent. We are therefore not able to find financial variables that consistently provide an early-warning signal of an upcoming financial crisis across all the six episodes. However, we find that some key macroeconomic variables give a somewhat more robust signal. Our results also suggest that five of the six multiple crisis episodes coincide with a global financial crisis of some type, and that the most serious global episodes coincide with a two- to threefold increase in the probability of a financial crisis in Iceland. A companion paper (Part II) extends our analysis of the Icelandic financial boom-bust cycle to identifying financial cycles in our long data set, i.e. cycles that are of lower frequency and last longer than common business cycles and are characterised by co-movement of many key financial variables and often have peaks closely associated with financial crises.

Keywords: Financial crises, economic fluctuations, Iceland

JEL classification: E32, E44, G01, G20, H12, N1

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"There is nothing new except what has been forgotten"
Marie-Jeanne Rose Bertin (Queen Marie Antoinette's dressmaker and confidante)

1 Introduction

Iceland suffered a severe financial crisis in 2008 which can only be described as the perfect storm, with the currency falling by more than 50% and over 90% of the domestic financial system collapsing. What followed was a deep recession, with output declining by almost 12% from its pre-crisis peak in late 2007 to its post-crisis trough in early 2010. The collapse in domestic demand was even more punishing: consumption fell by 21% from peak to trough and total domestic absorption by 30%, while unemployment rose by 7 percentage points.

This was not the first financial crisis experienced in Iceland, however. In fact, over a period spanning almost one and a half century, we identify over twenty instances of financial crises of different types. Recognising that crises tend to come in clusters, we identify six serious multiple financial crisis episodes occurring every fifteen years on average. The first two episodes occur during the early 1900s: the first coincided with the First World War (WWI) and lasted into the early 1920s, when a sharp collapse in economic activity led to an inflation crisis that was followed by a sudden stop of capital inflows and a currency crisis and eventually by a systemic banking crisis; while the second crisis coincided with the outbreak of the Great Depression in the early 1930s when another systemic banking crisis followed a recession and morphed into a currency crisis in 1932. There are two further episodes occurring at the end of the 1940s and in the late 1960s that are related to a serious deterioration of external conditions, in both cases leading to currency and inflation crises: the first followed a sharp deterioration of terms of trade and a contraction in economic activity; the second of these episodes following a collapse in fish catch. The fifth episode occurs during the early 1990s when falling economic activity, following the rein in of the chronic inflation of the 1970s and the 1980s, led to a twin currency and (non-systemic) banking crisis in 1993. The final episode is the most recent one when a build-up of enormous imbalances in the run-up to the crisis were followed by a sudden stop and a twin currency and banking crisis in 2008, further compounded by the global financial crisis occurring at the same time.

These financial crisis episodes seem to share many commonalities. They usually involve a large collapse in demand that in most cases serves as a trigger for the ensuing crisis. What typically follows is a currency crisis, sometimes coinciding with a sudden stop of capital inflows and an inflation crisis, and most often a banking crisis – usually towards the end of the episode. Three of those episodes involve a systemic banking crisis and they tend to leave the largest footprints on the real economy although all six episodes lead to large contractions in demand and output. In line with international evidence, we find that contractions coinciding with these large financial crises tend to be about twice as deep as regular business cycle downturns and last almost twice as long. We also find that two of the more serious episodes coincide with a sudden stop crisis. Although the crisis episodes share many common elements, each one of them is also different to some extent. While we find evidence of financial imbalances playing an important role in the run up to the first three financial crises – as reflected

in markedly above-trend growth in money, credit and bank leverage (and to a lesser extent, house prices), the financial crises in the late 1960s and early 1990s had pure real economy sources. The latest episode saw major financial and macroeconomic imbalances combine to make it the most serious crisis of them all. We therefore find no single financial variable consistently providing an early-warning signal of an upcoming financial crisis across all the six episodes. However, we find that some macroeconomic variables, such as output, domestic demand, the trade deficit and, to a lesser extent, the real exchange rate, give a somewhat more robust warning signal.

Our results also suggest an important role of contagion from global financial crises in most of these episodes, with five of the six episodes coinciding with a global financial crisis of some type; only the financial crisis in the late 1960s seems almost exclusively local. Our results also suggest that of the different types of financial crises, banking crises have the strongest global component while currency and inflation crises mainly seem to be of local nature. We also find that the most serious global episodes coincide with a two- to threefold increase in the probability of a financial crisis in Iceland.

The paper is organised as follows. In Section 2 we use data on aggregate economic activity to identify regular business cycle downturns and the more serious demand disasters used for reference in our analysis of the financial boom-bust episodes over the period 1875-2013. We also introduce the macroeconomic and financial variables that we use in the paper and discuss their key business cycle properties and historical context. In Section 3, we move on to identify and date different types of financial crises, i.e. the closely related currency and inflation crises, and banking crises. Not surprisingly, we find that these different types of financial crises often tend to overlap and to capture this clustering nature of financial crises, Section 4 applies a non-parametric common cycle algorithm to identify the more serious, multiple financial crises in a single indicator. This approach allows us to identify six major financial crisis episodes that we discuss in more detail in the remainder of Section 4. We discuss the main properties of these episodes and the development of our macroeconomic and financial variables in the run-up to these crises and in the period when the crises unfold. In Section 5, we analyse whether our financial and macroeconomic variables consistently provide early-warning signals in the run up to the multiple financial crises, whether these crises make recessions worse, and to what extent these episodes coincide with global financial crises. Section 6 concludes the paper. Robustness checks, documented in Appendices 1 and 2, suggest that our key results are robust to variations in crisis definitions. In a companion paper (Part II) we use the same dataset to identify and analyse financial cycles, i.e. cycles that are of lower frequency and last longer than common business cycles and are characterised by co-movement of many key financial variables and often have peaks closely associated with financial crises. The companion paper also contains discussions of policy implications of our findings.

2 The data

Our analysis of the financial boom-bust cycle in Iceland and its relationship with financial crises and the traditional business cycle encompasses data on overall economic activity, exchange

rates, terms of trade and inflation, asset prices, money and credit, and data on the banking system assets, leverage, and liability composition. This section of the paper describes the data we use and gives a broad-brush description of its main properties and stylised historical context, as well as presenting our identified dates of economic downturns (both regular cyclical downturns and more punishing demand disaster episodes).

The fact that financial boom-bust cycles usually take a long time to complete – decades even – calls for a longer data span than is usually required for analysing most other macroeconomic phenomena. We have therefore constructed an annual frequency database covering a 139 year period from 1875 to 2013 (described in more detail in Appendix 3). As is often the case, the need for a long data span comes at the cost of only having annual data available and thus the loss of higher frequency information found in quarterly data. Although we acknowledge that some finer points of dating business cycles and financial booms and busts may be lost using annual data, our focus on financial crises necessitates it. At the same time we gain some unique insight into the domestic financial boom-bust cycle that would be lost by focusing on a shorter time period, and the tragic but universal truth that "we've been there before" when it comes to financial crises really becomes all too clear.

2.1 Economic activity and downturns

A central variable in any analysis of financial boom-bust cycles is some measure of aggregate economic activity, not only for measuring the real economy consequences of financial crises but also for analysing the interactions of economic activity and financial booms and busts, and phasing the crisis episodes in terms of the business cycle. We use GDP as our measure of overall activity and as a basis for estimating and dating cyclical downturns although we acknowledge that a more broad-based analysis of multiple indicators for identifying the business cycle might be more appropriate. For example, small open economies can use the current account to absorb shocks and smooth output although there is also ample evidence suggesting that this risk sharing property may be overstated as discussed below. Thus, we also look at overall domestic demand as it can shed important additional light on economic activity over the financial boom-bust cycle.

The data on GDP and domestic demand comes from official national accounts for the period from 1945. Prior to that we use data compiled by the economic historian Gudmundur Jónsson and published by the now defunct National Economic Institute in 1999 (see also Jónsson, 2004). This dataset does not directly include data on domestic demand but we construct the series by subtracting nominal net exports (available from the same source) from nominal GDP and use the implicit GDP price deflator to construct real domestic demand. Appendix 3 gives the details.

Table 1 summarises key properties of output and demand, together with other variables in our dataset, for the whole sample and for two subsamples which divide the data into two roughly equally long periods and coincide with the period up to the end of World War II (WWII) and the post-WWII period, respectively. The first subsample therefore covers the modernisation of the Icelandic economy, beginning around 1890, when increased foreign demand,

technological innovation, and financial deepening paved the way for export-oriented industrialisation and ends with a "great leap forward" in terms of the modernisation of the economy during WWII (Jónsson, 2004), while the second subsample covers the period from which Iceland had caught up with other advanced economies in terms of income levels. As Table 1 shows, average annual growth of real GDP and demand over the whole sample has measured just under 3½%, somewhat higher and less volatile in the post-WWII period – although the economy remains very volatile compared to other industrial countries as documented in Einarsson et al. (2013).

Table 1 Summary statistics

	Total sample (1875-2013)		First half (1875-1944)		Second half (1945-2013)	
	Mean	St.dev.	Mean	St.dev.	Mean	St.dev.
Real house prices	0.010	0.064	0.015	0.062	0.008	0.066
Real credit	0.064	0.129	0.072	0.149	0.057	0.110
Credit-to-GDP ratio	1.082	0.734	0.644	0.377	1.457	0.759
Real M3	0.061	0.113	0.090	0.110	0.036	0.110
M3-to-GDP ratio	0.381	0.203	0.303	0.189	0.448	0.192
Credit-to-M3 ratio	2.814	1.182	2.179	0.794	3.356	1.194
Bank assets-to-GDP ratio	0.676	1.132	0.349	0.257	1.008	1.520
Bank leverage ratio	11.085	3.945	10.042	4.113	12.143	3.486
Foreign non-core liabilities	0.096	0.108	0.059	0.053	0.128	0.132
Total non-core liabilities	0.169	0.135	0.161	0.121	0.176	0.146
Real GDP	0.034	0.051	0.030	0.058	0.037	0.042
Real domestic demand	0.033	0.084	0.031	0.087	0.035	0.082
Trade deficit-to-GDP ratio	-0.009	0.063	-0.036	0.062	0.018	0.052
USD exchange rate	-0.059	0.163	-0.008	0.101	-0.109	0.196
Real exchange rate	0.000	0.106	0.014	0.083	-0.014	0.123
Terms of trade	0.006	0.123	0.010	0.160	0.002	0.068
Inflation	0.081	0.133	0.028	0.107	0.136	0.136

The table reports summary statistics for the total sample from 1875-2013 (139 years) and for two subsamples: the period 1875-1944 (70 years) and the period 1945-2013 (69 years). USD exchange rate refers to number of US dollars per 1 unit of Icelandic króna. Bank leverage ratio refers to the ratio of total banking system assets to equity. The non-core financing ratios refer to the ratio of non-core banking liabilities (either foreign or total) to total banking liabilities. Real house prices, real credit, real M3, real GDP, real domestic demand, USD exchange rate, real exchange rate, and terms of trade are reported as log differences of each variable. Inflation is measured as the log difference of consumer prices.

Source: Authors' calculations (data sources described in Appendix 3).

Figure 1 shows real GDP and domestic demand in levels and growth rates for the period 1875-2013 together with dates of business cycle downturns as identified by the Harding and Pagan (2002) turning point algorithm.[41] This seeks to identify cyclical peaks and troughs in the GDP series using a simple algorithm that identifies local maxima and minima over a specific window by imposing restrictions on the minimum length of the cycle (the distance between two consecutive peaks and troughs) and the minimum length of each phase (the length from peak

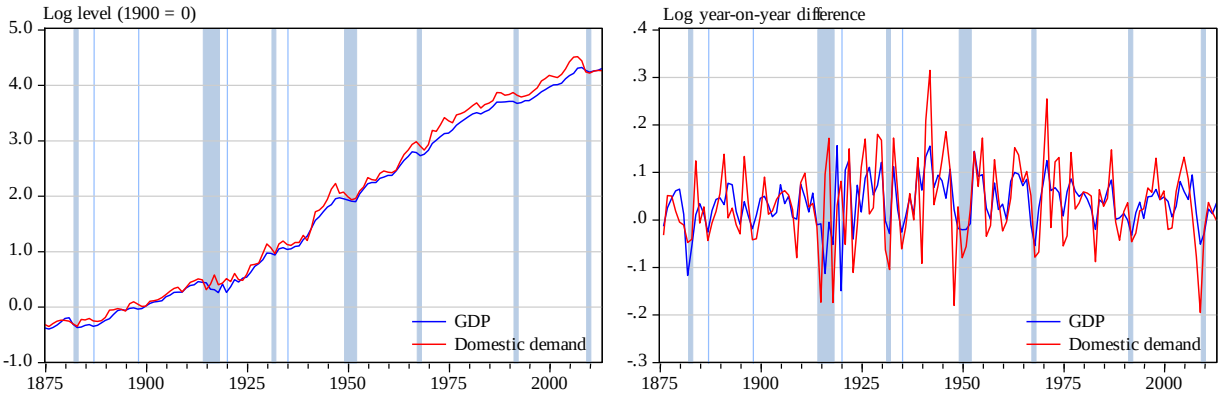
[41] This turning point approach to dating business cycles goes back to the pioneering work of Burns and Mitchell (1946) and is widely used for dating business cycles, see Claessens et al. (2011, 2012) for a discussion and Einarsson et al. (2013) for an application using Icelandic quarterly data since 1970.

to trough or trough to peak). The screening process also requires peaks and troughs to alternate. If two peaks (troughs) occur in a row the higher (lower) one is chosen.

The duration of business cycles is typically assumed to last between 5 quarters and 8 years. With this in mind, and given the restrictions imposed by using annual data, we assume that the minimum phase of expansions and contractions is 1 year and the minimum length of a complete cycle is 2 years. Given these restrictions, we define the peak (trough) of the business cycle in a given year as the highest (lowest) value of GDP within a 2-year symmetric window (i.e. within a 5 year window centred at the given year). The use of a 2-year symmetric window is not ideal though as it will probably lead to an identification of too few business cycle turning points. However, the alternative of using a 1-year symmetric window is even less appealing, especially given the relatively high volatility in Icelandic macroeconomic data, as it would simply replicate all years of contractions in GDP (however small) and thus arguably identify too many cycles (see the second panel of Figure 1). To compensate for this drawback (which comes from using annual data), we also allow for the algorithm to be overruled if the annual contraction in GDP exceeds one standard deviation of total sample GDP growth. Although it is still likely that we are missing some of the smaller business cycle downturns, our filtering choices allow us to concentrate on the most important ones which are the ones of most interest to us in the context of our analysis of financial booms and busts.

Figure 1 GDP and domestic demand

Business cycle downturns shown as shaded areas



Source: Authors' calculations (data sources described in Appendix 3).

This approach identifies eleven downturns in GDP over the 139 year period (17% of the total sample). This gives a cyclical downturn every 10 years which lasts for 2.1 years with output contracting by 7.6% on average. The identified dates are reported in Table 2. Most of the downturns identified are well-known in the chronology of the Icelandic business cycle. The first one we identify occurs in 1882-1883 when output contracts by no less than 16%. This and the short contraction in 1887 are mainly due to large negative terms of trade shocks and unusually cold weather (see, Jónsson, 1999, 2004). Another short and relatively shallow contraction follows in 1898, which is mainly related to a collapse of the important export market

for wool in the UK.[42] The first and most severe downturn identified in the 20th century occurs during WWI with output contracting by almost 18%. This is followed by a short but sharp contraction in 1920 when output fell by 14% following a 40% deterioration of terms of trade during the global post-WWI recession and widespread foreign liquidity shortages in the domestic banking system. Two relatively short contractions occurred in the Great Depression in the early 1930s coinciding with a systemic banking crisis (see the discussion on banking crises in Section 3.2).

Table 2 Economic downturns in Iceland

Business cycle downturns			Demand disasters		
Date	GDP contraction	Duration (in years)	Date	Per capita domestic demand contraction	Duration (in years)
1882-83	0.161	2			
1887	0.027	1			
1898	0.020	1			
1914-18	0.179	5	1914-15	0.192	2
			1918	0.166	1
1920	0.140	1	1923-24	0.137	2
1931-32	0.034	2	1931-32	0.179	2
1935	0.027	1			
1949-52	0.071	4	1948-51	0.309	4
1967-68	0.067	2	1968-69	0.155	2
			1975-76	0.106	2
1991-92	0.036	2	1988-93	0.136	6
2009-10	0.079	2	2007-10	0.276	4
Average	0.076	2.1	Average	0.184	2.8

The table gives the dates of economic downturns identified by the Harding and Pagan (2002) turning point algorithm and the dates of domestic demand disasters based on the criteria suggested by Barro and Ursúa (2008) for consumption disasters. The table reports the duration of the given episode in years and the contraction in GDP for business cycle downturns and per capita domestic demand for demand disaster dates between the start and end of the crisis.

Source: Authors' calculations (data sources described in Appendix 3).

The cyclical downturns are fewer and less severe in the post-WWII period, as reflected in the declining output volatility referred to earlier. The first downturn is a relatively sharp contraction following large negative terms of trade shocks in the late 1940s due to a weakening of export prices that were further exacerbated by a global trade contraction in connection with the Korean War and an overvalued real exchange rate. This is followed by another sharp contraction in the late 1960s with the collapse of fish stocks causing output to fall by close to 7%. No business cycle contraction is identified until the early 1990s when output fell by 3½% following a tightening of monetary conditions in the latter half of the previous decade (see Pétursson, 2002), further exacerbated by a negative terms of trade shock and a contraction in fish catches in the early 1990s. Finally, a sharp contraction is identified in 2009-10 following the most recent financial crisis when output fell by 8%.

[42] The downturns in the late 1800s coincide, and are followed, by unusually large emigration flows to North America (mainly Canada), which lasted into the first decades of the 20th century.

Although some of these downturns can be attributed to different types of financial distress, it is clear that downturns related to negative supply shocks (whether they are terms of trade or fish catch shocks) dominate the Icelandic business cycle.[43] These shocks can obviously also trigger some type of financial distress or interact with the underlying financial cycle to amplify financial shocks occurring at a similar time. We will indeed see examples of both when we revisit some of these episodes in our discussion of financial crises below.

Using the turning point algorithm on domestic demand gives broadly the same dates, although the exact start or finish of some differs slightly from those identified using GDP. However, not surprisingly given that domestic demand is more volatile than output, the algorithm also identifies additional downturns using the demand series. By focusing on the more severe episodes, i.e. what we can call "demand disasters" following the definition of Barro and Ursúa (2008) of "consumption disasters" as periods where per capita demand contracts by more than 10% from peak to trough, gives us nine disaster episodes occurring every 12 years on average with duration of almost 3 years.[44] In most cases, these episodes coincide with the downturns identified by the turning point algorithm for GDP (see Table 2) although the downturns in the late 1800s drop out as the large contractions in domestic demand are offset by a large decline in total population, so that the per capita measures falls below the 10% threshold. The sharp contraction in domestic demand in 1909, following a large terms of trade deterioration and loss of foreign bank funding in the aftermath of the global bank panic of 1907 (see below), and the downturn in the mid-1930s, related to the loss of important export markets in Southern Europe, also drop out as the cumulative contractions fall just shy of 10%. By this measure, there was also a downturn in the mid-1970s related to the first oil shock where per capita demand fell by 10½% while GDP growth only slowed down to 0.7% in 1975 and picked up strongly the year after.

2.2 Trade balance

As previously discussed, a small open economy should in principle be able to use its external accounts to absorb shocks and smooth activity by borrowing in bad times and saving when conditions improve. A current account deficit would therefore open up during bad times, which is reversed when the economy improves. At the same time, numerous studies suggest that the

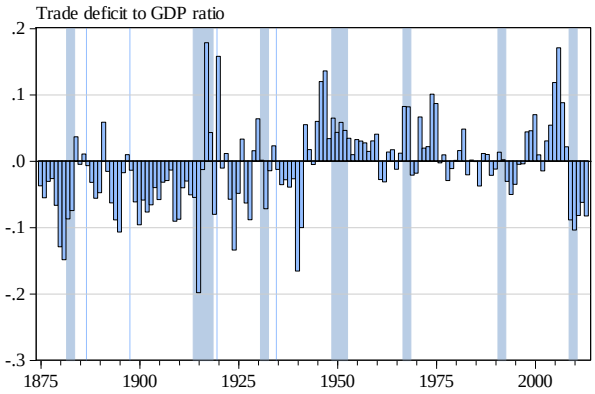
[43] This is indeed what Gudmundsson et al. (2000) find using a structural VAR (see also Daníelsson, 2008). Although our focus is mainly on the largest downturns, the business cycle chronology presented here corresponds quite well to conventional wisdom, such as Jónsson (2004), Magnússon and Einarsson (1985) and Pétursson (2000). Pétursson uses Hamilton's (1989) Markov-switching model to identify cyclical downturns in the post-WWII period, finding similar results over the period in question but additional downturns in the mid-1970s and early- to mid-1980s. Using this Markov-switching model over the extended period analysed here gives broadly similar results, although it misses the pre-WWII downturns in the late 1880s and 1890s, and the ones in 1920 and 1930s identified by the turning point approach, but as in Pétursson (2000) also adding the slow post-WWII growth periods in 1956-57 and 1961, and the short-lived contraction in 1983. Einarsson et al. (2013) focus on the post-1970 period where quarterly data is available and find broadly similar results, although the quarterly data allows them to identify a larger number of short downturns which are missed using annual data.

[44] We use per capita domestic demand as consumption data is not available before 1945. Using domestic demand (the bulk of which is private consumption) gives almost identical disaster dates (also identified by Barro and Ursúa, 2008) as using consumption does in the period where both series are available (the episodes are identical but start or end dates differ slightly in some cases).

current account and capital flows tend to be pro-cyclical and fuel asset price and financial boom-bust cycles, in particular among emerging market economies (cf. Kaminsky and Reinhart, 1999, Aguiar and Gopinath, 2007, and Korinek, 2011).[45]

Figure 2 Trade balance

Business cycle downturns shown as shaded areas



Source: Authors' calculations (data sources described in Appendix 3).

With no data on the current account available for the whole period, we use the trade balance as a proxy for this net capital flow cycle (see also Reinhart and Rogoff, 2009).[46] This is shown in Figure 2 together with the previously identified business cycle downturns (the trade balance data we use is obtained from Jónsson, 1999, as described above). One noteworthy feature of the data is the shift from persistent trade surpluses in the first half of our sample to persistent deficits after WWII. This is also borne out in Table 1 which shows how the average balance goes from a surplus of 3.6% of GDP in the first period to a deficit of 1.8% in the second. Another striking feature is the general tendency for large deficits to build up in the period leading into recessions only to be reversed around the time a cyclical downturn starts (of which the latest crisis period is a notable example). Exceptions to this, where the temporal order is reversed, i.e. from a surplus leading into the recession reversing into a deficit, emerge in the period prior to 1922, during Iceland's membership in a monetary union with Denmark. In that period there was a limited role for nominal exchange rate adjustment and hence deflationary pressures often emerged during downturns and in turn reinforced them (see the discussion in the next section). Most of the trade balance reversals in our sample are therefore consistent with a build-up of deficits leading into the recessions with the accompanying capital inflows, which reverse once the economy weakens. Trade deficits therefore tend to be pro-cyclical and to reinforce the cycle rather than being used to absorb shocks and smooth output, consistent with

[45] Aguiar and Gopinath (2007) find that this emerging market phenomenon is strongly linked to an unusually high ratio of permanent to temporary shocks. As Reinhart and Rogoff (2009) argue, policymakers in these countries seem to have a tendency to interpret favourable shocks as being permanent, leading to spending sprees and borrowing binges that ultimately lead to sudden stops in funding and a sharp recessions and a reversal in the current account.

[46] In Section 2.6 below, we also consider gross capital flows in the form of cross-border banking liabilities, which Borio et al. (2014) emphasise in relation to systemic banking crises.

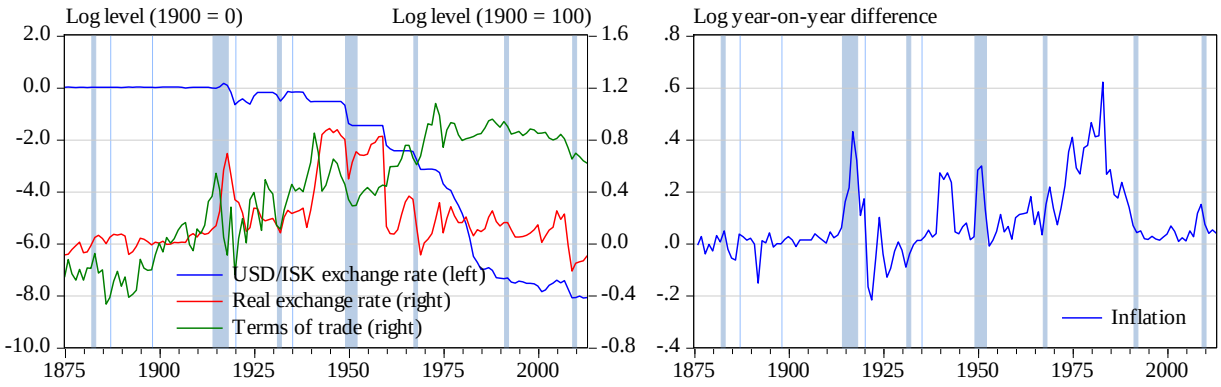
the findings in Kaminsky and Reinhart (1999) and Aguiar and Gopinath (2007). We will return to this theme in the context of our discussion of currency crises below.

2.3 Exchange rate, terms of trade, and inflation

Another way for a small open economy to absorb external shocks is through adjustments in its exchange rate. Thus, the currency depreciates in bad times and supports net exports and reduces real economic volatility. At the same time, the results from Breedon et al. (2012) suggest that exchange rates in very small open economies such as Iceland have in fact not served as a shock absorber but rather as an important source of shocks and therefore as an amplifier of the business cycle. The exchange rate cycle is also of interest in our analysis of the financial boom-bust cycle as a number of studies have found the real exchange rate to be a leading indicator of currency and banking crises (cf. Kaminsky et al., 1998, Kaminsky and Reinhart, 1999, Goldstein et al., 2000, and Gourinchas and Obstfeld, 2012). Bruno and Shin (2014) provide a model consistent with these finding and emphasise the interactions between currency appreciations, borrowers' balance sheet strength, and greater risk-taking by banks in driving financial cycles in small open economies (see also Korinek, 2011).

Figure 3 Exchange rate, terms of trade, and inflation

Business cycle downturns shown as shaded areas



Source: Authors' calculations (data sources described in Appendix 3).

Figure 3 shows the development of the nominal (number of US dollars per 1 unit of Icelandic króna) and real exchange rate together with the business cycle downturns from above (data sources and how the data is constructed is described in Appendix 3). The nominal exchange rate remains tightly pegged to the US dollar up to WWI within the gold standard regime through Iceland's monetary union with Denmark and the rest of the Nordic countries within the Scandinavian Monetary Union. This breaks down during the war and in 1922 Iceland exits the monetary union with Denmark and establishes its own currency, which starts its long and arduous downward slide to its most recent collapse in 2008.[47] As shown in Table 1, this

[47] See Gudmundsson et al. (2000) for a description of the history of Icelandic exchange rate regimes leading up to the country's adoption of a floating exchange rate regime with an explicit inflation target in 2001.

depreciation bias has been particularly strong in the post-WWII period with exchange rate volatility also increasing – in part reflecting the greater exchange rate flexibility over the last two decades. The real exchange rate has remained more stable around a broadly fixed level, notwithstanding some extreme real exchange rate adjustments, in particular during the two World Wars, the start of the 1950s and 1960s, and the financial crisis in 2008-9.

While exchange rate volatility has increased in the post-WWII period, terms of trade shocks (a key driver of the Icelandic business cycle as one can gather from Section 2.1) have in fact been more moderate as shown in Table 1 and Figure 3 (data sources described in Appendix 3). Improvements in terms of trade played an important role in the previously discussed modernisation and catch-up of the Icelandic economy relative to other advanced economies, with terms of trade improving by no less than 274% over the period 1886-1915. After a sharp deterioration during WWI and again after WWII, terms of trade improved again and peaked in the early 1970s. They remained relatively stable up to the recent global crisis which has seen terms of trade deteriorate by 20% from its 2006 peak.

Finally, Figure 3 reports the development of inflation (data sources described in Appendix 3), highlighting some wild fluctuations in the rate of price changes, both during deflationary periods in the pre-WWII period (in particular the years following WWI) and frequent inflationary bouts, especially during the World Wars and in the post-WWII period (in particular in the 1970s and 1980s). The high and volatile inflation is much more apparent in the latter half of the sample period, as reflected in the nominal exchange rate developments. These exchange rate and inflation developments will be revisited in our discussion of currency and inflation crises below.

2.4 Residential house prices

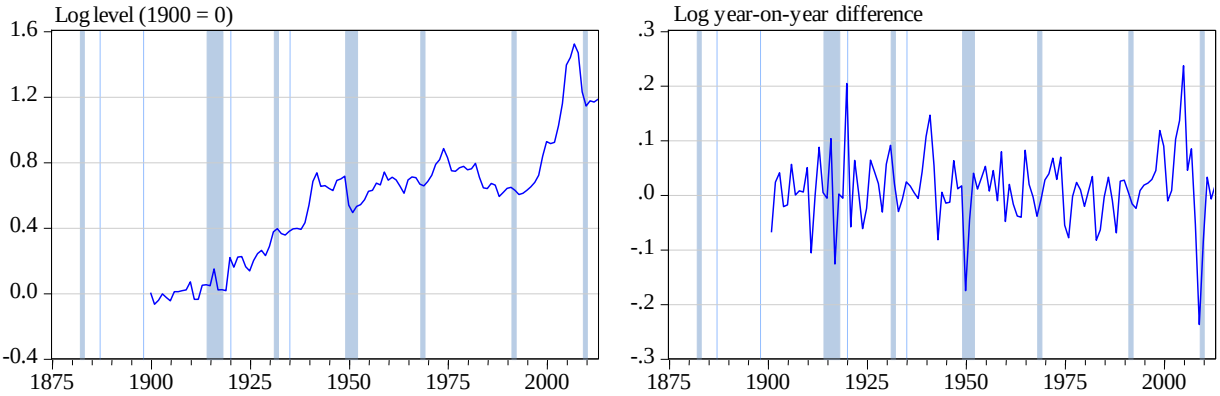
Residential house price cycles are usually at the centre of any financial boom-bust cycle. In fact a number of studies have established the prominent role of house prices in the run-up to and aftermath of banking crises, with a house price boom leading into the crises (particularly if its debt-driven), followed by a substantial and persistent decline after the bust (see e.g. Bordo and Jeanne, 2002, and Reinhart and Rogoff, 2008). Furthermore, Reinhart and Rogoff (2009) find that real house prices are a robust leading indicator of financial crises, banking crises in particular.

As Reinhart and Rogoff (2009) argue, large house price declines can have marked real economic consequences even if they do not coincide with banking crises, and indeed this is borne out by the Icelandic data (see Figure 4):[48] while the large declines in real house prices in 1917-19 (cumulative decline of 12.5%) and 2008-10 (cumulative decline of 31.5%) coincide with systemic banking crises (see the discussion on banking crises below), the sharp decline in 1950-51 (cumulative decline of 20%) did not, although all three coincide with a cyclical downturn and a demand disaster (see Table 2 above). The figure also clearly shows the pro-cyclical nature of real house prices in Iceland, with booms in the run-up to recessions followed

[48] House price data (described in Appendix 3) is only available from 1900, which coincides with the beginning of commercial bank mortgage lending in Iceland (Björnsson, 1961).

by declines just before, during or shortly after the business cycle turns. Interestingly, unlike inflation and the exchange rate, the comparison of real house prices over the two subsamples in Table 1 does not suggest that real house prices have become more volatile in the post-WWII period. We will discuss this house price cycle in more detail in Section 4.2.

Figure 4 Real house prices
Business cycle downturns shown as shaded areas



Source: Authors' calculations (data sources described in Appendix 3).

2.5 Money and credit

Credit aggregates are the measurable results of the credit creation process where liquidity conditions and perceptions of value and risk interact and lead to changes in exposure and financing capacity. Surges and shortfalls of liquidity and their accompanying balance sheet expansions and deleveraging can have severe repercussions for economic activity and overall macroeconomic stability.[49] Hence, studies of financial boom-bust cycles logically include credit aggregates as one of the key elements capturing the nexus between the financial system and the real economy (Claessens et al., 2011, 2012, Drehmann et al., 2012, and Aikman et al., 2015). Other studies examine to what extent monetary aggregates, or the ratio of total credit to money (which captures the extent of non-monetary funding of credit creation), can serve as indicators for the state of the financial cycle or signal increasing vulnerabilities in the latter stages of financial cycle upswings (Borio and Lowe, 2004, and Shin and Shin, 2011).

To capture these aspects of the financial cycle and its link to financial crises we consider both credit and broad money measures. Our credit aggregate is based on data on total lending and bond holdings of the credit system. We use total credit as data availability does not allow us to focus solely on credit to the non-financial private sector over such a long period. Our broad money measure is M3. The data is available from 1886 when the first commercial bank

[49] Liquidity is an unobservable property of the financial system and refers to the ease of financing in financial markets and encompasses both funding liquidity (the ease of raising cash by selling new obligations to investors) and market liquidity (the ease of raising cash by selling assets). Liquidity depends on actions of private investors, financial institutions, and monetary authorities, and is best understood as a flow variable, which can disappear altogether, rather than a stock of available funding which can be redistributed in a time of crisis.

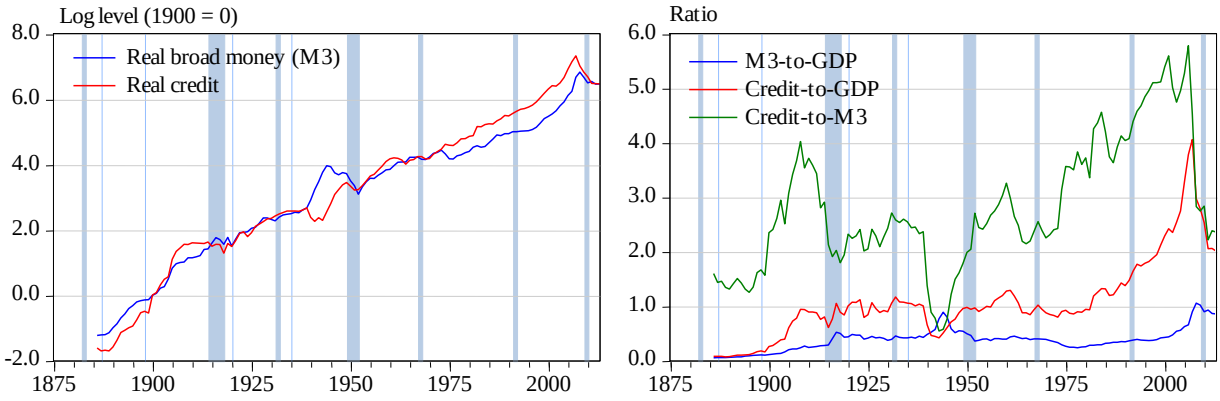
(the state-owned Landsbanki) was founded. Hence, our series extend back for 128 years (further details are in Appendix 3).

Figure 5 shows credit and money in levels (in real terms), their shares in nominal GDP, and the money-to-credit ratio. As Table 1 shows, average annual real credit and money growth has been similar over the whole sample although money growth was considerably higher in the first half of the sample than in the post-WWII period, mainly due to high growth during the two World Wars. The credit-to-money ratio decreased sharply during the occupation of Iceland in WWII when cash holdings rose considerably following a large influx of foreign soldiers, while lending remained weak.

Iceland's rapid financial catch-up is also evident in Figure 5 in the marked rise in money and credit relative to GDP, especially after the creation of the country's first and only foreign-owned commercial bank in 1904 (Íslandsbanki). The money-to-GDP ratio remained within 40-50% range from 1916-40, which is close to the average ratio reported for developed economies in Schularick and Taylor (2012). The credit ratio settled at an even higher level, or approximately 100% of GDP, which in part reflected the important role of non-money financed bank credit in Iceland and the importance of credit extension by investment credit funds at the time.

Figure 5 Money and credit

Business cycle downturns shown as shaded areas



Source: Authors' calculations (data sources described in Appendix 3).

Iceland's financial catch-up proved short-lived, however, and the financial system deteriorated consistently until the end of the 1970s due to chronic macroeconomic instability and mismanagement of the then almost fully state-owned banking system. This is apparent in the steady decline of savings in the chronic high inflation era when real interest rates were negative for years and the money-to-GDP ratio reached a low of 23½% in 1978. Credit remained close to 100% of GDP on average, however, so the credit-to-money ratio was increasing and bank credit extension relied on increased leverage within the banking sector, as will be discussed in the next section. Widespread indexation of savings and loans to inflation was formally introduced in 1979 and this marked the beginning of a new catch-up phase where credit and money began to recover. In the subsequent two decades, the domestic financial

system was liberalised and integrated with international financial markets. Finally, the run-up to and aftermath of the financial crisis in 2008 is clearly evident from the break-neck pace in pre-crisis credit expansion, with the credit ratio peaking at a whopping 400% of GDP in 2007, and the accompanying large post-crisis deleveraging, with the credit-to-GDP ratio collapsing by half and the credit-to-money ratio by almost two-thirds.

2.6 Banking system balance sheet

Financial boom-bust cycles reflect changes in the ease of managing balance sheets, in particular those of financial intermediaries. During boom phases, economies often experience a self-enforcing feedback loop of increased capital inflows, appreciating exchange rates, asset price surges, and apparently strengthening balance sheets – all of which contribute to boosting economic activity. Market participants are often inclined to take on too much debt and rely on excessively risky form of finance during such episodes, giving rise to excessive levels of financial fragility. These individual agents do not internalise the overall effects of their borrowing decisions through exchange rate and asset price changes, making financial fragility a by-product of external borrowing in small open economies with imperfect financial markets. During busts, adverse spirals kick in and induce deleveraging in the financial sector: obtaining funding becomes more difficult, capital inflows turn to outflows, exchange rates depreciate, currency mismatches increase, and asset price booms unwind; all of which can lead banks and other market agents to respond by fire-selling their assets, which reduces their net worth further, and reinforces the balance sheet constraints. These amplification effects lead to pecuniary externalities as the destabilising macroeconomic conditions cause adverse effects for the whole economy (e.g. Brunnermeier et al., 2009, Bianchi, 2011, Jeanne and Korinek, 2010, and Korinek, 2011). We therefore want to look beyond the traditional financial variables analysed in the literature, i.e. credit, money, and asset prices, and analyse the role of the entire banking system balance sheet (total assets, leverage, and the composition of liabilities) in the build-up of financial imbalances and their subsequent unwinding.[50]

First, we construct a measure of the size of the banking system relative to GDP to capture systemic risk arising from mismatches between the domestic authorities' capacity and the banking system's possible need for support in times of financial stress. This measure can also function as a proxy for market liquidity of the asset side of the banks' balance sheet, as assets may become more difficult to sell with limited price impact once the banking sector becomes very large relative to the economy. This variable can therefore be an important part in the financial boom-bust cycle and in determining the economic impact of the crisis (as found by Ólafsson and Pétursson, 2011, in a cross-country analysis of the latest global financial crisis).

The second balance sheet variable we construct is a measure of banking system leverage (the ratio of banking system assets to book-value equity) to capture to what extent assets are being financed with debt. This variable is often emphasised but missing in the literature due to limited data availability over sufficiently long periods (cf. Drehmann et al., 2012). This leverage

[50] See Pálmason (1994) for a brief history of the development of Iceland's banking system since the late 19th century to the mid-1990s.

measure is more general than the credit-to-money ratio discussed above as it encompasses a greater number of assets and liabilities, and can therefore provide additional information for analysing the financial boom-bust cycle.

Our final banking system balance sheet variable is the ratio of non-core liabilities to total liabilities, which reflects the claims on the domestic banks not held by the ultimate domestic creditors. This measure is a proxy for the funding liquidity position of the banking system and aims to capture to what extent banks shift towards more unsustainable funding sources as the traditional (monetary) ones are exhausted in financial booms. This measure has been emphasised by Hahm et al. (2013) and Borio et al. (2011) but their studies cover a much shorter time period than ours. We also distinguish between foreign and total non-core liabilities to capture the possible distinctive vulnerabilities of relying on cross-border funding and their relation to banking and currency crises which could play an important role in the financial boom-bust cycle of a small open economy, such as Iceland. A particular benefit of the length of our data series is that it allows us to analyse cross-border funding during the first phase of globalisation in the pre-WWII period (see discussion in Borio et al., 2014).[51]

As shown in Table 1, the size of the banking system increased almost threefold in terms of GDP to roughly one times GDP in the post-WWII period. The leverage ratio shows that this expansion was largely accomplished through borrowing rather than increased equity, while the non-core financing ratio suggests that an important source of this funding was through foreign borrowing. The different development phases of Iceland's banking system, discussed in the previous section are also apparent in Figure 6 in the evolution of the size of the banking system: the financial catch-up early on when bank assets reached a level of over 75% of GDP, followed by a lengthy stagnation and deterioration until 1978 when assets reached a post-WWII trough below 40% of GDP. In fact, the bank asset-to-GDP ratio was similar in Iceland as the median case documented in Schularick and Taylor (2012) from 1920 to the late 1960s, but the rate of balance sheet expansion was very different from 1970-1995 and the asset ratio did not reach its pre-WWII peak until 1998. However, the balance sheet expansion reached an unprecedented level following the liberalisation of capital flows and privatisation of the state-owned banks, resulting in bank assets peaking at close to a staggering 940% of GDP in 2007 with cross-border assets and liabilities making up a large share of the balance sheet. Hence, this is an example of total banking system assets far exceeding the domestic credit-to-GDP ratio due to cross-border activities and asset holdings.

Another noteworthy feature of Figure 6 is that during the post-WWII period, leverage has peaked at times of balance sheet stagnation or reduction, rather than expansions. Hence, changes in leverage over this period may to a larger extent reflect the banks' response to declining deposit funding (discussed above) rather than increased willingness to expand and take on more risk.[52] This comes with a caveat: although the sharp expansion in the run-up to

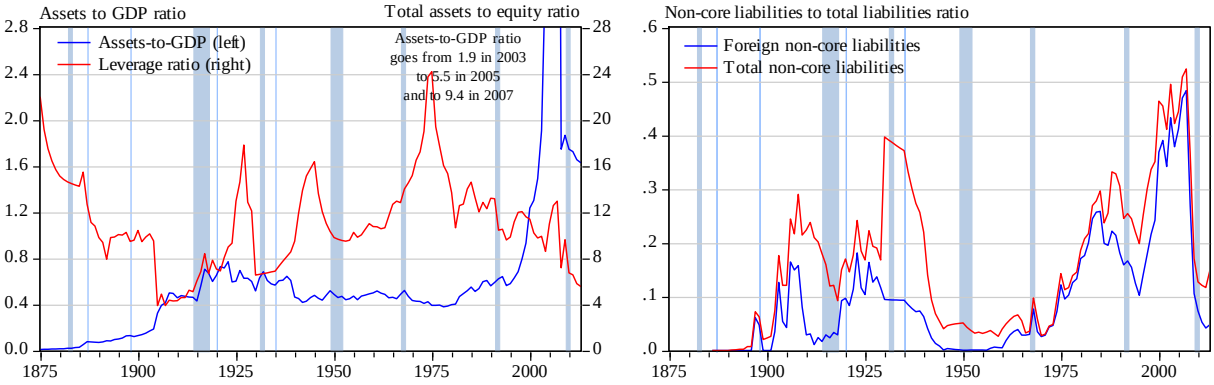
[51] Our four balance sheet measures are based on various sources of balance sheet data for commercial banks and savings banks, with banking system assets and leverage available from 1875 while the two non-core liability measures are available from 1886 (see Appendix 3 for details).

[52] The peak in leverage in the 1920s is different, however, as it was driven by the Icelandic authorities' efforts to expand the poorly capitalised state-owned Landsbanki and dismantle the foreign-owned Íslandsbanki after the latter experienced foreign-currency shortages in 1920-21 (see the discussion in Section 3.2). Following a change

the financial crisis in 2008 was not reflected in large increases in leverage based on book value, de facto quality and quantity of bank capital in this period has been seriously questioned (Rannsóknarnefnd Althingis, 2010).

Figure 6 Banking system balance sheet

Business cycle downturns shown as shaded areas



Source: Authors' calculations (data sources described in Appendix 3).

Finally, Figure 6 shows the evolution of non-core liabilities, which mainly consist of bond issuance and credit from other financial institutions, both domestically and on foreign wholesale markets.[53] The two phases of financial globalisation are apparent as cross-border funding plays an important role prior to the Great Depression and again from the 1970s and onwards. In 1906-08, approximately 15% of the banking system's borrowings came from abroad but the scale of foreign funding was actually larger as Íslandsbanki had foreign equity amounting to close to 10% of GDP. Access to foreign funding became more restricted following the global bank panic in 1907 and during WWI, but opened up again after WWI reaching a pre-WWII peak of 18% of total liabilities in 1923, but only after the government had intermediated state-guaranteed foreign funds to the banking system following the foreign liquidity crisis in 1920-21. After the collapse of Íslandsbanki in 1930 (see Section 3.2), a state-controlled banking system was resurrected, although only after foreign creditors agreed to swap a share of their claims into bank equity which was subsequently paid down. From WWII and until the mid-1970s, non-core liabilities played a limited role in the banks' funding.

Access to foreign funding increased again in 1970 after Landsbanki joined a cross-national consortium of Nordic banks to gain an easier access to global wholesale markets (Jacobsen and Tschoegl, 1999). A short-lived decrease in cross-border funding took place following the Nordic banking crisis in the early 1990s, only to skyrocket after the liberalisation of capital flows in 1995 and Iceland's participation in the European "passport" system through its membership in the European Economic Area, which enabled the recently privatised

in law in 1921 forcing Íslandsbanki to sell its base metal reserves to Landsbanki at a discount, the state-owned bank expanded and became the country's central bank with a further capital injection, and an explicit state-guarantee on all its liabilities in 1927 and 1928 (Björnsson, 1961, 1981).

[53] The split between domestic and foreign is not clear-cut in the pre-WWII period as some foreign borrowing may have been categorised as domestic in the bank's accounts (Björnsson, 1981).

commercial banks to expand their cross-border operations and thus sow the seeds of their own destruction (Gudmundsson, 2013). Non-core banking liabilities peaked at over 50% of total banking system liabilities prior to the latest financial crisis (the bulk of it being in foreign currency) before collapsing to its 1970s level of 4% in 2012.

3 Different types of financial crises

Although financial crises come in many shapes and forms, and can be defined in several ways, they share a number of commonalities that allow us to define them as episodes involving, inter alia, severe disruptions in financial intermediation that typically include large collapses in asset prices and credit volumes, serious strains on balance sheets, and collapses of financial institutions. Government intervention is often required in an attempt to contain these disruptions which often involves the use of fiscal resources and central bank balance sheets. These events can often spread over national borders and become global, either through common sources or through contagion across countries.

The fact that financial crises can take on many guises requires an identification of different types of financial crises. In this section we therefore aim to identify the most common types: currency crises (and their close relatives, inflation crises) and banking crises.[54] As financial crises often come in waves, we also construct a "multiple financial crisis indicator" in Section 4 to capture the clustering nature of the most severe crisis episodes in a single indicator.

3.1 Currency and inflation crises

Currency crises usually involve a speculative attack that can lead to a large devaluation or depreciation of the currency. They can also involve large interest rate hikes, a rapid depletion of foreign reserves, or restrictions on capital outflows as the authorities attempt to halt the collapse of the currency. These crises are often triggered by unsustainable economic fundamentals, but can also be triggered by a self-fulfilling panic in a multiple equilibria context or arise due to serious balance sheet mismatches (see Claessens and Kose, 2014, for an overview).

[54] The literature has identified other types of financial crises, mainly stock market, debt, and sudden-stop crises (cf. Reinhart and Rogoff, 2009, and Claessens and Kose, 2014). We do not cover stock market crises in Iceland as stock market data does not extend further back than the mid-1980s, while no incidences of sovereign debt crises are recorded for Iceland (see Reinhart and Rogoff, 2011), although the introduction of capital controls and frequent inflationary bouts are certainly versions of default – although default through inflation holds less clout for Iceland as a significant chunk of government debt is indexed to inflation. Sudden-stop crises are discussed in the main text in the context of other crises, mainly currency and banking crises, as these tend to be closely intertwined in such a small economy like Iceland.

Table 3 Currency and inflation crises in Iceland

Currency crises				Inflation crises		
Date	Duration (in years)	Cumulative depreciation	Average depreciation per year	Date	Duration (in years)	Average inflation per year
1919-20	2	0.526	0.263	1916-18	3	0.383
1932	1	0.219	0.219			
1939	1	0.211	0.211	1940-43	4	0.291
1950	1	0.508	0.508	1950-51	2	0.335
1960	1	0.535	0.535			
1968-69	2	0.497	0.248	1969	1	0.241
1974-85	12	0.978	0.082	1973-89	17	0.392
1988-89	2	0.324	0.162			
1993	1	0.151	0.151			
2001	1	0.194	0.194			
2008-9	2	0.482	0.241			
			Averages			
11 episodes	2.4	0.420	0.256	5 episodes	5.4	0.328

The table reports the dates of currency and inflation crises as identified by the numerical thresholds suggested by Reinhart and Rogoff (2009, 2011): exchange rate crises are defined as episodes where annual depreciations is greater than 15% per annum and inflation crises as episodes where annual inflation is in excess of 20% per annum (there are a few exceptions though explained in the main text).

Source: Authors' calculations (data sources described in Appendix 3).

To identify currency and inflation crises, we adopt the numerical criteria suggested by Reinhart and Rogoff (2009, 2011): for currency crises the threshold value is an annual depreciation of more than 15% per annum, while the threshold for inflation crises is an annual inflation rate of more than 20% per annum.[55] This criteria gives eleven episodes of currency crises in Iceland in our sample period with an average duration of 2.4 years (see Table 3 and Figure 7).[56] As can be seen, most of the currency crises identified are short-lived with more than half of the episodes lasting a year. One episode stands out in terms of its longevity: the currency crisis starting in the mid-1970s which lasts for more than a decade with a cumulative depreciation amounting to almost 98%. Some of the shorter crisis episodes are also nastier than others: the crises in the early 1920s, in 1950, the two crises in the 1960s, and the latest one, all saw a collapse of close to 50%.

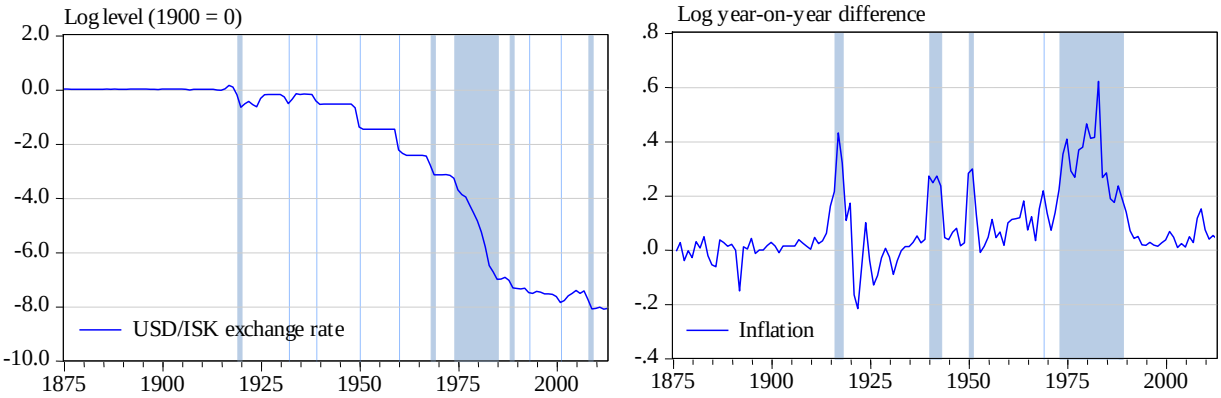
[55] The currency threshold is similar to the 25% threshold proposed by Frankel and Rose (1996) but the inflation threshold is somewhat lower than what is sometimes used in similar studies (with 40% a common threshold), but as Reinhart and Rogoff (2009, 2011) point out inflation is usually well below the 20% during the gold standard period and a higher threshold would lead us to miss some potentially important crisis episodes. The threshold chosen is also well below standard definitions of hyperinflation but our interest goes beyond such extreme episodes. In fact, the use of standard definitions of hyperinflation would turn up zero events for Iceland. In Appendix 2 we analyse how sensitive our dating results are to variations in the threshold levels for currency and inflation crisis. Unsurprisingly, we find that the number of crisis episodes declines when the threshold level is increased: for currency crises the number of episodes falls to seven or eight when the threshold is raised to 30-50%, while the number of inflation crises falls to three when the inflation threshold is doubled to 40%.

[56] Although the average currency depreciation falls just short of the 15% threshold in 1974, we decide to start the currency crisis in that year rather than in 1975 as the currency was already depreciating by 20-40% in the latter half of 1974. For the same reason we decide to start the crisis in 1988 rather than in 1989 (with the currency already declining by 20% in the latter half of 1988). With the average depreciation in 1977 just shy of 10%, the simple threshold criteria suggests that the crisis ends in 1976 and resumes in 1978, but we decided to include 1977 as well.

Another noteworthy feature is that all but the last episode occur during a period which Iceland was following some type of an exchange rate peg (see Gudmundsson et al., 2000). Many of these episodes reflect attempts to depreciate an overvalued currency following a sharp deterioration of terms of trade or a collapse in export demand (1950, 1960, 1968-69, and 1993), while some also reflect capital flow reversals and foreign currency shortages (1919-20, 1932, and 2008-09). In all too many of these cases the peg proved unsustainable, with monetary policy too accommodative, fiscal policy too expansive, and domestic demand unsustainably high. A clear example of this is the chronic crisis episode in the mid-1970s to late 1980s, and the episode culminating in a currency attack on the fixed exchange rate regime in 2001 that finally brought an end to any attempt to peg the currency. Although the latest currency crisis occurs within a floating exchange rate regime, most of the characteristics described above also came together during this crisis: unsustainable level of demand and a large current account deficit, a sharp deterioration of external conditions following the global financial crisis, and large and vulnerable balance sheets following the enormous asset price and credit booms in the preceding years. We will return to this theme in our discussion of multiple financial crises in Sections 4 and 5.

Figure 7 Currency and inflation crises

Currency crises (left) and inflation crises (right) shown as shaded areas



Source: Authors' calculations (data sources described in Appendix 3).

Not surprisingly, the dating of inflation crises closely follows those of currency crises.[57] Our criteria gives five inflation crisis episodes with an average duration of 5.4 years. All the inflation crisis episodes coincide with currency crisis episodes, with the temporal sequence usually from a currency crisis to an inflation crisis, although it can be argued that the key source

[57] The simple correlation between these two types of fiat-money crises is 0.51, while the concordance index (see Table 5 below), which measures the relative frequency of both indicators giving the same signal, is 0.85. A close connection between inflation and currency crises is also found in Reinhart and Rogoff (2009). As with the currency crisis dates, we also need to make a judgement call on the inflation crisis dates as average inflation for 1987 falls just below the 20% threshold (measures 18.9%), but we decided to include that year in our chronic inflation crisis episode in the 1980s rather than having the crisis end in 1986 and resume in 1988 (with inflation ranging between 12% and 18% in the first half of 1987 and above 20% in the latter half of the year).

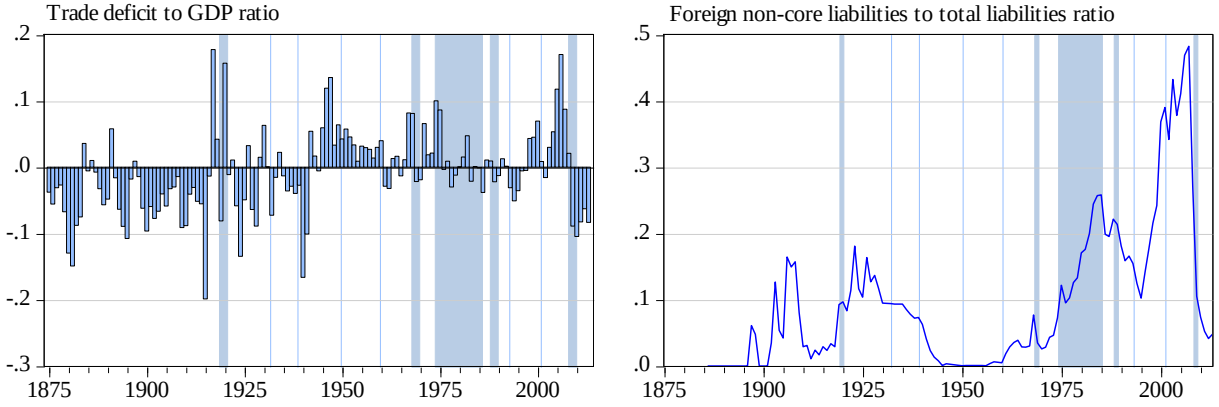
for the high real exchange rate and its subsequent correction is usually to be found in the chronic inflation throughout a large part of the period.

Currency crises and sudden stops

Currency crises frequently occur during periods of sharp current account reversals as funding of large current account deficits suddenly halts and capital starts flowing out of the country leading to strong pressures on the currency. Sudden stop crises (or balance of payment or capital account crises) therefore often go hand in hand with currency crises (see Claessens and Kose, 2014, for an overview). Although we do not have data on aggregate capital flows for the whole sample period, we see this pattern clearly in the trade balance data discussed previously (see Figure 8). All of the currency crisis episodes coincide with an improvement in the trade balance and seven of the eleven currency crises coincide with relatively large improvements (more than one standard deviation): the three first episodes in the 1920s and 1930s, the one in the late-1960s, the chronic episode in the 1970s to 1980s, the 2001 episode, and the latest 2008-9 crisis.

Figure 8 Trade balance and foreign funding of domestic banks

Currency crises shown as shaded areas



Source: Authors' calculations (data sources described in Appendix 3).

Sudden stop crises are commonly defined as episodes where large capital flow reversals (using a threshold value of two standard deviations) coincide with output collapses (cf. Calvo et al., 2008, and Forbes and Warnock, 2012). Applying this definition to our trade balance data narrows this down to two episodes: the 1919-20 crisis and the most recent 2008-9 crisis. Both led to a very large depreciation of the currency and a reversal of the trade balance amounting to 20-30% of GDP from peak to trough. It is also interesting that widespread capital controls were introduced in both instances: temporary controls on current account and capital account movements in the first episode, while widespread capital account restrictions were introduced in the most recent crisis in 2008-9, which have yet to be fully abolished. Widespread current

and capital account controls were also introduced in the early 1930s, but that episode falls just shy of the two standard deviation threshold.[58]

This pattern of currency crises and sharp capital flow reversals is less clear when looking at foreign currency funding of local banks (Figure 8): although the foreign funding share usually declines following a financial crisis, these are usually relatively small and only in the last episode do we see a clear reversal when the foreign currency share plummets from a historical record high of 48% of total banking liabilities in 2007 to 7% in 2010. The domestic banks nevertheless faced severe foreign funding pressures in the crises in the 1920s and 1930s, but in both instances the government intervened and foreign funding was maintained. Despite the sequence of currency crises in the 1970s, the banks' foreign funding rose throughout this period. This probably reflects Landsbanki's membership of a cross-national consortium of Nordic banks, which was discussed in Section 2.6.

3.2 Banking crises

Banking crises are the type of financial crises which often have the most profound effects on the real economy in terms of lost output and jobs (see e.g. Kaminsky and Reinhart, 1999, and Frydl, 1999). They can arise for a multitude of reasons through weaknesses on either the asset or liability sides of bank's balance sheets (Claessens and Kose, 2014, give an overview of the literature). These weaknesses can be system-wide or start in an individual bank and spread through panic to a significant part of the banking system. They can end with outright failures of banks or a significant restructuring – often through costly government interventions.

Unlike the numerical criteria for dating currency and inflation crises, the criteria for identifying banking crises is more subjective which often makes the specification of the exact start and finish of the crises elusive. This reflects the fact that a specific and unified numerical measure to signal an onset of a banking crisis is hard to come by as they tend to vary in how they develop. We therefore follow the standard practice in the literature in basing our event criteria on identifying dates were there are significant signs of financial distress in the banking system, as reflected in large-scale bank runs (be that a conventional run on deposits or a more "modern" run on wholesale funding) that lead to the closure, merging, or public sector takeover of a significant share of the banking system (see e.g. Reinhart and Rogoff, 2009, and Laeven and Valencia, 2013). We also identify the less onerous banking crises that do not lead to large-scale banking collapses but still require some type of restructuring and capital injection from the public sector to some important financial institution as being non-systemic. The fact that banking crises in Iceland from the 1970s to the present day have already been identified by Caprio and Klingebiel (2003), Reinhart and Rogoff, (2009) and Laeven and Valencia (2013) makes life somewhat easier for us. Our task therefore basically involves extending the already existing dates back to the start of our sample period in 1875.

[58] The 1939 crisis also sees a trade reversal that exceeds the two standard deviation threshold but in that case we observe a large increase in domestic demand and output rather than a contraction due to the positive effects from the outbreak of WWII on the Icelandic economy.

Using these criteria, we identify five banking crisis episodes, covering 10 years (or 7.2%) of our 139 year sample period. Thus, banking crises occur on average every 22 years and last for 2 years (see Table 4). The 7.2% share of years in a banking crisis is very close to the average share found in Reinhart and Rogoff (2009, Table 10.5) for other European countries (6.3%) and advanced economies in general (7.2%) for the period 1800 to 2008. The average duration of 2 years also closely matches what they find for other European countries and advanced economies in general (2.1 and 2.2 years, respectively).

We follow Caprio and Klingebiel (2003) in defining two of these as non-systemic (see also Reinhart and Rogoff, 2009, 2011). The first of the two occurs in 1985-86 when one of the three state-owned banks (Útvegsbanki), with a market share of roughly 7% of total lending at the time, became insolvent following a bankruptcy of a major borrower, eventually leading to a government-led merger of the bank with three private banks in 1990. The second non-systemic banking crisis occurs in 1993 when the larger of two state-owned banks (Landsbanki), with a market share of roughly 17% of total lending at the time, needed a capital injection amounting to 1% of GDP due to large loan losses following the recession in the years leading up to the crisis. As Table 4 shows, neither of these two non-systemic banking crises led to a contraction in the aggregate supply of real credit to the economy or had a very large impact on government finances.

Table 4 Banking crises in Iceland

Date	Type	Duration (in years)	Market share of distressed institutions[1]	Change in real credit[2]	Change in fiscal balance[3]	Increase in government debt[4]
1920-21	Systemic	2	0.798	-0.172	-0.033	0.136
1930-31	Systemic	2	0.664	-0.097	-0.028	0.115
1985-86	Non-systemic	2	0.074	0.091	-0.053	0.039
1993	Non-systemic	1	0.172	0.015	-0.009	0.088
2008-10	Systemic	3	0.935	-0.813	-0.160	0.640
Average		2.0	0.529	-0.195	-0.057	0.204

The table reports the dates of banking crises used in this study. The dates identified for the 1985-86 and 1993 crises are obtained from Caprio and Klingebiel (2003) (also used by Reinhart and Rogoff, 2009, 2011), while we use Laeven and Valencia (2013) to date the start of the latest crisis. To date the two pre-WWII crises we used archived documentation (see the main text). 1. Share of distressed financial institutions in total credit by deposit money banks and other lending institutions in year $T-1$, where T is the starting year of the banking crisis. 2. Change in total real credit between year $T-1$ and T. 3. Change in central government fiscal balance between year $T-1$ and the post-crisis trough in years T to $T+3$ (ratio to GDP). 4. Change in central government debt between year $T-1$ and the post-crisis peak in years T to $T+3$ (ratio to GDP).

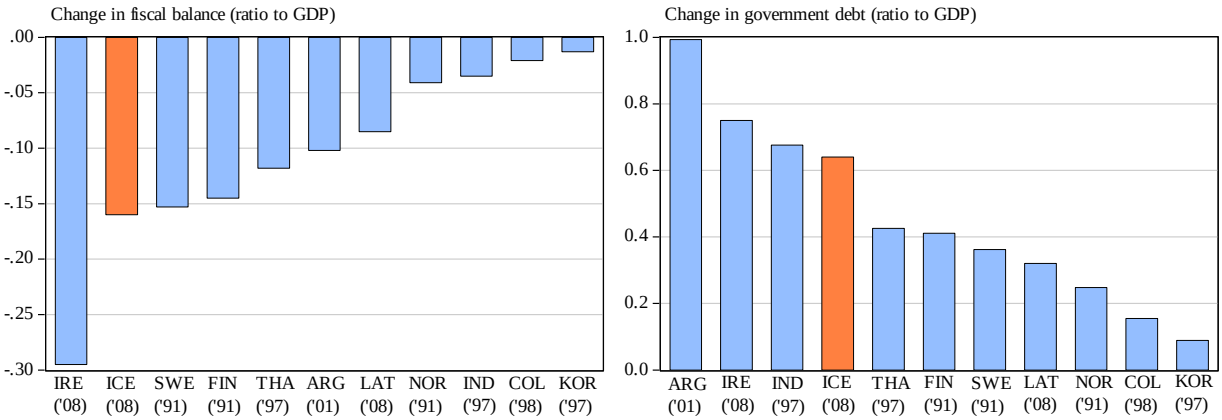
Source: Authors' calculations (data sources described in Appendix 3).

The three remaining crises were much more serious and left larger footprints on the real economy and none more so than the latest one, which hit in late 2008. Iceland's three large cross-border commercial banks collapsed following Lehman Brothers' bankruptcy in the autumn of 2008 (amounting to roughly 85% of the financial system), shortly followed by the failure of most of the smaller saving banks and other financial institutions, eventually leading to failure of more than 90% of the total financial system. We follow Laeven and Valencia (2013) and date the start of the crisis in 2008 rather than a year earlier as in Reinhart and Rogoff (2009, 2011). As in all of these studies, the crisis is assumed to end in 2010 with the completion of

bank failures when the three largest savings banks were taken over by the financial supervisory authorities. The macroeconomic consequences of the crisis were huge: per capita domestic demand collapsed by almost 28% and GDP lost 8% from 2008 to 2010. The fiscal impact was also enormous: the fiscal balance deteriorated by 16% of GDP and central government debt rose by 64% of GDP.

The other two systemic crises were not as severe and fell upon a banking system that was dwarfed in terms of sheer size compared to the latest episode, but would still register on any banking crisis barometer. The former occurred in the start of the 1920s when the banking system ran into loan losses and foreign currency shortages that led to a seizure of cross-border payments for some months. The government eventually bailed out the two large commercial banks (Íslandsbanki and Landsbanki), suppliers of almost 80% of total lending, by guaranteeing a large foreign loan amounting to 8% of GDP (see Ísleifsson, 1986, Nordal, 1997, and Jónsson 2009).[59] The fiscal impact is sizeable, with government debt rising by almost 14% of GDP. The second crisis takes place in the early 1930s and is slightly smaller than the previous one. It starts when Íslandsbanki (with a market share of 30%) again ran into loan losses and foreign currency liquidity problems, which eventually led to its bankruptcy in 1930. Landsbanki (with a market share of roughly 35%) also experienced severe foreign currency shortages in 1931, which led to the introduction of limits to current account trades and related foreign exchange transactions (see Björnsson, 1961, and Nordal, 1997).

Figure 9 Fiscal impact of selected banking crises



Change in government fiscal balance between year $T - 1$ and the post-crisis trough in years T to $T + 3$ (ratio to GDP) and change in government debt between year $T - 1$ and the post crisis peak in years T to $T + 3$ (ratio to GDP). The countries are Argentina (ARG), Columbia (COL), Finland (FIN), Iceland (ICE), Ireland (IRE), Indonesia (IND), Korea (KOR), Latvia (LAT), Norway (NOR), Sweden (SWE) and Thailand (THA). Year of start of crisis in parenthesis.

Sources: International Monetary Fund (WEO database), Laeven and Valencia (2013) and Table 4.

The average share of roughly half of the financial system in distress over the five episodes is slightly higher than the 40% share that Caprio et al. (2005) find for banking crises since 1970 among medium and high income countries. The average increase in government

[59] This also coincided with a number of bank collapses in Scandinavian during the 1920s, including some of the main creditors of the Icelandic banks (see Cohn, 1958, and Wetterberg, 2009).

debt of 20% of GDP is also comparable to the 24% increase Laeven and Valencia (2013) find for advanced economies for the period 1970-2011. Comparing average values, however, masks how the latest episode stands out in terms of severity. Caprio et al. (2005) record only seven instances where 90% or more of the banking system fails (Bangladesh, Cote d'Ivoire, Guinea and Tanzania in the late 1980s, and the Central African Republic, Costa Rica and Poland in the early 1990s), while very few financial crises have left a larger hole in government finances as seen in Figure 9.

4 Multiple financial crises

4.1 Identifying multiple crises

In Table 5 we summarise the key statistical properties of the indicator variables we have constructed to capture the dates of different types of financial crises and economic downturns (both regular cyclical downturns and the more serious demand disaster episodes). We report the number of years in a given crises, the number of crisis episodes, and the average duration of each crisis for the whole sample period and for the two subsamples. The first thing to notice is that the incidence of currency and inflation crises is mostly concentrated in the post-WWII period, both in terms of number of episodes and the number of years in a state of crisis. Currency and inflation crises have also tended to last longer in the second period, but no such difference is apparent for banking crises, whose relative incidence and duration is very similar across the two subsamples. The table also shows that while regular cyclical downturns have become slightly less common in the post-WWII period (albeit lasting longer) in line with declining economic volatility reported in Table 1, the incidence of the more catastrophic demand disaster has actually increased.

Finally, Table 5 reports the concordance index originally suggested by Harding and Pagan (2002) adopted here to capture the co-movement of any two crisis indicators (i.e. the relative number of years when a pair of two indicators gives the same signal). Thus, the currency and inflation crisis indicators give an identical signal in 85% of the time, with the index in general ranging from 0.7-0.9 for other indicator combinations, suggesting that the indicators tend to give the same signal most of the time. This measure, however, overstates the coincidence of our crisis signals as the relatively frequent "no crisis" signal inflates the statistics.

At the same time, the concordance index may provide a too narrow measure for capturing the typical clustering behaviour of different types of financial crises (a common finding in the literature, see Reinhart and Rogoff, 2009, for an overview) as it only captures crisis episodes occurring within the same year. The concordance index therefore does not capture the possibility of crises that come in a sequence over a period of some years. For example, Kaminsky and Reinhart (1999) find that currency and banking crises often go hand in hand (a so-called twin crisis) with problems in the banking sector usually predating the currency crisis, as problems in the banking system lead to a collapse in overall confidence in the economy and a run on the currency. An inflation crisis would typically follow the currency crisis, especially in small open economies with poorly anchored inflation expectations. The alternative

sequence is of course also possible, with a currency collapse wreaking havoc in private non-financial sector balance sheets (especially if they are characterised by currency mismatches), leading to large loan losses and eventually to bank collapses.[60] Finally, financial turbulences can also be triggered by adverse events in the real economy, such as a sharp deterioration of terms of trade and a marked slowdown of growth. The financial crisis can therefore amplify the economic downturn instead of triggering it. Indeed, Reinhart and Rogoff (2009) find that this amplifying nature of financial crises is quite common. Furthermore, these crisis clusters typically lead to deeper and longer recessions (see also Bordo et al., 2001) and are usually associated with severe disaster episodes as defined by Barro and Ursúa (2008).

Table 5 Summary statistics for crises and downturns

	Currency crises	Inflation crises	Banking crises	Multiple financial crises	Cyclical downturns	Demand disasters
			Total sample (1875-2013)			
Number of years	26	27	10	22	23	25
Share of sample	0.19	0.19	0.07	0.16	0.17	0.18
Number of episodes	11	5	5	6	11	9
Duration (in years)	2.4	5.4	2.0	3.7	2.1	2.8
			First subsample (1875-1944)			
Number of years	4	7	4	10	13	7
Share of sample	0.06	0.10	0.06	0.14	0.19	0.10
Number of episodes	3	2	2	2	7	4
Duration (in years)	1.3	3.5	2.0	5.0	1.9	1.8
			Second subsample (1945-2013)			
Number of years	22	20	6	12	10	18
Share of sample	0.32	0.29	0.09	0.17	0.14	0.26
Number of episodes	8	3	3	4	4	5
Duration (in years)	2.8	6.7	2.0	3.0	2.5	3.6
			Concordance index (total sample)			
Currency crises	1.00	0.85	0.81	0.78	0.72	0.79
Inflation crises		1.00	0.76	0.73	0.71	0.74
Banking crises			1.00	0.87	0.82	0.82
Multiple financial crises				1.00	0.91	0.91
Cyclical downturns					1.00	0.84
Demand disasters						1.00

The table reports the number of years in a given crisis and the relative share of years in a crisis state (the number of years in crisis divided by total or subsample size). The table also reports the number of crisis episodes and the average duration of each crisis in years. The dates for currency and inflation crises can be found in Table 3, while the dates for banking crisis can be found in Table 4 and dates for the multiple financial crises indicator in Table 6 below. Dates for cyclical downturns and demand disasters are reported in Table 2. The table reports summary statistics for the total sample from 1875-2013 (139 years) and for two subsamples: the period 1875-1944 (70 years) and the period 1945-2013 (69 years). The concordance index of Harding and Pagan (2002) measures the fraction of time each pair of indicators gives the same signal.

Source: Authors' calculations (data sources described in Appendix 3).

To capture this clustering nature of financial crises in a single "multiple financial crisis indicator", we apply a version of the Harding and Pagan (2006) non-parametric common cycle

[60] A currency crisis that goes hand in hand with loss of cross-border funding and limited domestic lender of last resort capacity in foreign currency can also lead to a more rapid banking system collapse.

algorithm in an attempt to identify episodes where our different indicators signal a common crisis. Specifically, we calculate the end-date of a crisis for the three financial crisis indicators and our two macroeconomic measures capturing cyclical downturns and the more punishing demand disaster episodes, as we want to concentrate on the more severe crisis episodes. For each indicator we then calculate the minimum distance at each point of time to the end-date of the next crisis and from that we construct a single common end-date indicator as the median of the calculated distances for the five indicators. A common crisis is then identified when the following two conditions are fulfilled: (1) there is a local minimum in the common indicator; (2) there is as cluster of end-dates, identified when at least 4 of the 5 indicators have an end-date within two years from the common end-date. If the common end-date is not uniquely determined using the above algorithm we use the date which gives the lowest average distance to the end-date of the individual indicator, as in Drehmann et al. (2012).

Table 6 Multiple financial crises in Iceland

Multiple financial crises		Cumulative contraction		Coinciding crises and economic downturns				
Dates	Duration (in years)	Per capita demand	GDP	Currency crises	Inflation crises	Banking crises	Demand disasters	Cyclical downturns
1914-21	8	0.127	0.086	1919-20	1916-18	1920-21	1914-15 1918 1923-24	1914-18 1920
1931-32	2	0.179	0.034	1932		1930-31	1931-32	1931-32
1948-51	4	0.309	0.043	1950	1950-51		1948-51	1949-52
1968-69	2	0.155	0.045	1968-69	1969		1968-69	1967-68
1991-93	3	0.075	0.023	1993	1973-89	1993	1988-93	1991-92
2008-10	3	0.266	0.069	2008-9		2008-10	2007-10	2009-10

The table reports the dates of multiple financial crises identified and the currency, inflation and banking crises, and demand disasters and cyclical downturns previously identified around these financial crisis episodes (see Tables 2-4). Also reported is the duration of these financial crises and the cumulative loss in per capita domestic demand and output in these episodes.

Source: Authors' calculations (data sources described in Appendix 3).

This algorithm gives us six common crisis episodes with end-dates in 1918, 1932, 1951, 1969, 1993, and 2010.[61] We adopt these end-dates for the common multiple crisis indicator

[61] Thus, our algorithm excludes the currency and inflation crises in the 1970s and 1980s and the non-systemic banking crisis in the mid-1980s as output and domestic demand were actually growing robustly throughout most of the period. Extending the cluster width to 3 years as in Drehmann et al. (2012) does not alter our results. Neither does adding turning point censoring rules as suggested by Harding and Pagan (2006). We also tried specifying the algorithm in terms of common starting dates. This gave us the same six common crisis episodes, except that the one in the early 1990s becomes only weakly identified (only identified by three of the five indicators or needing an extension of the window to 4 years). The common starting dates, although not as tightly identified as the common end-dates in the main text, are also very similar to those chosen. We also applied the algorithm exclusively to the financial crisis indicators where a cluster is identified when at least two of the three have an end-date within two years from the common end-date. This gave us the same six episodes with broadly the same end-dates but also included three additional end-dates (1941, 1986, and 1989). However, the first two additional dates can hardly be categorised as severe financial crises as they coincided with robust economic activity (average GDP growth ranged from 12% to 17% per year in 1940-1942 and was over 3% throughout the latter half of the 1980s).

(although extending the first one to 1921, as explained below), while looking at each episode in turn to define the start dates according to the corresponding start-dates of individual financial crisis episodes or a demand disaster (explained below). Table 6 summarises key statistics for the six episodes.

4.2 The anatomy of the six multiple crisis episodes

In this subsection we discuss our six crisis episodes in more detail, both in terms of the exact timing of the crises and the sequence of events. We also discuss the development of our macroeconomic and financial variables, shown in Figure 10, in the run-up to and aftermath of each episode. To analyse their behaviour, we look at each variable relative to its long-term trend. The pattern we are interested in is whether our variables, the financial variables in particular, tend to grow faster than what is implied by their trend in the lead up to the crisis and fall below their trend once the crisis unfolds. If a set of particular variables shows such behaviour systematically in the run-up to financial crises, they might serve as useful early-warning indicators for future financial crises. Alternatively, we may find that each episode is different and that an alternative set of variables signals an upcoming crisis in each case.

To estimate the long-run trend of each variable we need to strike a balance between allowing a relatively smooth trend that can still capture possible changes in the trend due to structural breaks over the long period we analyse, for example due to financial deepening and shifting degree of financial globalisation, against simply matching the actual variable too closely. We therefore use the Hodrick-Prescott (1980, 1997) filter, which is a standard method for estimating flexible trends in economic data. This approach has also been used for analysing financial cycles in a number of studies, such as Gourinchas et al. (2001) and Mendoza and Terrones (2008), and is recommended by the Basel Committee (2010) for estimating financial gaps for establishing capital buffers (see also Drehmann et al., 2010).

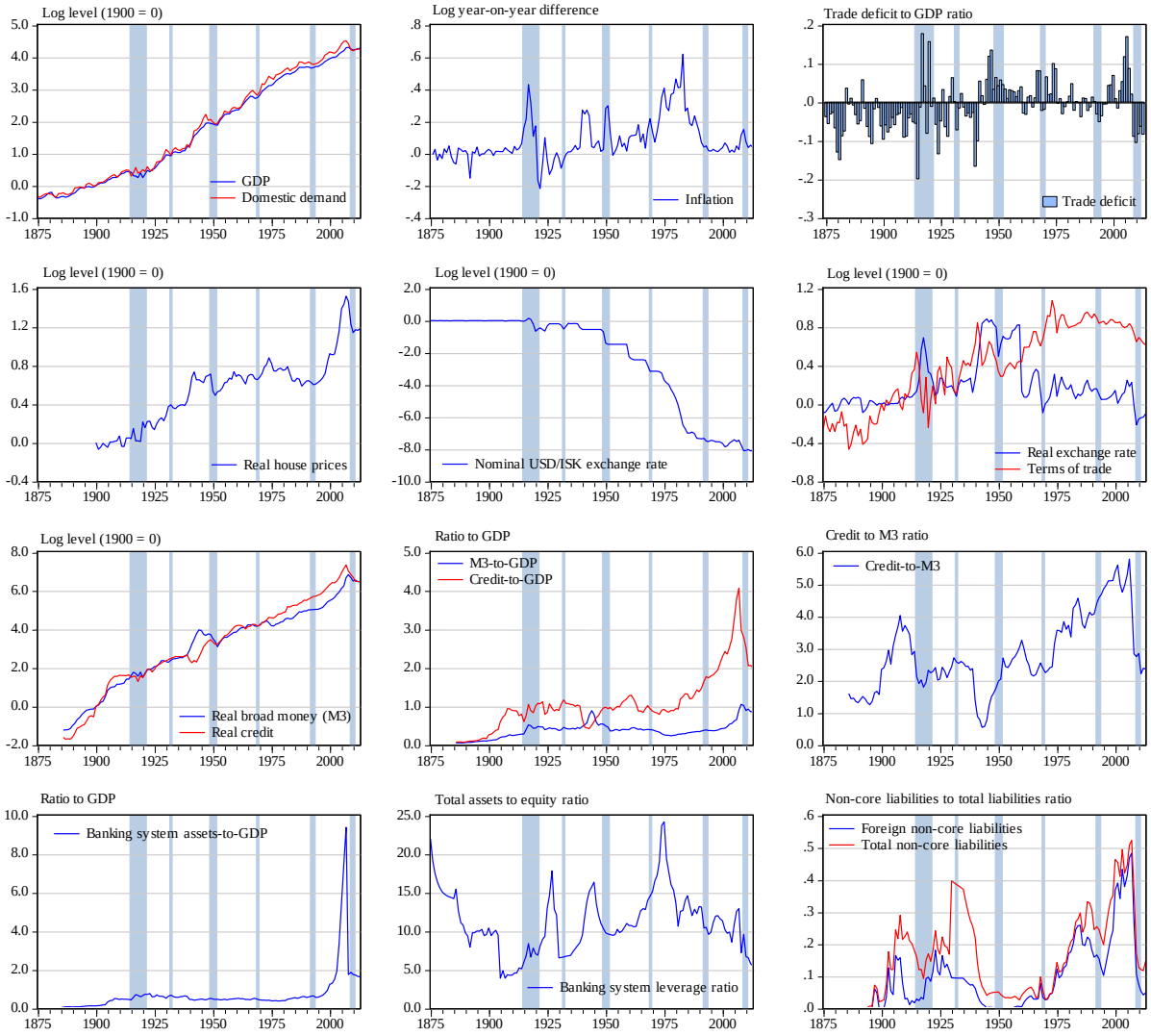
When using the Hodrick-Prescott filter, one must choose the value of λ, which determines how much weight to put on minimising the variability in the cyclical component of the series relative to the smoothness of the trend component (a higher value of λ imposes more smoothness on the estimated trend). Hodrick and Prescott recommend using λ = 1,600 for quarterly data, which has become a standard value for business cycle analysis with quarterly data and can be shown to correspond to a business cycle frequency of roughly 7.5 years. As financial cycles are thought to be longer than regular business cycles, the Basel Committee (2010) recommends using a higher λ value.[62] In particular, based on the results in Drehmann et al. (2010), they recommend using the value 400,000 for quarterly data which corresponds to a financial cycle that is four times longer than the regular business cycle [$\approx 4^4 \times 1{,}600$)]. To derive the corresponding weight for annual data, we follow Ravn and Uhlig (2002) who show that the optimal transformation involves multiplying the quarterly λ weight with the fourth power of the observation frequency ratio. This gives us a λ value of 1,563 [= $(¼)^4 \times 400{,}000$)] which we use

[62] The properties of the financial cycle in Iceland is the topic of our companion paper (Part II).

in this paper.[63] Finally, as in Mendoza and Terrones (2008), we choose to base our trend estimate on the full sample estimate rather than using recursive estimate as in Gourinchas et al. (2001) or a fixed rolling window estimate in the run up to each crises as in D'Ariccia et al. (2012) as our annual observations would leave us with too few observations to estimate the trend with any precision in the early part of the sample or in the run-up to crisis that follow fast on the heels of one another.

Figure 10 Multiple financial crises in Iceland

Multiple financial crises shown as shaded areas



Source: Authors' calculations (data sources described in Appendix 3).

[63] For the regular business cycle weight of 1,600 for quarterly data this corresponds to a value of 6.25 [= (¼)^4 × 1,600)] for annual data. This is a much lower than the value of 100 originally suggested by Hodrick and Prescott for annual data (obtained as (¼)^2 × 1,600, which Ravn and Uhlig show is a sub-optimal transformation). Our λ value is close to the λ value of 1,000 used by Gourinchas et al. (2001) but higher than the value of 100 used by Mendoza and Terrones (2008). We also tried using a value of 100 with broadly similar results.

Tables 7.a-c summarise the results in terms of heat maps for each of the six crisis episodes for the period [T – 5 to T + 5], where T is the first year of the crisis. The upper panel of each table shows the financial variables included in our sample and the lower panel the macroeconomic variables. Each heat map shows the deviations of a given variable from its long-term trend in terms of the number of standard deviations of the cyclical component of each variable. Red colours denote that the variable is above trend, while blue colours denote that the variable is below trend, with darker shades denoting larger deviations from trend. We now proceed to discuss each episode in turn.

The 1914-1921 crisis

We assume that the first multiple financial crisis starts in 1914 with the onset of WWI, which marked the beginning of a period of prolonged economic hardship and a sequence of financial crises. The Icelandic economy was especially vulnerable to the outbreak of WWI due to its heavy reliance on foreign trade. The country's export ratio was among the highest in Europe and most manufacturing goods and approximately half of food consumption were imported (Jónsson, 2004). Trade restrictions and enforced trade agreements associated with WWI therefore caused widespread shortages of imported goods and loss of important export markets. These negative external shocks led to a collapse in domestic demand and output, as well as rampant inflation as import prices rose steeply and convertibility of the currency was suspended. As peace resumed and foreign trade was restored in 1919 the economy experienced a brief recovery, but havoc returned as export prices collapsed in the global post-WWI crisis, resulting in extensive bankruptcies of heavily indebted fisheries companies and the emergence of a black market for the overvalued domestic currency. Hence, the economy underwent a sudden stop and a currency crisis and eventually a systemic banking crisis in 1920. The end-date of this crisis episode is assumed to be in 1921 when the banking crisis was brought to an end with the government's foreign-funded bail-out of the two largest banks.[64] Over this 8 year period, output fell by 8.6% and per capita demand by just under 13%, and it took a staggering 11 years for output to reclaim its pre-crisis peak again (13 years for demand), making this the deepest and most protracted recession of the 20th century.[65]

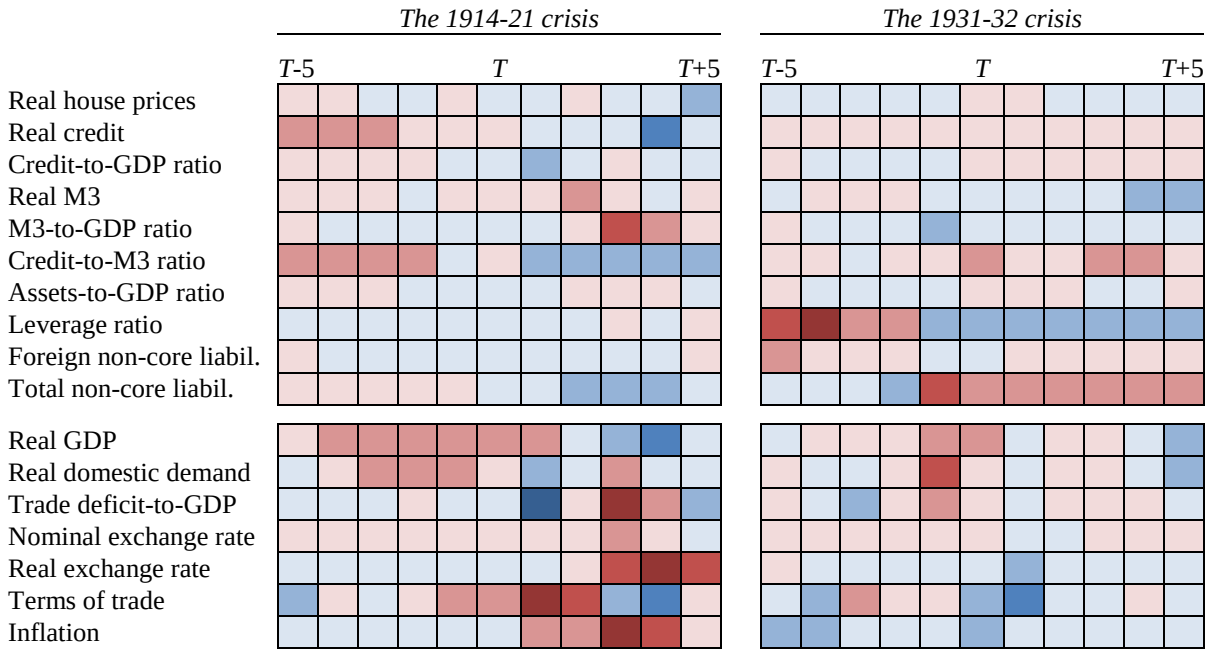
As Table 7.a shows, it is mainly output and domestic demand, as well as credit and, to some extent, non-core banking liabilities, which were above their long-term trend in the run-up to the crisis and subsequently fall below trend. The pattern in the run-up to the crisis reflects the export-led growth period spurred by the adaptation of credit-financed advanced fishing technology. The Achilles' heel of this growth strategy was that it was based on a narrow export base, concentration of credit risk, and the presence of liberalised cross-border flows of goods and capital. All of these factors were tested during WWI and these macro-financial linkages remained strong throughout this period. This is, for instance, reflected in real credit remaining

[64] We decided to date the end of the crisis in 1921 although demand contracted again in 1923-24, due to the strong growth recorded in output and demand in the intervening year.

[65] Kjartansson (2003) refers to the period 1914-1923 as "the long economic downturn in Iceland's 20th century history". Note that both output and, in particular, demand experience a few repeated relapses after temporary reclaiming their pre-crisis level, but here we refer to a more sustained recovery.

below its trend for 11 years after the onset of the crisis and output for even longer.[66] Hence, real credit only returned to its trend 5 years after the banking crisis was resolved and even then it was based on bank leverage rising significantly above trend, which played a role in the next crisis in the early 1930s.

Table 7.a Financial and macroeconomic variables in the 1914-21 and 1931-32 crises



The table shows the development of each variable compared to its long-term trend for the five years in the run-up to and in the aftermath of a financial crisis, where *T* indicates the first year of the crisis. The long-term trend is estimated for the whole sample period using the Hodrick-Prescott filter with a smoothing parameter equal to 1,563 (see the main text for explanation). Red cells indicate that a variable was above trend in a given year with darker red cells indicating ever larger deviations above trend (■ indicates more than 1 standard deviation above trend, ■ more than 2 standard deviations above trend, and ■ more than 3 standard deviations above trend). Blue cells indicate that a variable was below trend in a given year with darker blue cells indicating ever larger deviations below trend (■ indicates more than 1 standard deviation below trend, ■ more than 2 standard deviations below trend, and ■ more than 3 standard deviations below trend).

Source: Authors' calculations (data sources described in Appendix 3).

The 1931-1932 crisis

The Great Depression did not make its mark on economic growth in Iceland until 1931 when export prices collapsed. This year marks the beginning of our second multiple financial crisis, which is much shorter than the previous one, lasting only from 1931-32.[67] Although short, it includes both a systemic banking crisis and currency crisis and its macroeconomic consequences are large: per capita demand falls by almost 18% and output by more than 3%. The effects of the crisis (and its resolution) are even to a larger degree reflected in the weak

[66] The credit-to-money ratio, as well as the total non-core financing ratio, also remained below trend for 8 and 9 years, respectively, as money financing increased during this period after convertibility of the currency was suspended. The terms of trade deterioration, the rise in inflation and the accompanying real exchange rate appreciation and worsening of the trade balance during the crisis are also evident from the heat map in Table 7.a.

[67] We choose to start this financial crisis in 1931 although we have previously dated the start of the banking crisis in 1930. The reason is that 1930 shows very strong growth in output and demand (well above 10%).

recovery in its aftermath with 11 years passing before per capita domestic demand reaches its pre-crisis level.

The macro-financial linkages at work in the run-up to and aftermath of this crisis seem broadly similar to the previous one. Just as in the run-up to the 1914-21 crisis, output and demand were above their long-term trend levels (see Table 7.a) supported by robust export growth related to credit-financed technological improvements in the fisheries sector, reflected in real credit rising above its long-term trend. Iceland's golden age as world-leading salt fish supplier reached its peak in the late 1920s, but following the outbreak of the Great Depression, fish prices collapsed, tariffs were introduced, followed by the collapse of the important export market in Spain during its civil war. Widespread financial distress and a series of bankruptcies followed. Hence, the narrow export base, concentration of credit risk, and reliance on foreign trade (and funding) proved a precarious combination once again.

Financial stability was further undermined this time around by the fact that the banking sector had not been put on a firm footing in the 1920s: many of the banks' borrowers remained in financial distress (due to a difficult mix of high debt, price deflation, high real interest rates, and the revaluation of the króna), the banks' equity position deteriorated (as reflected in bank leverage rising markedly above trend in Table 7.a). Hence, a twin currency and banking crisis occurred shortly after the effects of the Great Depression hit the domestic economy.

Just as in the previous crisis, the immediate policy response neither included a change in interest rates nor the abandoning of the fixed exchange rate peg, but relied instead on the introduction of capital and current account restrictions and a government-led intervention in the banks' foreign funding (the króna depreciated against the US dollar but remained fixed against the pound sterling until 1939). However, the restrictions were not short-lived this time around and the financial restructuring resulted in a state-controlled banking (and corporate) sector – both of which proved to be much more enduring in Iceland than in most other advanced economies.

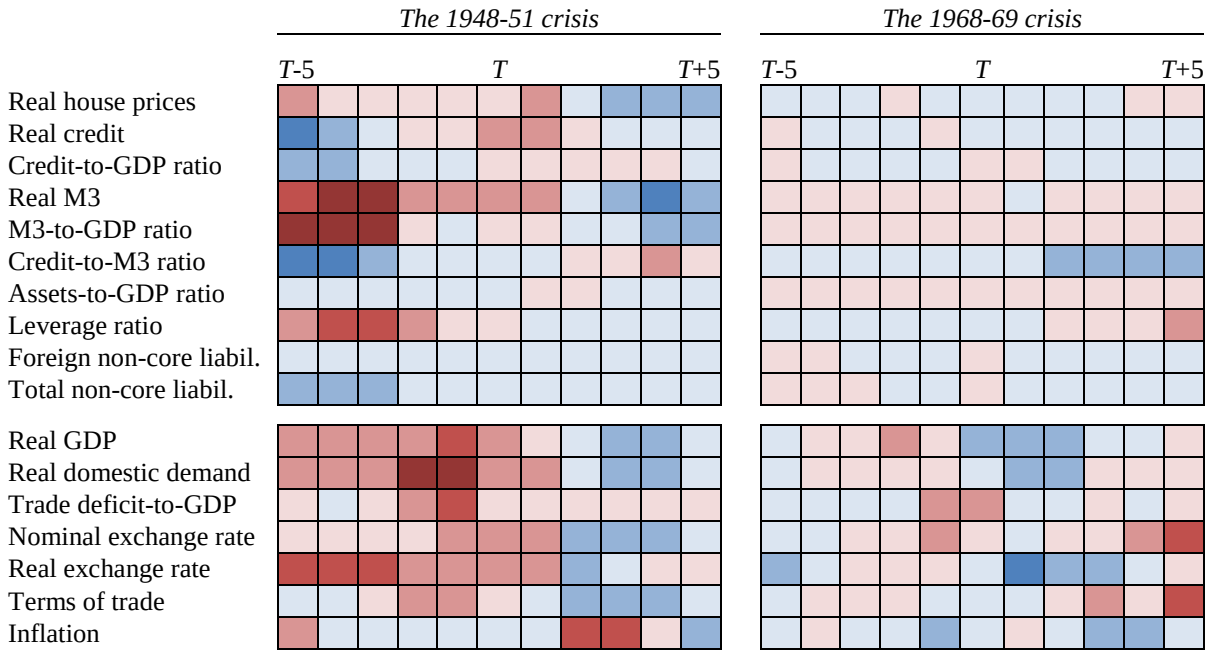
The 1948-1951 crisis

Our third multiple financial crisis follows the demand collapse in 1948 related to a negative terms of trade shock and loss of market share as European fisheries recovered after WWII. The weakening real economy eventually led to currency and inflation crises in 1950 and a further collapse of demand lasting into 1951. Per capita domestic demand fell by a staggering 31% (the largest contraction in per capita demand recorded in Iceland) while output fell by just above 4% – with output taking 6 years to reclaim its pre-crisis level and per capita demand an eye-popping 16 years to reclaim its pre-crisis level.

The crisis must be but into context with WWII, which had profound effects on the Icelandic economy. Demand for exports was exceptionally strong during WWII and domestic demand was stimulated further by the presence of the occupation forces of 20-30 thousand soldiers (or approximately 20% of the total population at the time). Average annual GDP growth during the war period was 10%, with domestic demand growing even more rapidly, and inflation was rampant. At the end of WWII, income levels were at an all-time high, banking system foreign reserves amounted to almost 50% of GDP, and its liquidity position was strong.

However, extensive macro-financial imbalances had built up and they increased considerably in the run-up to the crisis when a government-led investment boom took place, exhausting the foreign reserves by 1947.

Table 7.b Financial and macroeconomic variables in the 1948-51 and 1968-69 crises



The table shows the development of each variable compared to its long-term trend for the five years in the run-up to and in the aftermath of a financial crisis, where *T* indicates the first year of the crisis. The long-term trend is estimated for the whole sample period using the Hodrick-Prescott filter with a smoothing parameter equal to 1,563 (see the main text for explanation). Red cells indicate that a variable was above trend in a given year with darker red cells indicating ever larger deviations above trend (■ indicates more than 1 standard deviation above trend, ■ more than 2 standard deviations above trend, and ■ more than 3 standard deviations above trend). Blue cells indicate that a variable was below trend in a given year with darker blue cells indicating ever larger deviations below trend (■ indicates more than 1 standard deviation below trend, ■ more than 2 standard deviations below trend, and ■ more than 3 standard deviations below trend).

Source: Authors' calculations (data sources described in Appendix 3).

Hence, once again, the conditions were ripe for a negative feedback loop between an external shock, an overextended domestic economy, and a banking system lacking the necessary resilience. These conditions are clearly evident in Table 7.b, for instance, in a significantly overvalued real exchange rate and a rapidly growing trade deficit. Warning signs are also clear in the financial system with money balances rising well above its trend level, bank leverage increasing in a poorly capitalised banking system, signs of overextension in the housing market, and credit rising above its long-term trend. Just as in previous crises, the authorities were reluctant to use the exchange rate and interest rate when responding to the crisis, but instead reinforced capital and current account restrictions, increased the government's role within the economy, and reintroduced substantial subsidies to the troubled export sector.

The 1968-1969 crisis

The fourth multiple financial crisis follows the natural resource crash in 1968 with collapsing demand and an onset of a currency crisis, leading to further collapse of demand and an inflation

crisis in 1969. Per capita demand fell by almost 15.5% but output by less or 3%, while both took 4 years to reclaim their pre-crisis levels.

The negative (real) external shock to the economy was no less severe than in the previous crisis but the extent of macro-financial imbalances heading into the crisis were considerably smaller this time around as clearly reflected in Table 7.b. That probably played an important role in making this a relatively short-lived crisis compared to the previous ones.

The 1991-1993 crisis

The fifth multiple financial crisis is assumed to start in 1991 with a weakening of the real economy eventually leading to currency and non-systemic banking crises in 1993, with per capita demand falling by 7.5% and output by more than 2% – and taking 4 and 6 years respectively to reclaim their pre-crisis levels. Here, we needed to make a judgement call as the demand disaster identified in Section 2.1 is assumed to start earlier, or in 1988. That followed a sharp increase in real interest rates to bring the persistent inflation and currency crises discussed in Section 3.1 to a halt. However, we decided to date this crisis only from 1991 as output continued to grow until 1990 and only started to contract in 1991 when we assume the crisis starts. By then a global economic downturn reinforced the domestic disinflationary pressures resulting in a recession. But just as in the 1968-69, the extent of macro-financial imbalances heading into the crisis were limited (see Table 7.c) and the crisis proved relatively short-lived.[68]

The 2008-2010 crisis

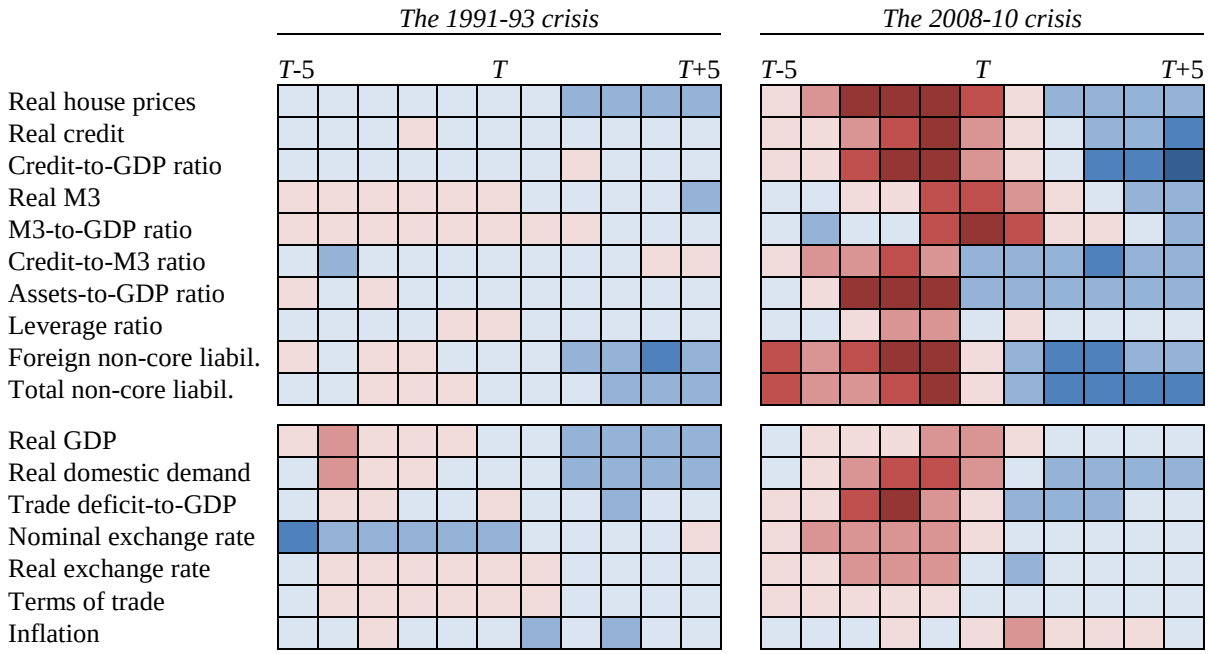
The sixth and final multiple financial crisis in our sample is truly the perfect storm. We assume that it starts in 2008 with a sudden stop and twin currency and systemic banking crises, and a collapse in demand lasting into 2010. The economic consequences are devastating: per capita domestic demand falls by a whopping 26.6% and output by 8% (based on annual data). Although output had almost regained its pre-crisis level in 2013, per capita domestic demand remained almost 25% below its 2007-level and will take years to reclaim that level based on any reasonable growth assumptions.

The extent of financial imbalances in the run-up to the 2008-2010 crisis is unprecedented and red lights blink across the board well before the crisis hits: all financial variables examined in Table 7.c exceeded their long-term trend levels by multiple standard deviations and many do so already 4 or 5 years before the start of the crisis. For example, in the year before the crisis (in 2007), we find that house prices and non-core bank funding are almost 4 standard deviations above trend, the credit-to-GDP ratio almost 6 standard deviations above trend, and bank assets-to-GDP a staggering 8 standard deviations above trend (the deviations of bank leverage from trend is smaller, or "only" just under 2 standard deviations above trend but that is probably due to an overvaluation of book-value equity as discussed in Section 2.6). The degree of (internal and external) macroeconomic imbalances are also evident from Table 7.c with output and demand well above trend, a very large trade deficit, and an overvalued

[68] In both crises, though, the effects on the labour market were more severe and emigration to other countries increased considerably.

currency. Hence, the severity of this crisis episode does not come as a surprise in light of these imbalances and the size of the external shock in the form of the global financial crisis and accompanying global recession.[69]

Table 7.c Financial and macroeconomic variables in the 1991-93 and 2008-10 crises



The table shows the development of each variable compared to its long-term trend for the five years in the run-up to and in the aftermath of a financial crisis, where *T* indicates the first year of the crisis. The long-term trend is estimated for the whole sample period using the Hodrick-Prescott filter with a smoothing parameter equal to 1,563 (see the main text for explanation). Red cells indicate that a variable was above trend in a given year with darker red cells indicating ever larger deviations above trend (■ indicates more than 1 standard deviation above trend, ■ more than 2 standard deviations above trend, and ■ more than 3 standard deviations above trend). Blue cells indicate that a variable was below trend in a given year with darker blue cells indicating ever larger deviations below trend (■ indicates more than 1 standard deviation below trend, ■ more than 2 standard deviations below trend, and ■ more than 3 standard deviations below trend).

Source: Authors' calculations (data sources described in Appendix 3).

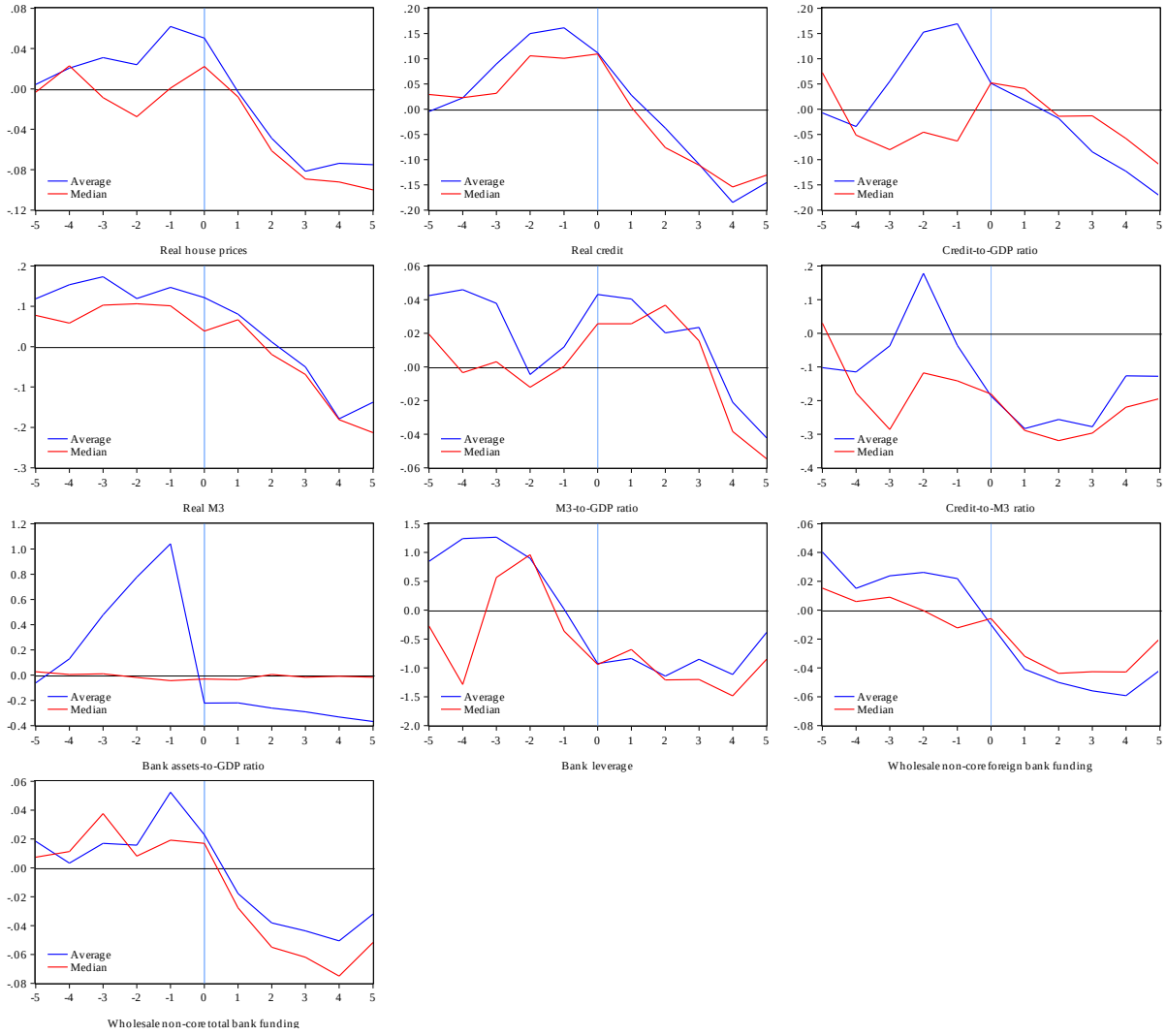
5 General properties of financial crises in Iceland

Although our identification of these six multiple crisis episodes involves some degree of judgement, it allows us to capture the clustering nature of these different types of financial crises while concentrating on the more serious ones. It also allows us to highlight some common features among these episodes. We see, for example, that a serious financial crisis occurs every 15½ years on average and although the incidence of these multiple crises is broadly the same in the two subsamples (see Table 5 above), the duration is greater in the first half of our sample period. We also note that all the episodes involve a demand disaster and in most cases this serves as a trigger for the ensuing financial crisis. Furthermore, all six cases involve a currency crisis that follows or coincides with the demand disaster. In all but two cases does a banking

[69] An extensive literature on this crisis, its sources and how it spread world-wide has emerged in recent years, see Bordo and Landon-Lane (2012) and Reinhart and Rogoff (2009) to name but few. Many aspects of the Icelandic crisis are discussed earlier in this paper but also in papers such as Gudmundsson (2013), Rannsóknarnefnd Althingis (2010), and Ólafsson and Pétursson (2011).

crisis emerge – usually towards the end of the crisis episode. We also note that three of the multiple crisis episodes involve a twin crisis with a currency crisis and a systemic banking collapse (two of which also involve a sudden stop crisis) and these lead to the largest output loss and take the longest time to recover from (this is less clear for demand due to the unusually large contraction in 1948-51). Interestingly, those episodes are concentrated in the two periods of financial globalisation where foreign funding pressures of the domestic banks coincided with similar problems among their main foreign creditors, while the two non-banking crisis episodes occur in periods where external funding of the domestic banking system was very limited.

Figure 11 Financial variables in the run-up to and aftermath of financial crises in Iceland



Deviations from long-term trend (estimated using the Hodrick-Prescott filter) for the period [$T-5$ to $T+5$], where $T=0$ is the first year of the financial crisis. The figure shows the average and median values across the six financial crises in Table 6.

Source: Authors' calculations (data sources described in Appendix 3).

Figure 11 summarises the typical behaviour of our financial variables in the run-up to and aftermath of the six multiple financial crises. On average we find that real house prices peak at 6% above trend a year before a crisis starts and then fall significantly below trend as

the crisis unfolds. However, the average behaviour of real house prices is somewhat dominated by the latest crisis episode, as reflected in the median path. This also holds true for some of the other financial variables, such as the ratios of banking system assets, credit, and money to GDP and the credit-to-money ratio. For other financial variables, the average and median paths are more similar. Thus, we see imbalances consistently build up in real credit and money in the years leading up to a crisis, with rising bank leverage and non-core funding. Real credit typically peaks shortly before the crisis, while real money and leverage peak 2-3 years prior to the crisis and non-core funding even earlier. The post-crisis pattern of the financial variables is even clearer: all (except bank assets perhaps) fall markedly below trend, thus magnifying the ensuing economic contraction. We will return to this issue in our comparison of economic consequences of financial crises and regular business cycle downturns in Section 5.2.

5.1 Early-warning signals

The analysis above suggests that no single financial indicator consistently warns of an ensuing financial crisis over all the crisis episodes. While there were clear warning signals across the whole spectrum of financial variables leading into the latest crisis, we find cases where each financial variable is relatively silent in the run-up to some of the earlier crises and, in two of the episodes (in the late 1960s and early 1990s) none of the financial variables gave a clear warning signal heading into the crisis. A simple way to summarise the ability of our data to consistently give an early-warning signal of an upcoming financial crisis is the non-parametric signal extraction approach originally suggested by Kaminsky and Reinhart (1999), reported in Table 8. This approach is based on monitoring the evolution of a number of variables in the run-up to a financial crisis and interpreting a pattern of behaviour were a variable deviates sufficiently from its trend as a warning signal about an upcoming crisis within a specified period of time. A variable that frequently sends a correct signal about future crises, while seldom sending a false signal – either by signalling a crisis when no crisis follows or missing an upcoming crisis – is deemed as having good signalling properties.

To make this operational, we first define a signal indicator for each variable which is 1 when the variable deviates by more than 1.5 standard deviations from its long-term trend, defined by the Hodrick-Prescott trend previously discussed, and zero otherwise.[70] The use of a 1.5 standard deviation threshold is motivated by its common usage in defining credit booms (cf. D'Ariccia et al., 2012, and Mendoza and Terrones, 2008). A lower threshold would increase the frequency of crisis signals and thus increase the probability of an indicator signalling a crisis while increasing the risk of Type 2 errors (wrongfully signalling a crisis). A higher threshold would however increase the risk of Type 1 errors (failure to signal an actual crisis). Having defined the signal indicator for each variable, we judge a signal of 1 (0) to be correct if a crisis (no crisis) occurs any time within a three-year horizon (Drehmann et al., 2010, also use a three year horizon, while Kaminsky and Reinhart, 1999, use a two-year horizon in a data set of monthly frequency). Thus, signals that occur prior to the three-year window are not counted,

[70] We use the year 1900 as our starting point as that is the first observation for house prices – the variable available over the shortest period in our sample.

nor are signals that occur once a crisis has started. Table 8 reports various measures of the signalling properties of our financial and macroeconomic variables.

Table 8 Early-warning signals for multiple financial crises

	Fraction of crises called	Fraction of good signals	Fraction of false signals	Noise-to-signal ratio	Difference between conditional and unconditional crisis probabilities
Real house prices	0.167	0.167	0.031	0.188	0.342
Real credit	0.167	0.167	0.063	0.375	0.175
Credit-to-GDP ratio	0.167	0.167	0.000	0.000	0.842
Real M3	0.333	0.167	0.031	0.188	0.342
M3-to-GDP ratio	0.333	0.111	0.021	0.188	0.342
Credit-to-M3 ratio	0.167	0.111	0.052	0.469	0.128
Assets-to-GDP ratio	0.167	0.167	0.000	0.000	0.842
Leverage ratio	0.500	0.222	0.083	0.375	0.175
Foreign non-core liabilities	0.167	0.167	0.063	0.375	0.175
Total non-core liabilities	0.333	0.222	0.073	0.328	0.206
Real GDP	0.667	0.333	0.010	0.031	0.699
Real domestic demand	0.500	0.389	0.010	0.027	0.717
Trade deficit-to-GDP	0.500	0.333	0.000	0.000	0.842
Nominal exchange rate	0.167	0.111	0.083	0.750	0.042
Real exchange rate	0.333	0.278	0.052	0.188	0.342
Terms of trade	0.500	0.167	0.031	0.188	0.342
Inflation	0.000	0.000	0.073	–	-0.158
			Averages		
Financial variables	0.250	0.167	0.042	0.248	0.357
Macroeconomic variables	0.381	0.230	0.037	0.197	0.404
All variables	0.304	0.193	0.040	0.229	0.376

The table reports the signalling properties of each variable based on deviations from its Hodrick-Prescott trend that are larger than a threshold value of 1.5 standard deviations over a three-year window in the run-up to each of the six financial crises identified. The second column gives the fraction of crisis episodes correctly signalled by each variable. The third column reports the number of correct crisis signals as a fraction of years in which a crisis signal could have been issued (1 – Type 1 errors). The fourth column reports the number of false crisis signals as a fraction of years in which a no-crisis signal could have been issued (Type 2 errors). The fifth column reports the ratio between the fractions of good and false signals (the third column divided by the second column). The sixth column gives the difference between the conditional probability of a crisis (the fraction of signals issued that were followed by a crisis in the subsequent three years) and the unconditional probability of a crisis (i.e. the relative number of crisis years in our sample).

Source: Authors' calculations (data sources described in Appendix 3).

First, the table reports the success of each variable in signalling crisis episodes, i.e. the relative success of signalling the six crises identified within the three year window. Second, the table shows the relative number of "good" signals, i.e. the fraction of crises predicted by correct signals – for a perfect signalling variable, this measure would be 1 (the variable would signal a crisis in all three years up to all the six crisis episodes). Third, the table shows the relative number of "false" signals, i.e. the fraction of time a crisis is signalled when no crisis occurs – for a perfect signal, this measure would be 0 (the variable would never signal a crisis that does not occur). The table also reports the noise-to-signal ratio, i.e. the ratio of the fractions of false to good signals. Although the best early-warning indicators are often chosen on the basis of minimising the noise-to-signal ratio, we also want variables that correctly signal an upcoming crisis, even though they would sometimes give a false signal: policymakers are likely to assign greater weight to the risk of missing a crises (Type 1 errors) than calling a crisis that does not

occur (Type 2 errors), cf. Borio and Drehmann (2009).[71] Finally, the table compares the conditional probability of a crisis (i.e. the fraction of signals issued by the variable that were followed by a crisis in the subsequent three years) to the unconditional probability of a crisis (the relative number of years in crises identified in our sample). For a variable containing useful information, the conditional probability should be higher than the unconditional one while variables with poor signalling properties would record a low or even a negative value – indicating that they contain no useful information.

Not surprisingly, given the outcomes in Tables 7.a-c, we find that the financial variables have given relatively few good signals across the six crisis episodes and some of them have a relatively high noise ratio. At first sight, variables such as the bank assets-to-GDP ratio may seem as a relatively good indicator, as it has a zero noise ratio, but at the same time it has a track record of only signalling one of the six crises. At a cost of a slightly higher noise ratio, the leverage ratio, total non-core bank funding and real money growth score higher on predicting future crises and might therefore prove more valuable as early-warning indicators despite some false signals.

While the financial variables seem somewhat underwhelming in their ability to consistently signal a crisis across the six episodes identified here, the macroeconomic variables, in particular output, domestic demand and the trade deficit, seem to do somewhat better: these three variables have a low noise ratio while being able to signal half to two-thirds of the crisis episodes and sending a correct signal 30-40% of the time. The real exchange rate and terms of trade also seem to contain some valuable information, while the nominal exchange rate and inflation do not seem to be very valuable early-warning indicators. It should be noted, that the trade deficit serves a dual role in our analysis as both an indicator of macroeconomic imbalances and financial fragility due to reliance on cross-border capital flows. Hence, its ability to warn of an ensuing crisis may reflect the fact that it captures the fragile reliance of booms being financed from abroad within such a small open economy.

Comparing the average scores across financial and macroeconomic variables suggests that while the frequency of false signals is roughly equal across both sets of variables, the main difference lies in the ability of the macroeconomic variables to correctly signal an upcoming crisis. This leads to a lower noise ratio for the macroeconomic variables and ties in well with the analysis above on their importance in triggering a crisis. The financial variables then play an important role in amplifying the crisis and the ensuing contraction (see the discussion below).[72] But as the latest episode so clearly shows, the financial variables can also serve as early-warning signals, especially when so many of them send an identical signal over such an extended period. It is also important to note that the latest episode is the only financial crisis in Iceland's history where both the real economy and the financial system are relatively advanced

[71] This is presumably why we value insights of people, such as one renowned economist who was once said to have foreseen ten of the last five financial crises.

[72] The importance of macroeconomic variables as early-warning indicators is also found in other studies, see for example Davis and Karim (2008) and the summary in Reinhart and Rogoff (2009). See, for example, Rose and Spiegel (2009) for a sceptical view on the ability of these early-warning methods in consistently predicting financial crises.

and modern. The latest episode might therefore be of more relevance than past episodes in constructing early-warning indicators to warn against possible future financial crises.[73]

5.2 Real effects of multiple financial crises

The discussion above suggests that financial crises in Iceland have been costly in terms of lost economic activity. But as crises usually coincide with "regular" business cycle downturns (and are indeed often triggered by these as discussed above), we also want to establish whether they simply reflect output losses related to the business cycle downturns or whether financial crises actually make the associated recessions more severe. Failure to distinguish between output losses in financial crises to those in regular business cycle downturns would suggest that financial crises are not that special in terms of economic consequences. Larger output losses in financial crises would, however, suggest that they trigger some macro-financial linkages that amplify the hardship of the recession (e.g. leading to financial disintermediation, liquidity spirals, rising risk premia, reducing access to working capital and external finance in general). Indeed, this is what is commonly found in the literature (cf. Bordo et al., 2001, Bordo and Landon-Lane, 2012, and Claessens et al., 2012) and is clearly visible in our data too, cf. Table 9.

First, the table reports the average cumulative contraction in GDP during business cycle downturns and in per capita demand during demand disasters from Table 2: the average contraction is 7.6% in GDP and 18.4% in per capita demand, respectively, with the downturns lasting for roughly 2-3 years. It is clear, however, from the table that downturns that overlap with financial crises are worse both in terms of accumulated losses and duration: output and demand contract by roughly 1½ times more on average during financial crises than during downturns that do not coincide with financial crises and these downturns last for about a year longer on average.

The table shows that most of the eleven business cycle downturns and nine demand disasters previously identified coincide with financial crises: business cycle downturns that coincide with financial crisis account for roughly two-thirds of all business cycle downturns. This is somewhat higher than the 50% share reported by Claessens et al. (2012) for a sample of 61 countries over the period 1960-2011 and may reflect the fact that our criteria for identifying business cycles possibly leaves out some of smaller downturns that have less to do with financial crises. Not surprisingly, the share in demand disasters is even higher, or almost 80%, creating some potential problems in comparing average outcomes over the two types of episodes due to the small number of observations in the case where no financial crises take

[73] The robustness analysis in Appendix 1 suggests that this overall finding of somewhat underwhelming success of giving early-warning signals of financial crises continues to hold when looking at the currency and banking crises separately. The ability to signal an upcoming crisis tends to deteriorate compared to what we find for the multiple financial crises, in particular the ability of the macroeconomic variables to predict an upcoming banking crisis. The robustness analysis in Appendix 2 also shows that the early-warning ability of the financial and macroeconomic variables continues to be somewhat underwhelming when the multiple financial crises that some might argue are real economic shocks rather than true financial crises are excluded from the analysis. The signalling performance tends to improve marginally when crises episodes that our variables fail to flag are left out, but the relative performance of the two set of variables tends to remain the same.

place. The lower panel of Table 9 therefore also compares outcomes for the average of all contractions in both series and the cumulative contraction and duration in years of subsequent contractions. Again, the data suggests that financial crises are particularly nasty: the average per-year contraction is 1½-2½ times larger while the cumulative contraction is roughly 3 times larger and the contractions last for up to a year longer on average. In Appendix 2 we show that these results continue to hold when the multiple financial crises that some might argue are real economic shocks rather than true financial crises are excluded from the analysis.

Table 9 Comparison of recessions with and without financial crises

Business cycle downturns and demand disasters

	GDP			Per capita domestic demand		
	All	With financial crisis	Without financial crisis	All	With financial crisis	Without financial crisis
Cumulative contraction	0.076	0.087	0.059	0.184	0.202	0.121
Average duration	2.1	2.6	1.3	2.8	3.0	2.0
Frequency	11	7	4	9	7	2

Yearly contractions

	GDP			Per capita domestic demand		
	All	With financial crisis	Without financial crisis	All	With financial crisis	Without financial crisis
Average contraction	0.032	0.037	0.025	0.057	0.094	0.039
Cumulative contraction	0.052	0.084	0.027	0.092	0.162	0.060
Average duration	1.7	2.3	1.3	1.7	1.9	1.6
Frequency	30	16	14	50	16	34

The upper panel of the table reports outcomes for the identified business cycle downturns and demand disaster episodes (see Table 2). Reported are the average cumulative contraction in GDP and per capita demand during these episodes, their average duration (in years) and the number of episodes. The table also compares episodes that coincide with multiple financial crises (see Table 6) and those that do not. The lower panel of the table similarly reports the outcomes for all contractionary years in GDP and per capita demand. Reported are the average yearly contractions and the average cumulative contractions over years of subsequent contractions, the average duration of periods of subsequent contractions (in years) and the number of years of contraction for the whole sample and years that coincide with multiple financial crises and years that do not.

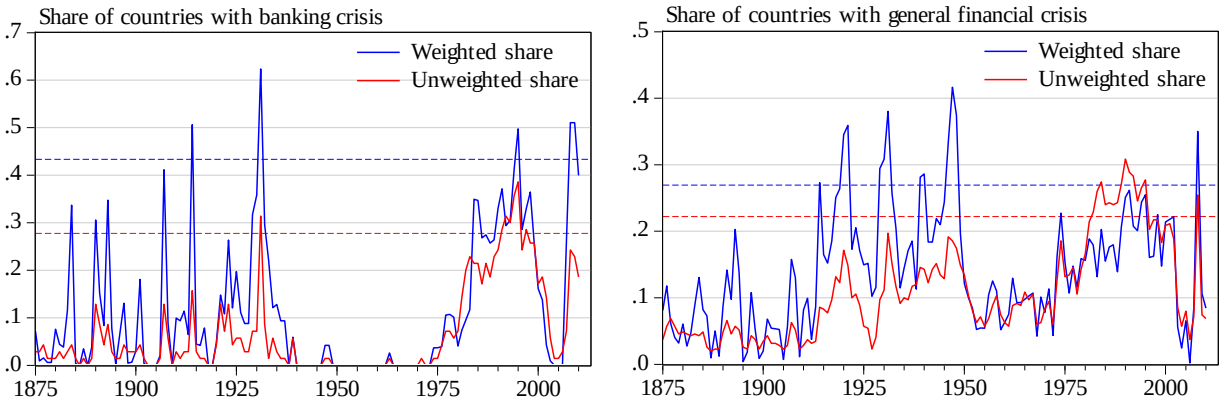
Source: Authors' calculations (data sources described in Appendix 3).

5.3 Are there important spillover effects of global financial crises to Iceland?

It is well known that financial crises often have an important international dimension of some kind, be that due to common sources of vulnerability in a financially integrated global economy, such as the credit and asset price bubbles experienced by many advanced economies in the run-up to the most recent crisis, or due to the transmission of crises from one country (often a global financial centre) to another as a result of cross-border contagion working through both financial and trade channels (see, for example, Kaminsky et al., 2003, and Borio et al., 2014). Both types of channels were at work in the recent global crisis but also played a part in many earlier episodes (cf. Bordo and Murshid, 2001). Not surprisingly, these global crises tend to be more severe and harder to recover from as the rest of the world is also suffering.

To measure the global incidence of financial crises, we use the aggregate indices for 70 countries constructed by Reinhart and Rogoff (2011) for banking crises and for general financial crises which also include currency, inflation, debt, and stock market crises (with equal weights for each indicator). Figure 12 shows the data for the period 1875-2010 (the last observation in Reinhart's and Rogoff's sample). To reflect the fact that a crisis in a large economy is more likely to resonate on a global scale than a crisis in a small economy, we also construct GDP-weighted indicators using PPP-adjusted GDP weights.[74]

Figure 12 International banking and general financial crises



Share of 70 countries in a given crisis from Reinhart and Rogoff (2011). The weighted series use each country's average 1950-2010 share in total GDP using PPP-adjusted nominal GDP in Geary-Khamis US dollars (from Penn World Tables). The multiple global financial crisis measure is obtained as the sum of currency, inflation, sovereign external debt, banking, and stock market crises indicators in Reinhart and Rogoff (2011). Horizontal broken lines denote 3 standard deviations from the whole-sample average share.

Sources: Reinhart and Rogoff (2011), Penn World Tables, and authors' calculations.

The figure also shows horizontal lines representing 3 standard deviations from the sample average of the country shares to capture the most serious global crises (see also Bordo and Landon-Lane, 2012). Looking at the GDP-weighted series, this allows us to identify four severe global bank-specific crises and six others of a more general nature.[75] The first crisis occurs in 1914 with the outbreak of WWI which led to a global liquidity crisis, stock market closings and widespread banking collapses. Another global financial crisis follows soon at the

[74] As weights, we use each country's average 1950-2010 share in PPP-adjusted nominal GDP in Geary-Khamis US dollars from the Penn World Tables using Reinhart and Rogoff's (2011) 70 country sample to proxy world output (the total share amounts to 82% of world output over the period 1950-2010). This is a slightly different weighting system from what Reinhart and Rogoff (2009, 2011) use but the difference should by minor. The index for overall global financial crises should therefore closely match the BCDI+-index constructed by Reinhart and Rogoff (2009).

[75] The banking panic of 1907 that began in the US following the San Francisco earthquake in 1906 and quickly spread out to a number of other industrial countries comes close to exceeding the threshold but just misses out. The Barings Bank crisis in the early 1890s and the Latin America debt crisis in the mid-1980s also come close. The higher values for the GDP-weighted series than the unweighted series over most of the sample period reflects the relative concentration of crisis episodes among the larger economies. The exception is the financial crisis in the late 1980s and early 1990s, which was more concentrated among smaller, emerging market economies. See Kindleberger and Aliber (2011), Eichengreen and Bordo (2003), Reinhart and Rogoff (2009) and Bordo and Landon-Lane (2012) for a more detailed description of these and other global financial crisis episodes discussed in this paper.

start of the 1920s with widespread currency crises and a global recession when international monetary conditions were tightened to rein in the inflation that had built up following WWI, with banking crises occurring in many small European countries (including the Scandinavian countries). This crisis was, however, dwarfed by what followed by the end of the decade with the onset of the Great Depression triggered by the stock market collapse in the US. Soon other market collapses followed, with a record number of bank failures and a sharp increase in sovereign defaults. There is another cluster of crises around the start and end of WWII, and extending into the late 1940s – mostly related to sovereign defaults and inflation crises (the latter period has also been identified as a global financial crisis episode by Kindleberger and Aliber, 2011, and Reinhart and Rogoff, 2009, 2011). The next episode relates to the banking crises of the early 1990s starting with the Scandinavian and Japanese crises at the beginning of the decade, followed by the Tequila crisis in 1994 and Asian crisis in 1997-98. The final episode is the most recent global crisis starting in the US but spreading rapidly throughout most of the world, in particular through widespread funding and asset market collapses and bank panics. In terms of its impact on real economic activity and asset markets and the ferocity with which it spread globally it stands out as the most serious global financial crisis since the Great Depression.

A quick comparison of the dates of these global episodes and the crisis dates for Iceland identified in Sections 3 and 4 suggests an important contagion effect from the global episodes to Iceland and this is further highlighted by the simple regression results shown in Table 10. The probit estimates suggest strong international contagion effects in the case of banking and multiple financial crises but less so for currency and inflation crises. Icelandic banking and general financial crises therefore seem to have a strong international component while domestic currency and inflation crises seem to be dominated by local factors (a common finding in the literature, cf. Joy et al., 2015). The significance of the lagged dependent variable, suggests furthermore that financial crisis in Iceland tend to be highly persistent.[76]

The estimation results suggest that a one standard deviation increase in the share of countries in a financial crisis (which represents roughly a doubling of the share of countries in a crisis) increases the probability of a financial crisis in Iceland by 5-7 percentage points.[77] Since the sample frequency of these crises in Iceland is relatively low (just above 7% for banking crisis and just under 16% for multiple financial crisis), this represents a significant increase in crisis probabilities within a range of plausible shocks to the global share of countries in a crisis. A more extreme shock of three standard deviations (our criteria for identifying the most serious global episodes) would correspondingly lead to a sharper rise in the crisis probability: the probability of a banking crisis in Iceland would rise by 17 percentage points,

[76] Thus, for any given year the probability of a crisis increases by about 50-75% if there is a crisis in the preceding year compared to if there is no crisis in the preceding year, other things kept constant. This persistence of financial crises is commonly found in the literature, cf. Reinhart and Rogoff (2009).

[77] A one standard deviation increase in the share of countries in a banking crisis represents an increase from the average share of 11.3% to 25.7%. A similar rise in the share of countries in a general financial crisis represents an increase from the average share of 14.1% to 23.1%.

while the probability of a multiple financial crisis would rise by more than 20 percentage points, thus leading to a two- to threefold increase in the probability of a financial crisis in Iceland.[78]

Table 10 International financial crises and the probability of a financial crisis in Iceland

	Different types of financial crises in Iceland							
	Curr-ency	Infl-ation	Bank-ing	Mult-iple	Curr-ency	Infl-ation	Bank-ing	Mult-iple
	Using the share of countries in banking crises				Using the share of countries in general financial crises			
Constant	*-1.35*	*-1.57*	*-2.49*	*-2.08*	*-1.66*	*-1.85*	*-2.24*	*-2.83*
	(0.19)	*(0.26)*	*(0.37)*	*(0.31)*	*(0.27)*	*(0.30)*	*(0.37)*	*(0.60)*
Lagged dependent variable	*1.44*	*2.61*	0.96	*2.44*	*1.41*	*2.55*	*1.66*	*2.39*
	(0.30)	*(0.36)*	(0.53)	*(0.42)*	*(0.31)*	*(0.35)*	*(0.53)*	*(0.42)*
Share of countries in crises	0.62	-1.38	*4.48*	*2.74*	2.54	1.16	3.07	*6.69*
	(0.94)	(1.17)	*(1.32)*	*(1.22)*	(1.54)	(1.64)	(2.04)	*(2.51)*
Marginal effects	–	–	0.056	0.049	–	–	–	0.069
Pseudo R^2	0.197	0.516	0.394	0.482	0.214	0.511	0.271	0.528
LR test (*p*-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

The table reports the outcomes of probit regressions of different financial crisis indicators for Iceland (see dates in Tables 2-4, 6) on its own one-year lag and the GDP-weighted share of countries in banking crises and general financial crises, respectively, from Reinhart and Rogoff (2011) (see note to Figure 12). The estimation period is 1875-2010 (135 observations). Numbers in parenthesis are robust (Hubert-White) standard errors and parameters significant at the 5% critical level are in italics. The LR test reports the *p*-value for the null hypothesis that the parameters (except the constant) in the probit regression equal zero. The table also reports the marginal effect of increasing the share of countries in crises by one standard deviation, evaluating the regressors at their sample mean. The table only reports the marginal effects where the global share is found to be statistically significant from zero.

Source: Authors' calculations (data sources described in Appendix 3).

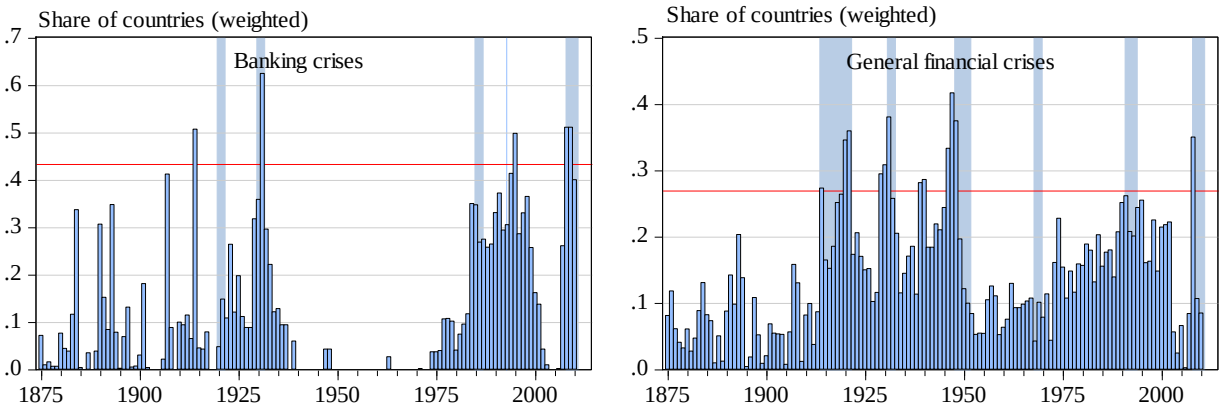
Finally, Figure 13 compares the dates of banking and multiple financial crises in Iceland discussed previously to their global counterparts, again confirming visually how strongly linked most of the Icelandic crises are to the above global events. In fact, it can be argued that the only true Iceland-specific crisis is the 1968-69 episode, which does not seem to have an international counterpart. The others can, to a different degree, all be linked to some international crisis episode: the impact of WWI; the financial crisis of 1920-21 and the Scandinavian banking crisis of the same period; the Great Depression; the global trade collapse and the Korean war by the end of the 1940s; the numerous financial crises of the early 1990s; and the latest global financial tsunami.[79]

[78] The robustness analysis in Appendix 2 shows that these results continue to hold when the multiple financial crises that some might argue are real economic shocks rather than true financial crises are excluded from the analysis. Appendix 2 also shows that our findings that global factors play less of a role for currency and inflation crises are found to be robust to variation in the currency and inflation crisis dates.

[79] Even the relatively small banking crisis of the mid-1980s has an international angle, with the Latin American debt crisis at the beginning of the decade followed by widespread banking problems, although it may not have reached the global proportions defined by the 3 standard deviation threshold used here.

Figure 13 International spillover of global financial crises to Iceland

Banking crises (left) and multiple financial crises (right) in Iceland shown as shaded areas



Share of 70 countries in a given crisis from Reinhart and Rogoff (2011) weighted by their average 1950-2010 share in total GDP of these countries using PPP-adjusted nominal GDP in Geary-Khamis US dollars (from Penn World Tables). The multiple global financial crisis measure is obtained as the sum of currency, inflation, sovereign external debt, banking, and stock market crises indicators in Reinhart and Rogoff (2011). Horizontal lines denote 3 standard deviations from the whole-sample average share.

Sources: Reinhart and Rogoff (2011), Penn World Tables, and authors' calculations.

6 Conclusions

In this paper we analyse financial crises in Iceland over a period spanning almost one and a half century. For this purpose, we construct a dataset that includes measures of overall economic activity (output and domestic demand) and macroeconomic variables capturing the small, open, commodity-based nature of the Icelandic economy (trade balance, nominal and real exchange rate, and terms of trade) for the period 1875-2013. We also include inflation to take account of the chronic inflation crises of the Icelandic economy. From our data on output and domestic demand we identify dates of regular business cycle downturns and the more punishing episodes of large collapses in per capita domestic demand (identified in the same way as Barro and Ursúa, 2008, define consumption disasters) which we use to analyse the interaction of economic downturns and financial busts.

Our dataset includes several financial variables as well. The key variables in any analysis of financial booms and busts: money, credit, and house prices, are included but also variables reflecting the banking system balance sheet to uncover additional sources of financial imbalances. On the asset side, we include banking system total assets relative to GDP as a general measure of financial vulnerabilities (reflecting both systemic risk and market liquidity). On the liability side, we include the banking system leverage ratio to capture the extent to which bank assets are being financed with debt, and the share of banking system non-core funding (both in foreign currency and in total) in overall funding to capture the stability of the funding position of the banking system. Our dataset therefore includes macroeconomic variables that reflect the structure of the economy and some financial variables that are rarely found in the literature on financial crises due to lack of data availability over sufficiently long periods to be useful in analysing financial boom-bust cycles.

We identify three types of financial crises. First, we identify eleven currency crises, ranging from some short, but nasty, episodes in the early 1920s, in 1950, 1960, and 2008, to the chronic crisis lasting from the mid-1970s to the mid-1980s. Two of these episodes (the one in the early 1920s and the latest episode; with the one in the early 1930s coming close) involve a sudden stop of capital inflows that eventually leads to the introduction of capital controls. We also identify five episodes of the closely related inflation crises, all of which coincide with a currency crisis (either lead to or, more commonly, follow). Finally, we identify five banking crises – of which three are adjudged to be systemic (in the early 1920s, early 1930s and in 2008), while two are non-systemic and therefore leave smaller footprints on the real economy (in the mid-1980s and in 1993).

Recognising that different types of financial crises tend to come in clusters, we also construct a single "multiple financial crisis indicator" using a non-parametric common cycle algorithm. This allows us to identify six major financial crises occurring every fifteen years with each lasting almost four years on average. The first episode coincides with the outbreak of World War I and lasts into the early 1920s. The second crisis starts in the early 1930s, coinciding with the Great Depression. While the third crisis has a clear link with the global financial crisis in the late 1940s following the collapse of global trade and the Korean War, the fourth crisis in the late 1960s has almost exclusively Iceland-specific sources related to collapsing fish catch. The fifth crisis episode occurs in the early 1990s, coinciding with numerous financial crises abroad, and was related to falling economic activity following attempts to rein in the chronic inflation of the 1970s and the 1980s. The final episode starts in 2008 and coincides with a serious global financial crisis. It turns out to be the largest financial crisis in the country's history with over 90% of the financial system collapsing. All but one of these six episodes therefore coincide with a serious global financial crisis and our empirical results, indeed, suggest that the most serious global episodes coincide with a two- to threefold increase in the probability of a financial crisis in Iceland.

We find that these six crisis episodes have many things in common. All, for example, involve a serious demand disaster and in most cases this serves as a trigger for the ensuing financial crisis. In all six cases does the crisis also involve a currency crisis that follows or coincides with the demand disaster. In all but two cases does a banking crisis emerge – usually towards the end of the crisis. We also find that these crises tend to have serious economic consequences: economic contractions coinciding with these episodes tend to be about twice as deep as regular business cycle downturns and last almost twice as long.

But at the same time we also find that each episode is unique in some way. Financial imbalances played an important role in the first three financial crises, with broad money, credit and bank leverage (and to a lesser extent, house prices) rising markedly above trend in the run up to these episodes. No clear signs of financial imbalances in the build-up to the crises in the late 1960s and early 1990s can be detected, however, suggesting that these episodes had pure real economy sources. Finally, we see a build-up of financial imbalances leading into the latest crisis episode that are truly unprecedented: most of the financial variables rise above their trend level by an eye-popping 4-8 standard deviations, while we also detect a build-up of significant internal and external macroeconomic imbalances leading into the crisis. Due to the different

importance of financial imbalances in these six crises, we are unable to find robust financial early-warning signals across all six episodes. However, we find that macroeconomic variables, such as output, domestic demand, the trade balance and, to a lesser extent, the real exchange rate, give a somewhat more robust warning signal.

Our analysis of financial crises naturally raises the question of whether our financial variables tend to move together in long "financial cycles", and if so, how these common cycles interact with regular business cycles and, more importantly, whether the peaks and troughs of these financial cycles tend to coincide with financial turbulences. This is the topic of the second part of our study, which also discusses the policy implications of our findings.

Appendix 1 Early-warning signals for currency and banking crises?

The results in Table 8 in the main text suggest that no single financial variable succeeds in providing an early-warning signal on a consistent basis for the six multiple financial crises we identify. However, our results suggest that some of the macroeconomic variables, such as output, domestic demand, the trade balance, and, to a lesser extent, the real exchange rate, do a somewhat better job. Here we redo our analysis separately for the currency and banking crises we identify in Section 3. Overall, we see no improvement in the signalling properties of our set of financial and macroeconomic variables compared to those reported in the main text. The noise ratio rises on average, especially for the macroeconomic variables in the case of banking crises. The somewhat underwhelming early-warning properties of our variables found in the main text for the six multiple financial crises therefore continue to hold for the currency and banking crises we identify.

Table A.1.1 Early-warning signals for currency crises

	Fraction of crises called	Fraction of good signals	Fraction of false signals	Noise-to-signal ratio	Difference between conditional and unconditional crisis probabilities
Real house prices	0.091	0.091	0.025	0.272	0.311
Real credit	0.091	0.091	0.074	0.815	0.044
Credit-to-GDP ratio	0.091	0.091	0.000	0.000	0.711
Real M3	0.091	0.030	0.062	2.037	-0.123
M3-to-GDP ratio	0.182	0.091	0.037	0.407	0.211
Credit-to-M3 ratio	0.091	0.061	0.037	0.611	0.111
Assets-to-GDP ratio	0.091	0.091	0.000	0.000	0.711
Leverage ratio	0.091	0.061	0.086	1.426	-0.067
Foreign non-core liabilities	0.182	0.121	0.049	0.407	0.211
Total non-core liabilities	0.273	0.182	0.062	0.340	0.256
Real GDP	0.273	0.121	0.049	0.407	0.211
Real domestic demand	0.273	0.152	0.025	0.163	0.425
Trade deficit-to-GDP	0.364	0.182	0.012	0.068	0.568
Nominal exchange rate	0.182	0.121	0.000	0.000	0.711
Real exchange rate	0.364	0.242	0.049	0.204	0.377
Terms of trade	0.182	0.061	0.086	1.426	-0.067
Inflation	0.091	0.091	0.062	0.679	0.086
			Averages		
Financial variables	0.127	0.091	0.043	0.631	0.237
Macroeconomic variables	0.247	0.139	0.041	0.421	0.330
All variables	0.176	0.111	0.042	0.545	0.275

The table reports the signalling properties of each variable based on deviations from its Hodrick-Prescott trend that are larger than a threshold value of 1.5 standard deviations over a three-year window in the run-up to each of the eleven currency crises identified in Table 3. The second column gives the fraction of crisis episodes correctly signalled by each variable. The third column reports the number of correct crisis signals as a fraction of years in which a crisis signal could have been issued (1 – Type 1 errors). The fourth column reports the number of false crisis signals as a fraction of years in which a no-crisis signal could have been issued (Type 2 errors). The fifth column reports the ratio between the fractions of good and false signals (the third column divided by the second column). The sixth column gives the difference between the conditional probability of a crisis (the fraction of signals issued that were followed by a crisis in the subsequent three years) and the unconditional probability of a crisis (i.e. the relative number of crisis years in our sample).

Source: Authors' calculations (data sources described in Appendix 3).

Table A.1.1 reports the average signalling properties of the financial and macroeconomic variables for the eleven currency crises identified in Table 3. Compared to the results in the main text, we find that the signalling properties of individual financial variables deteriorate in most cases through a combination of a declining fraction of good signals and a rising fraction of bad signals. The same applies for the macroeconomic variables, except for the nominal exchange rate where the noise ratio declines. The overall signalling properties of both sets of variables tends to deteriorate but the relative success of the financial and macroeconomic variables remains unchanged.

Table A.1.2 Early-warning signals for banking crises

	Fraction of crises called	Fraction of good signals	Fraction of false signals	Noise-to-signal ratio	Difference between conditional and unconditional crisis probabilities
Real house prices	0.200	0.200	0.030	0.152	0.368
Real credit	0.200	0.200	0.061	0.303	0.202
Credit-to-GDP ratio	0.200	0.200	0.000	0.000	0.868
Real M3	0.200	0.067	0.051	0.758	0.035
M3-to-GDP ratio	0.400	0.200	0.030	0.152	0.368
Credit-to-M3 ratio	0.200	0.133	0.051	0.379	0.154
Assets-to-GDP ratio	0.200	0.200	0.000	0.000	0.868
Leverage ratio	0.400	0.267	0.081	0.303	0.202
Foreign non-core liabilities	0.200	0.200	0.061	0.303	0.202
Total non-core liabilities	0.200	0.200	0.081	0.404	0.141
Real GDP	0.200	0.067	0.061	0.909	0.011
Real domestic demand	0.200	0.200	0.040	0.202	0.297
Trade deficit-to-GDP	0.400	0.267	0.020	0.076	0.535
Nominal exchange rate	0.200	0.133	0.081	0.606	0.068
Real exchange rate	0.400	0.333	0.081	0.242	0.253
Terms of trade	0.200	0.067	0.081	1.212	-0.020
Inflation	0.400	0.200	0.091	0.455	0.118
			Averages		
Financial variables	0.240	0.187	0.044	0.275	0.341
Macroeconomic variables	0.286	0.181	0.065	0.529	0.180
All variables	0.259	0.184	0.053	0.380	0.275

The table reports the signalling properties of each variable based on deviations from its Hodrick-Prescott trend that are larger than a threshold value of 1.5 standard deviations over a three-year window in the run-up to each of the five banking crises identified in Table 4. The second column gives the fraction of crisis episodes correctly signalled by each variable. The third column reports the number of correct crisis signals as a fraction of years in which a crisis signal could have been issued (1 – Type 1 errors). The fourth column reports the number of false crisis signals as a fraction of years in which a no-crisis signal could have been issued (Type 2 errors). The fifth column reports the ratio between the fractions of good and false signals (the third column divided by the second column). The sixth column gives the difference between the conditional probability of a crisis (the fraction of signals issued that were followed by a crisis in the subsequent three years) and the unconditional probability of a crisis (i.e. the relative number of crisis years in our sample).

Source: Authors' calculations (data sources described in Appendix 3).

Table A.1.2 repeats the exercise for the five banking crises in Table 4. For the individual financial variables we tend to see a slight improvement, mainly through a rising fraction of good signals, although the average noise ratio for the financial variables rises marginally compared to what we find in Table 8. The signalling power of most of the macroeconomic variables deteriorates significantly, however, mainly through a declining fraction of good signals. This is particularly striking for GDP, which loses most of its early-warning power, but

can also be seen in domestic demand and the terms of trade. Although the signalling power of the trade balance deteriorates as well, it still retains some of its early-warning information. But the overall signalling properties of the macroeconomic variables deteriorate markedly and become poorer compared to the financial variables.

Appendix 2 To be or not to be a financial crisis: how robust are the results to different crisis definitions?

In an economy as volatile as the Icelandic one, where large currency and inflation fluctuations have historically been common, it can be debated whether all the episodes we identify as currency and inflation crises constitute true crisis episodes or whether they are simply a part of the economy's normal, albeit volatile, business cycle. By the same token, it can also be debated whether all the multiple financial crises we identify in Section 4 are truly financial crisis episodes or whether some of them simply reflect the large real economy adjustments to external shocks this very small and open resource-based economy has commonly faced throughout the period.

In this Appendix, we check whether our key results are robust to different definitions of our financial crisis episodes. We start by looking at different threshold levels for identifying currency and inflation crises. In the second half of the Appendix, we test whether our analysis of the multiple financial crises are altered when excluding what may be viewed as the most contentious episodes from our crisis sample. We find that all of our key results are robust to these variations in crisis definitions.

A.2.1 Raising the threshold definition for currency and inflation crises

We start by documenting how our identification of currency and inflation crises changes when the threshold criteria is raised from the 15% per annum depreciation used by Reinhart and Rogoff (2009, 2011). The first panel of Table A.2.1 shows the currency crises identified when the threshold is doubled to a 30% per annum depreciation. In this case, the number of currency crisis declines to eight episodes from the original eleven episodes. Four episodes drop out of the original list: the episodes in 1932, 1939, 1993, and 2001, while the long crisis episode originally identified as starting in 1974 and ending in 1985 is now split into two episodes: one in 1975 and the other from 1978-85. The average duration of the currency crises remains almost identical to that using the original threshold level, however. The second panel of the table shows what happens when we raise the threshold even further. Here, we only include episodes where the currency depreciates by more than 50% per annum, but also retaining episodes that have depreciations over two consecutive years that exceed 50%. In this case the number of currency crises falls to seven, with the episode in the late 1980s dropping out and the long crisis episode starting in 1978 now ending in 1983 rather than 1985 as when the 30% threshold level is used. Other than that, the results are identical to those using the 30% threshold level.

The third panel of Table A.2.1 shows what happens when we similarly double the threshold level for inflation crises to a 40% per annum level of inflation. In this case, the number of episodes falls from five to three, with the two episodes in the early 1940s and 1950s and the episode in the late 1960s dropping out, while the chronic inflation crisis originally identified from 1973 to 1989 is now split into two shorter episodes from 1974-75 and 1978-83. Finally, the first episode, originally identified as starting in 1916 and lasting into 1918, is now concentrated to a single year in 1917.

Table A.2.1 Currency and inflation crisis dates: robustness analysis

Currency crises threshold raised to 30%			Currency crises threshold raised to 50%			Inflation crises threshold raised to 40%		
Date	Duration	Average depr. per year	Date	Duration	Average depr. per year	Date	Duration	Average inflation per year
1919-20	2	0.263	1919-20	2	0.263	1917	1	0.536
1950	1	0.508	1950	1	0.508			
1960	1	0.535	1960	1	0.535			
1968-69	2	0.248	1968-69	2	0.248			
1975	1	0.348	1975	1	0.348	1974-75	2	0.462
1978-85	8	0.119	1978-83	6	0.153	1978-83	6	0.561
1989	1	0.246						
2008-9	2	0.241	2008-9	2	0.241			
Average	2.3	0.313	Average	2.1	0.328	Average	3.0	0.520

The table reports the dates of currency and inflation crises identified by different thresholds to those used in the main text. The first panel shows the dates for currency crises when the threshold for currency depreciations is doubled to 30% per annum. The second panel shows the dates for currency crises when the threshold for currency deprecations is raised to 50% per annum while also including dates that do not fulfil that criteria but have deprecations over two consecutive years that exceed 50%. The third panel shows the dates for inflation crises when the threshold for annual inflation is doubled to 40% per annum.

Source: Authors' calculations (data sources described in Appendix 3).

A.2.2 Excluding some of the multiple financial crises

In the second part of this Appendix, we test whether the results in Section 5 are robust to variations in the identification of the six multiple financial crises. Specifically, we test our results on the early-warning signal properties of our macroeconomic and financial variables in Section 5.1, our comparison of downturns coinciding with these financial crisis episodes and those downturns that do not in Section 5.2, and the extent of global spillovers in Section 5.3, to sequentially leaving out the financial crises in 1948-51, 1968-69, and 1991-93. These three episodes are chosen as they do not coincide with a banking crisis (the 1948-51 and 1968-69 episodes) and could therefore rather be viewed as real economy crises, albeit serious ones, rather than outright financial crises. We also test whether excluding the 1991-93 crisis changes our results as that crisis does not include a systemic banking crisis (although it does include a non-systemic one).

We start by analysing the robustness of the early-warning signals properties shown in Table 8 in the main text. Table A.2.2 shows the average signalling properties of the financial and macroeconomic variables for each case. Compared to the baseline case in Table 8, we find that the signalling performance tends to improve marginally when the 1968-69 and 1991-93 episodes are left out, as all our variables failed to flag these episodes beforehand. The relative comparison of the signalling properties of the macroeconomic and financial variables remains intact, however, with the macroeconomic variables continuing to outperform the financial variables on average, although neither group of variables does a sterling job over all the crisis episodes. The only case where the relative performance of these two groups changes somewhat is when the 1948-51 crisis is left out. In this case, the financial variables do a slightly better job on average, although this is mainly due to a larger deterioration in the signalling properties of

the macroeconomic variables rather than a marked improvement in the signalling properties of the financial variables.

Table A.2.2 Early-warning signals: robustness analysis

	Excluding the 1948-51 crisis			Excluding the 1968-69 crisis		
	Financial variables	Macro variables	All variables	Financial variables	Macro variables	All variables
Fract. of crises called	0.240	0.314	0.271	0.300	0.457	0.365
Fract. of good signals	0.173	0.162	0.169	0.200	0.276	0.231
Fract. of false signals	0.044	0.058	0.050	0.040	0.036	0.039
Noise-to-signal ratio	0.307	0.332	0.316	0.201	0.159	0.185
	Excluding the 1991-93 crisis			Excluding the 1948-51 and 1968-69 crises		
	Financial variables	Macro variables	All variables	Financial variables	Macro variables	All variables
Fract. of crises called	0.300	0.457	0.365	0.300	0.393	0.338
Fract. of good signals	0.200	0.276	0.231	0.217	0.202	0.211
Fract. of false signals	0.040	0.036	0.039	0.043	0.056	0.048
Noise-to-signal ratio	0.201	0.159	0.185	0.238	0.258	0.246

The table reports the average signalling properties of the financial and macroeconomic variables when the financial crises in 1948-51, 1968-69 and 1991-93 are not defined as a multiple financial crises. See Tables 6 and 8 for details.

Source: Authors' calculations (data sources described in Appendix 3).

Next, we move on to testing whether economic downturns coinciding with financial crises tend to be deeper and longer than those that do not coincide with financial crises. Table A.2.3 compares all contractionary years in GDP and per capita domestic demand (to be compared to the lower panel of Table 9), again after leaving out the 1948-51, 1968-69, and 1991-93 crises, and the 1948-51 and 1968-69 episodes combined. The results turn out to be very similar to those reported in the main text: contractions tend to be close to twice as deep when coinciding with financial crises and last almost twice as long.

Finally, the upper panel of Table A.2.4 reports the results from the probit regressions in Table 10 in the main text when leaving out the 1948-51, 1968-69, and 1991-93 crises, and the 1948-51 and 1968-69 episodes combined. As the table shows, the global country share remains statistically significant for each variant of the crisis definitions and the marginal effects are very similar to those reported in Table 10. The lower panel of the table shows what happens when we use the currency and inflation crisis dates in Table A.2.1 as the dependent variable instead of those used in the main text. Again, we find that the global country share has no statistically significant effects on the probability of a currency and inflation crises in Iceland.

Table A.2.3 Economic contractions with and without financial crises: robustness analysis

	Excluding the 1948-51 crisis				Excluding the 1968-69 crisis			
	GDP		Per capita domestic demand		GDP		Per capita domestic demand	
	With fin. crisis	Without fin. crisis	With fin. crisis	Without fin. crisis	With fin. crisis	Without fin. crisis	With fin. crisis	Without fin. crisis
Aver. contr.	0.041	0.025	0.089	0.046	0.036	0.027	0.096	0.042
Cum. contr.	0.087	0.031	0.159	0.069	0.088	0.031	0.162	0.064
Aver. dur.	2.3	1.3	2.0	1.6	2.4	1.4	1.9	1.6
	Excluding the 1991-93 crisis				Excluding the 1948-51 and 1968-69 crises			
	GDP		Per capita domestic demand		GDP		Per capita domestic demand	
	With fin. crisis	Without fin. crisis	With fin. crisis	Without fin. crisis	With fin. crisis	Without fin. crisis	With fin. crisis	Without fin. crisis
Aver. contr.	0.040	0.024	0.101	0.040	0.040	0.026	0.090	0.047
Cum. contr.	0.091	0.027	0.170	0.061	0.094	0.036	0.159	0.073
Aver. dur.	2.4	1.4	1.9	1.6	2.4	1.4	2.0	1.6

The table compares contractions in GDP and per capita domestic demand for years that coincide with multiple financial crises and years that do not when the financial crises in 1948-51, 1968-69 and 1991-93 are not defined as a multiple financial crises. Reported are the average and cumulative contractions over years of subsequent contractions (in years), and the average duration of periods of subsequent contractions (in years). See Table 9 for further details.

Source: Authors' calculations. (data sources described in Appendix 3)

Table A.2.4 International linkages of financial crises: robustness analysis

Multiple financial crises excluded

	1948-51 crisis	1968-69 crisis	1991-93 crisis	1948-51 and 1968-69 crises
Coeff. est.	5.590	9.761	6.791	8.510
P-value	0.022	0.000	0.020	0.000
Marg. eff.	0.053	0.072	0.060	0.054

Currency and inflation crises threshold raised

	Currency crises threshold raised to 30%		Currency crises threshold raised to 50%		Inflation crises threshold raised to 40%	
	Global banking crisis share	Global financial crisis share	Global banking crisis share	Global financial crisis share	Global banking crisis share	Global financial crisis share
Coeff. est.	0.293	1.624	-0.379	1.359	-1.532	1.231
P-value	0.786	0.335	0.771	0.450	0.216	0.433

The table reports the outcomes of probit regressions of different financial crisis indicators for Iceland on the GDP-weighted share of countries in banking crises and general financial crises, respectively, from Reinhart and Rogoff (2011). The regressions also include a one-year lag of the dependent variable (not reported). The estimation period is 1875-2010 (135 observations). The *p*-values reported are based on robust (Hubert-White) standard errors. The upper panel of the table reports the outcomes of probit regressions in Table 10 when the financial crises in 1948-51, 1968-69 and 1991-93 are not defined as a multiple financial crises. The marginal effects reported are based on a one standard deviation increase in the country share, evaluating the regressors at their sample mean. The lower panel of the table reports the outcomes of probit regressions in Table 10 when the dates for currency and inflation crises in Table A.2.1 are used instead of those in Table 3. See Tables 3, 6 and 10 for further details.

Source: Authors' calculations (data sources described in Appendix 3).

Appendix 3 Data sources

Financial variables

Banking system assets (1875-2013)
For savings banks in the period from 1875-1990 we use data on total assets (*Hagskinna: Icelandic Historical Statistics*, Table 13.7). This is only available at five-year intervals and we therefore use linear interpolation to obtain data for the intervening years. For commercial banks we use data on total assets for the period 1964-1990 (*Hagskinna: Icelandic Historical Statistics*, Table 13.6b-c) and for the period 1875-1929 we use data on total assets of Landsbanki (founded in 1885) and Íslandsbanki (founded in 1904) (*Hagskinna: Icelandic Historical Statistics*, Tables 13.2 and 13.3). For the period 1930-1963, we use data on "total" assets of commercial banks, which is only available at five-year intervals until 1950 (annual data from 1953) and we therefore use linear interpolation to obtain data for the intervening years (*Hagskinna: Icelandic Historical Statistics*, Table 13.6a). However, we adjust "total" commercial banks assets in this period from 1930-1963 as data on foreign assets is only provided in net terms. This is done by using data on foreign assets of Landsbanki from Björnsson (1961, tables on p. 126-127) and data on base metal reserves, claims on foreign banks, and assets in foreign currency for Íslandsbanki and its successor, Útvegsbanki, from Björnsson (1981, tables on p. 106, 119, and 129). Data from Björnsson (1961) is only available at three-year intervals until 1954 and two-year intervals until 1960 and we therefore use linear interpolation to obtain data for the intervening years. Data from Björnsson (1981) is available annually for 1938-1946 and then for the years 1930, 1950, 1954, and 1957 and we therefore use linear interpolation to obtain data for the intervening years. Furthermore, we assume that total foreign assets of the banking system in 1957-1960 developed in line with the developments of the foreign assets of Landsbanki (excluding its Central Bank division). For the period 1997-2012, we use data on total assets of commercial banks and savings banks from the Financial Supervisory Authorities. For the remaining years (1991-1996 and 2013), total banking system assets are assumed to develop in line with total assets of deposit money banks (data from Central Bank of Iceland *Annual Reports*).

Banking system equity (1875-2013)
For savings banks in the period from 1875-1990 we use data on reserve funds, retained earnings, and other equity capital (*Hagskinna: Icelandic Historical Statistics*, Table 13.7). This is only available at five-year intervals and we therefore use linear interpolation to obtain data for the intervening years. For commercial banks in the period 1886-1929 we use data on initial capital reserves, retained earnings, and reserve funds of Landsbanki and data on share capital and reserve fund of Íslandsbanki (*Hagskinna: Icelandic Historical Statistics*, Tables 13.2 and 13.3). For the period 1930-1990 we use data on commercial bank share capital and capital contribution, reserve funds and retained earnings, and other equity capital (*Hagskinna:*

Icelandic Historical Statistics, Tables 13.6a-c). This data is only available at five-year intervals until 1950 (annual data from 1953) and we therefore use linear interpolation to obtain data for the intervening years. We correct values for 1963 and 1966-1967 where data on other equity has mistakenly been used as data on total equity in Table 13.6b. For 1963 we use data from Table XVI on p. 186 in *Fjármálatíðindi* September-December 1965 and for 1966-67 we use data from Table 1 in Gudnason (1972). For the period 1997-2012, we use data on total equity from the Financial Supervisory Authorities' website for commercial banks and savings banks. For the remaining years (1991-1996 and 2013), banking system equity is assumed to develop in line with deposit money bank total equity (data from Central Bank of Iceland *Annual Reports*).

Broad money (M3) (1886-2013)
Data for the period 1991-2013 is obtained from the Central Bank of Iceland (data for 1991-1993 from the Bank's *Annual Report* in 2007). For the period 1886-1990 we use data from Statistics Iceland (*Hagskinna: Icelandic Historical Statistics*, Table 13.1).

Credit (1886-2013)
For the period 1970-2007 we use total lending and bond holdings of the credit system, obtained from the Central Bank of Iceland. This series is extended to 2013 using total lending and bond holdings of financial firms from the new financial accounts from the Central Bank of Iceland. For the period 1886-1969 we use data on total credit from Statistics Iceland for deposit institutions (*Hagskinna: Icelandic Historical Statistics*, Table 13.9) and investment credit funds (*Hagskinna: Icelandic Historical Statistics*, Table 13.12). Data on investment credit funds is only available at five-year intervals until 1950 and we therefore use linear interpolation to obtain data for the intervening years (the same applies for missing data in 1951, 1963, and 1971-1972).

Non-core banking system liabilities (1886-2013)

<u>Domestic non-core liabilities</u>
For the period 1991-2013 we use data on domestic bond issuance of deposit money banks obtained from the Central Bank of Iceland. For savings banks in the period from 1875-1990 we use data on credit from other financial institutions (excluding the Central Bank) and sundry liabilities (*Hagskinna: Icelandic Historical Statistics*, Table 13.7), which is only available at five-year intervals. We therefore use linear interpolation to obtain data for the intervening years. For commercial banks in the period 1930-1973 we use data on credit from other domestic financial institutions (excluding the Central Bank) and sundry liabilities (*Hagskinna: Icelandic Historical Statistics*, Tables 13.6a-b and 13.7), for the period 1974-1990 we add data on domestic bond issuance. For commercial banks in the period 1886-1929 we use data on bank bonds, sundry liabilities, credit from the mortgage department (which was a legally separate entity), and funds awaiting disbursements for Landsbanki, and data on bank bonds, sundry

liabilities, funds awaiting disbursements and rediscounted bills of exchange for Íslandsbanki (*Hagskinna: Icelandic Historical Statistics*, Tables 13.2 and 13.3).

Foreign non-core liabilities

For the period 1964-1990 we use data on foreign liabilities of commercial banks (*Hagskinna: Icelandic Historical Statistics*, Tables 13.6b-c). For the period 1991-2013 we use data on total foreign liabilities of deposit money banks obtained from the Central Bank of Iceland. For the period 1886-1929 we use data on credit from foreign banks, the so-called "English long-term loans", and bank bills of exchange for Landsbanki and data on credit from foreign banks for Íslandsbanki (*Hagskinna: Icelandic Historical Statistics*, Tables 13.2 and 13.3). *Hagskinna: Icelandic Historical Statistics* does not provide data on commercial banks' foreign liabilities for the period 1930-1963, only data on net foreign assets. For the period 1930-1960 we therefore use data on foreign liabilities of Landsbanki from Björnsson (1961, tables on p. 126-127) and data on credit from foreign banks and the English loans from 1921 and 1935 for Íslandsbanki and its successor Útvegsbanki from Björnsson (1981, tables on p. 106, 119, and 129). Other commercial banks did not have foreign liabilities during this period. Data from Björnsson (1961) is only available at three-year intervals until 1954 and two-year intervals until 1960 and we therefore use linear interpolation to obtain data for the intervening years. Data from Björnsson (1981) is only available annually for 1938-1946 and then for the years 1930, 1950, 1954, and 1957 and we therefore use linear interpolation to obtain data for the intervening years. Furthermore, we assume that total foreign liabilities of banking system in 1957-1960 developed in line with the development of the foreign liabilities of Landsbanki (excluding its Central Bank division). For Íslandsbanki and its successor Útvegsbanki in the period 1930-1960, we exclude foreign equity (also the part of foreign debt, mainly from the Danish Post Office, which was swapped into equity of Útvegsbanki after the collapse of Íslandsbanki) and categorise bank bonds issued by Íslandsbanki as domestic debt as was done in the bank's accounts although the Supreme Court ruled after the bank's collapse that they should be defined as foreign debt. For the period 1961-1963 we use linear interpolation between our constructed series for the period 1930-1960 and the data from *Hagskinna: Icelandic Historical Statistics*, Tables 13.6c, for 1964 to obtain data for these three years.

Total non-core liabilities

Total non-core banking system liabilities are given by the sum of our two constructed series for foreign and domestic non-core banking system liabilities.

Exchange rates, terms of trade and prices

Domestic price level (1875-2013)

The domestic price level is constructed using annual averages of the consumer price index (excluding housing) from Statistics Iceland for the period 1914-2013. For the period 1875-1913 we use a "general price level" obtained from Statistics Iceland (*Hagskinna: Icelandic Historical Statistics*, Table 12.25).

House prices (1900-2013)
For the period 1945-2013 we use the annual average of the housing stock implicit price deflator from Statistics Iceland. For the period 1900-1944 we use the building cost index from Statistics Iceland as these series match almost perfectly for the period for which they are both available, up to 1993, when Statistics Iceland changed the way they measured house prices.

Nominal exchange rate (1875-2013)
We use the exchange rate of the króna vis-á-vis the US dollar. The annual average exchange rate for 1961-2013 is obtained from the Central Bank of Iceland. For the period 1914-1960 we use data from Statistics Iceland (*Hagskinna: Icelandic Historical Statistics*, Table 13.16). For the period 1875-1913 we use data on the exchange rate of the Danish króna vis-á-vis the US dollar (as Iceland was in a monetary union with Denmark in that period) from Abildgren (2004).

Real exchange rate (1875-2013)
We use an annual average of a real exchange rate index from the Central Bank of Iceland for the period 1960-2013 (relative consumer prices). For the period 1875-1959 we follow Nordal and Tómasson (1985) in calculating a real exchange rate using a simple average of real exchange rates vis-á-vis the US, UK and Denmark (by far the three most important trading partners in that period). The nominal exchange rates are obtained from Statistics Iceland (for 1914-1959; *Hagskinna: Icelandic Historical Statistics*, Table 13.16) and Abildgren (2004) (for 1875-1913). The domestic price series is explained above, while the price series for the three other countries for the period 1875-1959 are obtained from Abildgren (2004).

Terms of trade (1875-2013)
For the period 1945-2013 we use annual averages obtained from Statistics Iceland (adjusting for the structural break in the data in 1997 due to a methodological change related to the introduction of the ESA-2010 national accounts standards introduced in September 2014). Data for the period 1875-1944 is taken from *Hagskinna: Icelandic Historical Statistics*, Table 10.23.

Real economy

Nominal GDP (1875-2013)
For the period 1945-2013 we use annual averages obtained from Statistics Iceland (adjusting for the structural break in the data in 1997 due to a methodological change related to the introduction of the ESA-2010 national accounts standards introduced in September 2014). Data for the period 1875-1944 is taken from a statistics publication of the National Economic Institute (Jónsson, 1999; Table V.14.6).

Real GDP (1875-2013)
For the period 1945-2013 we use annual averages obtained from Statistics Iceland (adjusting for the structural break in the data in 1997 due to a methodological change related to the introduction of the ESA-2010 national accounts standards introduced in September 2014). Data for the period 1875-1944 is taken from a statistics publication of the National Economic Institute (Jónsson, 1999; Table V.14.6).

Nominal domestic demand (1875-2013)
For the period 1945-2013 we use annual averages obtained from Statistics Iceland (adjusting for the structural break in the data in 1997 due to a methodological change related to the introduction of the ESA-2010 national accounts standards introduced in September 2014). Data for the period 1875-1944 is constructed by backing out domestic demand using nominal GDP, imports and exports taken from a statistics publication of the National Economic Institute (Jónsson, 1999; Tables V.14.6 and V.15.4).

Real domestic demand (1875-2013)
For the period 1945-2013 we use annual averages obtained from Statistics Iceland (adjusting for the structural break in the data in 1997 due to a methodological change related to the introduction of the ESA-2010 national accounts standards introduced in September 2014). Data for the period 1875-1944 is constructed by deflating nominal domestic demand explained above with the implicit GDP price deflator obtained from the data on nominal and real GDP explained above.

Trade deficit as a % of nominal GDP (1875-2013)
For the period 1945-2013 we use annual averages obtained from Statistics Iceland. Data for the period 1875-1944 is constructed by using nominal GDP, imports and exports taken from a statistics publication of the National Economic Institute (Jónsson, 1999; Tables V.14.6 and V.15.4).

Other data

Data related to banking crises in Table 4
For measuring the market share of distressed financial institutions, we use credit supplied by institutions which are adjudged to fall into distress (either fail or need a major recapitalisation) as a share of total credit of commercial and savings banks and other credit institutions (including the government mortgage lender Íbúðalánasjóður). For the 1920 and 1930 crises, we use data for the years 1919 and 1929, respectively (from *Hagskinna: Icelandic Historical Statistics*, Tables 13.2 and 13.3). For the 1985 and 1993 crises, we use data for the years 1984 and 1992, respectively (from Central Bank of Iceland *Annual Reports*, Tables 25 and 29 in the 1986 *Report* and Table 21 in the 1994 *Report*). Finally, for the 2008 crisis, we use data from the Financial Supervisory Authority (*Heildarniðurstöður ársreikninga fjármálafyrirtækja og verðbréfa- og fjárfestingarsjóða fyrir árið 2007*, page 4).

For measuring the impact of banking crises in Iceland on the fiscal balance in Table 4, we use data on the central government income and expenditure from *Hagskinna: Icelandic Historical Statistics*, Tables 15.3 and 15.4 for the period 1875-1944, Table 15.9 for the period 1945-1979, and the Statistics Iceland database for the period 1980-2013. For measuring the impact on government debt, we use data on central government debt from *Hagskinna: Icelandic Historical Statistics*, Table 15.16 for the period 1908-1989, and the Statistics Iceland database for the period 1990-2013.

Population (1875-2013)

To obtain per capita domestic demand, we use population data obtained from Statistics Iceland. The data reports population at 1 January each year – which we use as a measure of the population in the previous year.

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CHAPTER 3

THE LONG HISTORY OF FINANCIAL BOOM-BUST CYCLES IN ICELAND – PART II: FINANCIAL CYCLES[80]

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The long history of financial boom-bust cycles in Iceland

Part II: Financial cycles*

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Abstract

Claudio Borio recently quipped that "macroeconomics without the financial cycle is like Hamlet without the Prince" (Borio, 2014, p. 183). We rise to his call to arms and tackle the Prince's existential question head-on. Our findings suggest that there exists a well-defined financial cycle in Iceland that has gradually become more prominent as the financial deepening and sophistication of the Icelandic economy has increased. Using a dataset spanning more than a century, including data on credit, house prices, and bank balance sheet size and composition, we find that the aggregate financial cycle is much longer than the typical business cycle, with a median duration of sixteen years. We find that there is a large difference in economic performance over different phases of the financial cycle, suggesting that it has played a prominent role in the country's macroeconomic development. In fact, we find that almost all of the peaks in the financial cycle coincide with some type of a financial crisis and that cyclical expansions provide a robust early-warning signal for subsequent crises. We find strikingly strong ties between the Icelandic financial cycle and its global counterpart (proxied by the US financial cycle), with almost all of the cyclical peaks in the Icelandic financial cycle occurring close to peaks in the global cycle. Our findings suggest that understanding economic fluctuations in Iceland is hard without understanding the financial cycle and that we ignore the financial cycle at our peril. We conclude the paper with a first attempt at exploring some of the policy questions that our findings raise.

Keywords: Financial cycle, business cycle, financial crises, global financial spillovers, Iceland
JEL classification: E32, E44, F44, G01, G20, N1

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"History does not repeat itself, but it rhymes"
Mark Twain

1 Introduction

Claudio Borio recently quipped that "macroeconomics without the financial cycle is like Hamlet without the Prince" (Borio, 2014, p. 183). We rise to his call to arms and tackle the Prince's existential question head-on. Our findings suggest that there exists a well-defined financial cycle in Iceland that has gradually become more prominent as the financial deepening and sophistication of the Icelandic economy has increased. We find that this financial cycle has played a key role in the country's macroeconomic developments and, in particular, the financial crises that have regularly hit the economy over a period spanning more than a century. We also find that Iceland is no island in the vast ocean of global high finance, uncovering extremely strong spillover effects from the global financial cycle.

To analyse the financial cycle we use a database which spans the period 1875-2013 and contains annual data on financial prices and volumes, as well as banking system assets, leverage, and liability composition. Here, we focus on the lower frequency properties of our financial variables, i.e. cycles that are longer than typical business cycles. For this, we follow the approach in the growing literature on financial cycles (cf. Drehmann et al., 2012, and Aikman et al., 2015) and filter the data using a band-pass filter to extract cycles with a duration of eight to thirty years. We show that these medium-term cycles dominate typical business cycles in explaining the developments of our financial variables and most of the macroeconomic variables that we also include in our study.

While there is no agreed upon definition of the financial cycle, the term generally refers to the co-movement of a set of financial variables including both quantities and prices (Bank for International Settlements, 2014). Accordingly, Borio (2014, p. 183) characterises the financial cycle as the "self-reinforcing interactions between perceptions of value and risk, attitudes towards risk and financing constraints, which translate into booms followed by busts", making the term closely tied to the concept of the financial system's pro-cyclicality (cf. Borio et al., 2001, and Daníelsson et al., 2004).

To capture the aggregate financial cycle, Borio (2014) argues that its most parsimonious representation is in terms of the interaction between credit and property prices. We include a broader set of variables to attain further insights into the properties of the cycle and to expose potentially important small open economy features of the cycle and its interactions with the domestic economy. To make this operational, we aggregate the medium-term cycles in our financial variables using a principal component approach, which gives the linear combination of the variables that explains most of the combined variability of the individual cycles. We find that not all of our financial variables contribute to this aggregate financial cycle, but the ones that do attain roughly equal weights. This aggregate cycle is found to capture more than 60% of the variability of the aggregate financial data over the whole sample period, rising to 75% in the post-World War II (WWII) period and to more than 80% in the post-1980 period of

increased financial liberalisation and integration into the global financial system. We identify seven complete cycles in this aggregate measure with a median duration of sixteen years, which incidentally is almost identical to the 15½ year average interval between serious multiple financial crisis episodes found in Einarsson et al. (2015). The financial cycle in Iceland is therefore found to be much longer than the typical business cycle and its intensity and length is found to have increased over time relative to the business cycle. There is also a large difference in economic performance over different phases of the financial cycle: the average growth rate of output and domestic demand is almost three times higher in the expansionary phase of the financial cycle than in its contractionary phase (rising to almost four times higher in the post-WWII period).

This large difference in economic activity over different phases of the financial cycle shows how important the financial cycle is for understanding macroeconomic dynamics in Iceland. This is never as clear as in the latter stages of the expansionary phase of the cycle, when balance sheets become overextended and asset prices peak, and the subsequent bust when these imbalances are unwound, which can have severe effects on economic activity and even lead to a financial crisis. We find indeed that almost all of the cyclical peaks coincide with some type of a financial crisis. We also find that expansions in the financial cycle provide a robust early-warning signal for subsequent financial crises and that the aggregate cycle provides an improvement over individual financial and macroeconomic variables in signalling ensuing financial crises, highlighting the importance of the interaction of different financial variables in amplifying financial imbalances.

Previous studies have consistently failed to find important links between the Icelandic business cycle and the business cycles of other developed economies (e.g. Gudmundsson et al., 2000, and Einarsson et al., 2013). The prevalent view has therefore been that the Icelandic business cycle is dominated by country-specific supply shocks, such as idiosyncratic shocks to its important resource sectors. Our results suggest that this consensus may need to be revisited as it overlooks the importance of the financial channel through which global spillovers penetrate the Icelandic economy. We find strikingly strong ties between the Icelandic financial cycle and its global counterpart, which is proxied by the US financial cycle (captured by a composite measure of medium-term cycles in credit and house prices): over the whole sample period these two financial cycles spend close to 75% of the time in the same cyclical phase and almost all of the cyclical peaks in the Icelandic financial cycle occur close to peaks in the global cycle, with the peaks usually coinciding or the Icelandic cyclical peak lagging by a year or two. There is also evidence that these spillover effects have been growing stronger over time. We test whether there are additional regional spillover effects captured by the financial cycles in Denmark and Norway, both of which have strong political, economic, and cultural ties with Iceland, and the UK, given the strong and long-standing trade and financial links between the two countries (and UKs leading role in global finance in the early part of our sample period). We find limited evidence for such regional effects beyond the strong global spillover effects captured by the US financial cycle. There is, however, some evidence of additional regional spillover effects from the Danish credit cycle in the first half of the 20th century, consistent with the prominent role of Danish financing of the domestic financial system during that period.

Our results are very much in the spirit of the findings of recent papers on the importance of the financial cycle in other industrial countries, such as Claessens et al. (2011, 2012), Drehmann et al. (2012), and Aikman et al. (2015). Our study adds to this growing literature by adding yet another country to the sample of countries studied, a country that has been exposed to numerous financial crises of various types over a period spanning over a century, of which the most recent financial tsunami is only the latest example. But our paper also contributes to the literature by showing how more detailed data on bank balance sheets can provide further insights into the analysis of the financial cycle and by highlighting important small open economy features of the cycle and its interactions with the domestic economy, including the importance of contagion from the global financial cycle. We also present a simple way to aggregate individual financial variables that captures their relative importance to the aggregate cycle which allows us to document the importance of individual components to a given cyclical episode.

Our findings highlight the overarching importance of the financial cycle for economic fluctuations in Iceland. The strikingly high co-movement of the Icelandic financial cycle with its global counterpart and the strong coincidence of the cycle and financial crises have already been discussed, but our results show that the cycle's reach goes beyond that. They suggest that it is hard to understand fluctuations in capital flows, the surprisingly high volatility of private consumption in Iceland, and fiscal policy dynamics, to name only three important issues in the domestic economic debate, without understanding the financial cycle. Our results also raise some fundamental policy questions, such as how to design a policy framework that takes the financial cycle into account and its tendency to amplify volatility in real economic activity over its boom and bust phases. The strong global spillover effects may also suggest the need for capital flow management measures that compliment other policy tools and may even raise new questions concerning the optimal exchange rate regime for Iceland. We discuss each of these issues in turn, but it is clear to us that this can only be viewed as a first attempt and that further analysis is likely to be needed to explore the full implications of our findings.

The remainder of the paper is organised as follows. Section 2 presents the data and the motivation for their inclusion in our study. In Section 3 we analyse the key properties of medium-term cycles of individual financial and macroeconomic variables. In Section 4 we use evidence from the previous section to construct a composite measure of the financial cycle in Iceland and discuss its main properties. Here we also discuss its relation with the conventional business cycle and how different phases of the financial cycle interact with economic activity. In Section 5 we look at possible spillover effects from the global financial cycle and whether there are possible additional regional spillover effects from Scandinavia and the UK. Section 6 moves on to analyse the interaction of the Icelandic financial cycle and domestic financial crises and in Section 7 we highlight some policy implications coming out of our analysis. Section 8 concludes the paper.

2 The data

To estimate the financial cycle in Iceland, we use a range of financial variables that cover aggregate financial prices and volumes on the one hand and bank balance sheets on the other hand. We also include a number of key macroeconomic variables which are used to analyse the development of the real economy over the financial cycle and how it interacts through various macro-financial linkages with the cycle. These variables and their motivation are further discussed below while Appendix 1 provides information on data sources and summarises the data graphically.

The fact that financial cycles usually take a long time to complete – decades even – calls for a longer data span than is usually required for analysing most other macroeconomic phenomena. We have therefore constructed a database based on annual data over a period spanning 139 years (1875-2013). As is often the case, the need for a long data span necessitates the use of annual data which comes at the cost of losing higher frequency information on financial cycles found in quarterly data. However, by covering such a long time period we gain some unique insight into the domestic financial cycle that would be lost by focusing on a shorter sample period. Our long sample also brings the tragic but universal truth that "we've been there before" when it comes to financial boom-bust cycles sharply into focus.

2.1 Financial variables

Credit, money, and house prices

The first set of financial variables includes the variables which are central to any analysis of financial cycles, i.e. credit, money, and house prices.[81] The credit cycle, as reflected in surges and shortfalls of liquidity, easing and tightening of financial constraints, and their accompanying balance sheet expansions and deleveraging can have severe repercussions for economic activity and overall macroeconomic stability. Hence, studies of financial cycles logically include credit aggregates as one of the key elements capturing the nexus between the financial system and the real economy (Claessens et al., 2011, 2012, Drehmann et al., 2012, Jordà et al., 2013, 2014, 2015, Aikman et al., 2015, and Taylor, 2015). As our credit measure we use total lending and bond holdings of the credit system (data on credit to the non-financial private sector over the whole sample period is not available). We also include broad money (M3) in line with a number of studies examining to what extent monetary aggregates can serve as indicators for the state of the financial cycle or signal increasing vulnerabilities in the latter stages of financial cycle upswings (Borio and Lowe, 2004, Shin and Shin, 2011, and Kim et al., 2013). The credit and money series are included in real terms and as a ratio to GDP as different

[81] Our analysis does not include stock prices as stock market data does not extend further back than the mid-1980s (Drehmann et al., 2012, find that stock prices do not help explaining the financial cycle in a number of developed economies) but the medium-term cycle in stock prices does show a strong co-movement with the financial cycle over the short period available, in particular in the latest boom-bust episode. Juselius and Drehmann (2015) also emphasise the role of the aggregate debt service burden (interest payments plus amortisations relative to income) in addition to aggregate leverage (the stock of credit relative to asset prices). Historical data or estimates on debt service burden is, however, unavailable for Iceland.

data transformations may reveal alternative information on the financial cycle. The credit-to-money ratio is also included to capture the extent of non-monetary funding of credit creation (for instance, through bond issuance or cross-border loans).

Real residential house prices is another key variable of any analysis of the self-reinforcing interaction between financing constraints and perceptions of value and risk. House prices are usually at the centre of any financial boom-bust cycle and a number of studies have established the prominent role of house price booms and busts (particularly if it is debt-driven) during financial cycle peaks and troughs and in the run-up to and aftermath of banking crises, with a house price boom leading into the crises, followed by a substantial and persistent decline after the bust (e.g. Bordo and Jeanne, 2002, Reinhart and Rogoff, 2008, and Jordà et al., 2015).

Banking system balance sheet

The second set of financial variables aims to capture the potentially important role of financial institutions' balance sheets in fuelling financial cycles. During booms, for example, financial constraints are generally loose due to abundant liquidity and rising net worth, allowing for balance sheet expansion of banks and other sectors within the economy. This is reversed in busts, where adverse spirals can kick in and induce disorderly deleveraging in the financial sector: obtaining funding becomes more difficult, pushing banks and other economic agents to respond by fire-selling their assets, which reduces their net worth, and reinforces the balance sheet constraints (cf. Brunnermeier et al., 2013). Hence, information on the banks' balance sheets can potentially reveal additional insights into their role in amplifying shocks through various macro-financial linkages and financial sector interconnectedness (cf. Adrian and Shin, 2011, and the International Monetary Fund, 2013).

Our first balance sheet variable focuses on the asset side of the balance sheet, as measured by the ratio of total banking system assets to GDP. This measure provides insights into how banks' risk appetite with regards to channelling of funds to the real economy evolves over the financial cycle (Schularick and Taylor, 2012, and Kim et al., 2013). At the same time, it can also serve as a proxy for market liquidity of the banking system assets as they may become more difficult to sell with limited price impact once the banking system becomes large relative to the economy. Finally, it can also capture the potential mismatch between the domestic authorities' capacity and the banking system's possible need for support in times of distress.

The second balance sheet variable we construct is a measure of banking system leverage (the ratio of banking system assets to bank equity) to capture to what extent the expansion of banks' balance sheets is being financed with debt (cf. Drehmann et al., 2012). This leverage measure is more general than the credit-to-money ratio discussed above as it encompasses a greater number of assets and liabilities, and can therefore provide additional information for analysing the financial cycle (although this variable is also subject to some measurement disadvantages, as we discuss below).

Our final banking system balance sheet variable is the ratio of non-core banking liabilities to total liabilities, which reflects the claims on domestic banks not held by the ultimate domestic creditors. This measure serves as a proxy for the funding liquidity position of the banking system and aims to capture to what extent banks shift towards more unsustainable

sources of funding, such as wholesale funding, as traditional (monetary) ones are exhausted (cf. Borio et al., 2011, Hahm et al., 2013, and Kim et al., 2013). We also distinguish between foreign and total non-core liabilities to capture the possible distinctive vulnerabilities of relying on cross-border funding and their relation to banking and currency crises which could play an important role in the financial cycle of a small open (and at times tightly financially integrated) economy, such as Iceland.

2.2 Macroeconomic variables

We include seven macroeconomic variables to capture the multifaceted linkages between the financial cycle and economic developments in a small open economy such as Iceland. We use real GDP as our measure of overall economic activity but to capture the ability of the external account to serve both as a source and absorber of shocks, we also include the trade balance and real domestic demand.[82] This allows us to shed important additional light on the interactions between the financial cycle, cross-border capital flows, and domestic spending in small open economies. Our approach is inspired by numerous studies suggesting that current account deficits and capital flows tend to be pro-cyclical and fuel asset price and financial boom-bust cycles (cf. Kaminsky and Reinhart, 1999, Aguiar and Gopinath, 2007, Korinek, 2011, and Broner et al., 2013).[83]

We also include the exchange rate which can play a pivotal role in the real-financial nexus in small open economies. Some studies suggest that the exchange rate in very small open economies such as Iceland can be a source of shocks rather than a shock absorber (cf. Breedon et al., 2012) and others find the real exchange rate to be a leading indicator of currency and banking crises (cf. Kaminsky et al., 1998, Kaminsky and Reinhart, 1999, Goldstein et al., 2000, and Gourinchas and Obstfeld, 2012). Bruno and Shin (2015a, b) provide theoretical and empirical evidence consistent with these findings and emphasise the interactions between currency appreciations, borrowers' balance sheet strength, and greater risk-taking by banks in driving financial cycles and thereby affecting economic activity in small open economies. We include both the nominal (vis-à-vis the US dollar as emphasised by Avdjiev et al., 2015) and real (trade weighted relative consumer prices) value of the currency.

[82] Although cross-border banking liabilities can also serve as a proxy for (gross) capital flows, the findings in Einarsson et al. (2015) suggest that the capital flow cycle over the whole period is better captured by the trade balance data (see also Reinhart and Rogoff, 2009). This probably reflects the tight management of the capital account for a large part of the sample period and that our cross-border banking liabilities measure does not capture the role played by the government and its investment funds in intermediating foreign credit to the domestic economy, especially during the post-WWII period up until 1970 when the banks' access to foreign funding remained severely restricted.

[83] Aguiar and Gopinath (2007) find that this emerging market phenomenon is strongly linked to an unusually high ratio of permanent to temporary shocks. As Reinhart and Rogoff (2009) argue, policymakers in these countries seem to have a tendency to interpret favourable shocks as being permanent, leading to spending sprees and borrowing binges that ultimately lead to sudden stops in funding and sharp recessions and reversals in the current account. Korinek (2011) argues that exposure to international capital flows imposes externalities on countries in the form of financial instability arising from risky external debt accumulation by market participants who do not internalise the economy-wide effects of their borrowing decisions through exchange rate and asset price changes.

Finally, our set of macroeconomic variables includes inflation to capture the chronic inflation episodes and frequent inflation crises throughout Iceland's economic history and the terms of trade which have historically been found to be an important source of business cycle fluctuations and an important trigger of financial crises (cf. Gudmundsson et al., 2000, Daníelsson, 2008, and Einarsson et al., 2015).

3 Cycles in financial and macroeconomic variables

Early economic writers drew lessons from the financial boom-bust episodes which they experienced in their lifetime with regard to the factors affecting economic developments. Parts of Adam Smith's *Wealth of Nations* were thus inspired by the 1772 banking crisis and the pioneers of analysis into economic cycles, Sismondi and Dunoyer, used the first modern international financial crisis in 1825 to champion their argument for the importance of endogenous economic cycles (Sowell, 1972, and Benkemoune, 2009). Subsequent series of banking crises led to further analysis into the role of credit creation in the macroeconomy, especially by Knut Wicksell and the Austrian School. Emphasis on the role of financial factors in economic fluctuations and the presence of self-reinforcing interaction between medium-term "financial" cycles and the general business cycle culminated in the works of the Great Depression-era economists, such as Irving Fisher and Alvin Hansen. For example, writing about business cycles and lessons to be drawn from the Great Depression, Hansen (1941, p. 25) emphasised the importance of "building construction cycles" (a cycle closely related to the financial cycle due to its duration and the role played by credit and property prices) for understanding the Great Depression and business cycles in general:

> "It is […] not possible to give an adequate analysis of the major business cycle […] without taking account of the impact on that cycle of the longer cycle of building construction. This factor is one of the most profound of the various influences which cause one major business cycle to differ from another. And in this factor we are able to see against the background of earlier American experience a part of the explanation of the severity of the Great Depression starting in 1929."

However, financial features gradually lost their prominent role within macroeconomics in the post-WWII period and the lessons of the past were all but forgotten (Gertler, 1988). The recent global financial crisis, however, swiftly shifted the focus once again to the role of macro-financial linkages in explaining macroeconomic phenomena. A rapidly expanding literature has since emerged attempting to account for the importance of these financial features (cf. Brunnermeier et al., 2013, Taylor, 2015) and uncover the salient features of the financial cycle. In particular, Claessens et al. (2011, 2012), Drehmann et al. (2012), and Aikman et al. (2015) all find evidence of cycles in financial variables that tend to be longer and of greater amplitude than standard business cycles. Drehmann et al. (2012) and Aikman et al. (2015) also find

evidence of important links between these lower-frequency cycles and financial crises, suggesting an important role of these cycles in explaining such episodes.

3.1 Extracting cyclical components from the data

To identify short- and medium-term cycles in our data, we follow Aikman et al. (2015) and use the Christiano and Fitzgerald (2003) asymmetric band-pass filter to isolate the pre-specified frequency range of the data.[84] The short-term cycles we aim to identify coincide with typical business cycles, which are commonly thought to last between 5 quarters and 8 years. However, our use of annual data dictates that we restrict the minimum phase of these short-term cycles to 2 years. Following Drehmann et al. (2012), we identify the medium-term cycles as those that have a duration between 8 and 30 years. While the upper bound in their paper is dictated by data limitations, our earlier study (Einarsson et al., 2015) finds that major financial crisis occur in Iceland on average every 15½ years indicating that 8 to 30 years should be a sufficiently large window to focus on when identifying the financial cycle in Iceland.[85] As has become standard in this literature (cf. Comin and Gertler, 2006, and Drehmann et al., 2012), we apply the frequency filter to log-differences of the original variables, which under the common assumption that growth rates of economic series are stationary implies a zero trend in the filter. To construct the medium-term cycles in the original variables we then cumulate these growth series into log-levels starting from zero at the first observation of the variable.[86]

3.2 Key cyclical characteristics of individual series

We start by looking at some key cyclical properties of our financial and macroeconomic variables, applying the terminology commonly applied in business cycle analysis. We report results on the typical length and intensity of medium-term cycles in each variable and how they have evolved over time. We also compare the volatility of medium-term cycles to that of the corresponding short-term (business) cycles in the data to establish which cyclical component has been the key driver of the behaviour of each series. Finally, we look at how the medium-term cyclical components of the data correlate with each other, interpreting evidence of cyclical co-movement of the financial variables as suggesting the presence of an aggregate financial cycle.

[84] Claessens et al. (2011, 2012) use the Harding and Pagan (2002) turning point algorithm, while Drehmann et al. (2012) apply both the band-pass filter and the turning-point approach. In Einarsson et al. (2015), we use the Hodrick-Prescott filter with a high smoothing parameter to analyse the cyclical behaviour of our financial and macroeconomic variables in the run-up to and aftermath of financial crises. Using the Hodrick-Prescott filter here to extract the medium-term cycles in the data gave broadly similar results to the band-pass filter but tended to identify more frequent and shorter cycles.

[85] Aikman et al. (2015) use an upper range of 20 years, while Comin and Gertler (2006) use an upper range of 50 years. Our results are found to be robust to variations in the upper range of duration of medium-term cycles.

[86] For the trade deficit and inflation (which can take both positive and negative values) and the two non-core bank liability measures (which equal zero for some years), we use the log-difference of one plus the variable.

Duration and intensity of medium-term cycles

The upper panel of Table 1 reports the key properties of the medium-term cyclical component of all our variables. We show the median duration and amplitude of the expansionary and contractionary phases of the medium-term cycles, and the median duration of a complete cycle (measured from peak to peak). In addition, we report the median "slope" (defined as the ratio of amplitude to duration) of expansionary and contractionary phases which measures how violent each cyclical phase is. The table shows that all the financial variables have a cyclical phase lasting 5 years or more. A complete cycle therefore lasts 10 years or more (with an average cycle of almost 12 years). GDP, and most of the other macroeconomic variables, have cycles with a duration of 10 years and therefore tend to be shorter than the corresponding cycles in most of the financial variables. This is consistent with other studies, such as Claessens et al. (2011) and Drehmann et al. (2012). Our finding that the expansionary phase of the cycles in the financial variables tend to be longer than the contractionary phase is also consistent with these studies.

We also find that medium-term cycles in the financial variables tend to have greater amplitude than the corresponding cycles in the macroeconomic variables. On average, the financial variables rise by 25% during the expansionary phase of the cycle and fall by 22% during the contractionary phase, which is roughly double that of the macroeconomic variables. Looking at individual variables, we find that cycles in house prices and the two non-core bank liability measures tend to be relatively less intense than in the other financial variables, while the cyclical intensity of the nominal exchange rate is a particularly distinctive feature among the macroeconomic variables, to some extent reflecting its asset price characteristics.

In the lower panel of Table 1 we repeat the exercise for three different subsamples. First, we split the sample in half with the first half covering the period up to the end of WWII and the second half covering the post-WWII period. The first subsample therefore covers the modernisation of the Icelandic economy, beginning around 1890, when increased foreign demand, technological innovation, and financial deepening paved the way for export-oriented industrialisation and ends with a "great leap forward" in terms of the modernisation of the economy during WWII (Jónsson, 2004), while the second subsample covers the period from which Iceland had caught up with other advanced economies in terms of income levels. The post-WWII subsample also corresponds to a period of rising homeownership and increasing importance of mortgage financing. The third subsample covers the post-1980 period, which splits the post-WWII subsample in half and roughly coincides with the modernisation of the Icelandic financial system and liberalisation of domestic financial markets (cf. Central Bank of Iceland, 2005 (Table 5.1), 2016), while also coinciding with a period of significant international financial liberalisation and globalisation (cf. Claessens et al., 2011, and Drehmann et al., 2012) and the global real estate lending boom of the last thirty years (Jordà et al., 2014).[87]

[87] We only report the subsample results for the aggregate data groups but the same development in the cyclical properties can be found for most of the individual variables. To simplify the presentation of our results, we only report subsample results for the duration of a complete cycle and the average of the expansionary and contractionary phases of the cycle for our amplitude and slope measures. Further detail is available upon request.

Overall, we find that medium-term cycles in our financial variables have on average lengthened by 3½ years compared to the first subsample to just under 16 years in the post-1980 period. The medium-term cycles in the macroeconomic variables have become shorter and more intense, however. The intensity of the cyclical components has also increased for some of the financial variables, although it remains broadly stable on average.

Table 1 Key characteristics of medium-term cycles

	Duration			Amplitude		Slope	
	Expan-sion	Con-traction	Full cycle	Expan-sion	Con-traction	Expan-sion	Con-traction
Real house prices	6.00	5.00	10.00	0.14	-0.12	0.03	-0.02
Real credit	6.00	5.00	13.00	0.41	-0.38	0.04	-0.04
Credit-to-GDP ratio	8.00	5.00	13.00	0.29	-0.21	0.04	-0.03
Real M3	6.00	5.50	10.00	0.30	-0.23	0.04	-0.04
M3-to-GDP ratio	7.00	6.00	12.00	0.30	-0.29	0.04	-0.03
Credit-to-M3 ratio	10.00	7.00	14.00	0.45	-0.40	0.04	-0.04
Assets-to-GDP ratio	6.00	6.00	12.00	0.20	-0.22	0.03	-0.04
Bank leverage ratio	6.00	6.00	12.00	0.34	-0.27	0.04	-0.05
Foreign non-core liab.	6.00	5.50	11.00	0.04	-0.04	0.01	0.00
Total non-core liab.	5.50	6.00	11.50	0.07	-0.04	0.01	-0.01
Real GDP	5.00	5.00	10.00	0.11	-0.14	0.02	-0.02
Real domestic dem.	5.00	5.50	10.00	0.16	-0.14	0.03	-0.03
Trade deficit-to-GDP	5.00	6.00	10.00	0.04	-0.05	0.01	-0.01
USD exchange rate	5.00	5.00	10.00	0.26	-0.25	0.05	-0.05
Real exchange rate	5.00	4.50	10.00	0.09	-0.16	0.02	-0.03
Terms of trade	5.00	4.00	8.50	0.12	-0.11	0.02	-0.02
Inflation	5.00	4.00	8.50	0.08	-0.07	0.01	-0.01
				Averages			
Financial variables	6.65	5.70	11.85	0.25	-0.22	0.03	-0.03
Macro variables	5.00	4.86	9.57	0.12	-0.13	0.02	-0.02
All variables	5.97	5.35	10.91	0.20	-0.18	0.03	-0.03

Different subsamples (group averages)

	Duration			Amplitude			Slope		
	1875-1944	1945-2013	1980-2013	1875-1944	1945-2013	1980-2013	1875-1944	1945-2013	1980-2013
Financial variables	12.25	13.40	15.70	0.28	0.23	0.32	0.04	0.03	0.04
Macro variables	11.21	9.43	10.07	0.10	0.19	0.14	0.02	0.04	0.02
All variables	11.82	11.76	13.38	0.20	0.22	0.24	0.03	0.03	0.03

The upper panel of the table reports summary statistics for the medium-term cyclical component of each variable for the total sample (1875-2013). *Duration* is the number of years between trough and peak (for expansions) or peak and trough (for contractions). The duration of the full cycle is measured from peak to peak. *Amplitude* is the change from trough to peak (for expansions) or peak to trough (for contractions). *Slope* denotes the ratio between amplitude and duration. For the three subsamples reported in the lower panel of the table, the duration of a full cycle (from peak to peak), the average amplitude (average of expansionary and absolute value of contractionary phases) and average slope (average of expansionary and absolute value of contractionary phases) are given. Duration, amplitude and slope are in all cases obtained using sample medians.

Source: Authors' calculations.

Relative volatility of medium- and short-term cycles

Table 2 reports the relative volatility of the medium- and short-term cyclical components for each series across different sample periods, which gives an idea of the relative importance of the medium- and short-term cyclical components in explaining the overall behaviour of each variable. As the table shows, it seems that the financial series are dominated by cycles at the medium-term frequency, with the standard deviation of medium-term cycles being more than double that of cycles at the business cycle frequency. The same holds for the macroeconomic variables, although the difference is smaller in most cases. The relative importance of the two components remains broadly stable over time for the financial variables, but the importance of medium-term cycles seems to be increasing for the macroeconomic variables and by the post-1980 period they have in all cases become more volatile than cycles at the business cycle frequency. The dominance of medium-term cycles in explaining the overall behaviour of the financial and macroeconomic variables can also be gauged from the figures in Appendix 2, which compare medium-term cycles in each variable with complete 2-30 year cycles. As the figures clearly show, the medium-term cycles capture a large part of the complete cycles in most of the series, suggesting that the business cycle (the difference between the two) plays a smaller role in explaining the overall variation in the data. This is consistent with what Drehmann et al. (2012) and Aikman et al. (2015) find for financial variables in several advanced economies and to what Comin and Gertler (2006) find for a range of macroeconomic variables in the US.

Table 2 Relative volatility of short- and medium-term cycles

	Total sample	1875-1944	1945-2013	1980-2013
Real house prices	2.28	2.33	2.16	2.30
Real credit	2.67	2.66	2.64	2.81
Credit-to-GDP ratio	2.21	2.20	2.20	2.24
Real M3	2.61	2.64	2.59	2.53
M3-to-GDP ratio	2.33	2.01	2.65	2.81
Credit-to-M3 ratio	2.99	3.71	2.32	1.68
Assets-to-GDP ratio	1.86	2.24	1.75	1.77
Bank leverage ratio	2.45	2.73	1.93	1.24
Foreign non-core liabilities	2.22	1.40	2.66	2.78
Total non-core liabilities	2.13	2.04	2.20	2.26
Real GDP	2.13	2.15	2.09	2.39
Real domestic demand	1.54	1.27	1.83	1.97
Trade deficit-to-GDP ratio	0.82	0.65	1.21	1.35
USD exchange rate	2.08	1.65	2.21	2.59
Real exchange rate	1.50	1.72	1.39	1.57
Terms of trade	0.93	0.85	1.30	1.96
Inflation	1.03	1.10	0.91	1.07
		Averages		
Financial variables	2.38	2.52	2.21	2.04
Macro variables	1.44	1.25	1.64	1.95
All variables	2.01	2.02	2.00	2.01

The table reports the relative standard deviations of medium-term (8 to 30 years) and short-term (2 to 8 years) cycles for each variable. A number above (below) unity indicates that the medium-term cyclical component is more (less) volatile than the short-term component.

Source: Authors' calculations.

Correlations of medium-term cycles in financial variables

The final part of our analysis of cyclical properties of individual variables looks at contemporaneous correlation coefficients of medium-term cycles in our financial variables over the whole sample and the three different subsamples.[88] Table 3 shows that medium-term cycles in most of the financial variables tend to co-move over time. The co-movement of credit, house prices, and wholesale bank funding is strong, while medium-term cycles in money and leverage do not seem well aligned with the corresponding cycles in the other financial variables.

Table 3 Correlations of medium-term cyclical component of financial variables

	Real house prices	Real credit	Credit-to-GDP	Real M3	M3-to-GDP	Credit-to-M3	Assets-to-GDP	Bank leverage	For. non-core liab.	Total non-core liab.
Real house prices	1.00	0.72	0.42	0.22	-0.22	0.41	0.41	-0.16	0.39	0.57
Real credit		1.00	0.87	0.08	-0.21	0.72	0.51	-0.31	0.55	0.72
Credit-to-GDP			1.00	-0.26	-0.29	0.86	0.48	-0.49	0.49	0.72
Real M3				1.00	0.84	-0.63	0.16	0.36	0.05	-0.20
M3-to-GDP					1.00	-0.74	0.10	0.27	-0.10	-0.38
Credit-to-M3						1.00	0.29	-0.49	0.40	0.71
Assets-to-GDP							1.00	-0.13	0.72	0.66
Bank leverage								1.00	0.08	-0.51
For. non-core liab.									1.00	0.71
Total non-core liab.										1.00

The table gives the contemporaneous correlations of the medium-term cyclical component of the financial variables for the total sample period. Shaded sells highlight correlation coefficients larger than or equal to 0.7.

Source: Authors' calculations.

Looking at different subsamples in Table 4 shows that the cyclical co-movement of most of the financial variables has strengthened over time: the number of correlation coefficients exceeding 0.7 increases from seven in the 1875-1944 period to twelve (eighteen) in the post-WWII (post-1980) period and the number of coefficients exceeding 0.8 rises from five in the 1875-1944 period to eleven in the post-1980 period.[89] The medium-term cycles of house prices, credit, bank assets, and bank wholesale funding become increasingly aligned, while the cycles in money and bank leverage continue to be out of sync with cycles in the other variables.

[88] We look at cyclical correlations of our macroeconomic variables in the context of our analysis of the aggregate financial cycle in Section 4.2 below.

[89] The simple average of correlation coefficients rises from 0.09 in the 1875-1944 period to 0.36 in the post-WWII period and further to 0.55 in the post-1980 period (excluding the two money measures and bank leverage gives an average correlation coefficient that rises from 0.50 in the first period to 0.70 in the post-WWII period and to 0.80 in the post-1980 period). It is important to note that the increasingly strong co-movement of the cyclical components does not rely on the inclusion of the latest boom-bust cycle (i.e. the results continue to hold if we end the sample in 2003).

Table 4 Subsample correlations of medium-term cyclical component of financial variables

	Real house prices	Real credit	Credit-to-GDP	Real M3	M3-to-GDP	Credit-to-M3	Assets-to-GDP	Bank leverage	For. non-core liab.	Total non-core liab.
					1875-1944					
Real house prices	1.00	0.64	0.27	0.16	-0.45	0.39	0.17	-0.29	0.19	0.55
Real credit		1.00	0.86	-0.23	-0.55	0.85	0.24	-0.54	0.48	0.79
Credit-to-GDP			1.00	-0.56	-0.50	0.93	0.36	-0.65	0.50	0.80
Real M3				1.00	0.71	-0.70	-0.16	0.45	0.10	-0.44
M3-to-GDP					1.00	-0.78	-0.02	0.41	0.14	-0.56
Credit-to-M3						1.00	0.26	-0.64	0.30	0.82
Assets-to-GDP							1.00	-0.50	0.36	0.49
Bank leverage								1.00	-0.03	-0.90
For. non-core liab.									1.00	0.23
Total non-core liab.										1.00
					1945-2013					
Real house prices	1.00	0.94	0.80	0.36	0.08	0.47	0.81	0.24	0.70	0.70
Real credit		1.00	0.89	0.37	0.11	0.52	0.76	0.13	0.68	0.69
Credit-to-GDP			1.00	0.06	-0.06	0.71	0.69	-0.11	0.62	0.67
Real M3				1.00	0.92	-0.61	0.32	0.28	0.03	-0.04
M3-to-GDP					1.00	-0.75	0.16	0.11	-0.19	-0.26
Credit-to-M3						1.00	0.35	-0.15	0.55	0.62
Assets-to-GDP							1.00	0.27	0.83	0.76
Bank leverage								1.00	0.19	0.00
For. non-core liab.									1.00	0.94
Total non-core liab.										1.00
					1980-2013					
Real house prices	1.00	0.98	0.94	0.67	0.39	0.58	0.93	0.53	0.76	0.75
Real credit		1.00	0.97	0.70	0.44	0.58	0.90	0.50	0.76	0.75
Credit-to-GDP			1.00	0.63	0.42	0.62	0.88	0.40	0.73	0.69
Real M3				1.00	0.92	-0.18	0.50	0.34	0.17	0.21
M3-to-GDP					1.00	-0.45	0.23	0.10	-0.16	-0.13
Credit-to-M3						1.00	0.67	0.30	0.86	0.80
Assets-to-GDP							1.00	0.55	0.85	0.83
Bank leverage								1.00	0.51	0.53
For. non-core liab.									1.00	0.98
Total non-core liab.										1.00

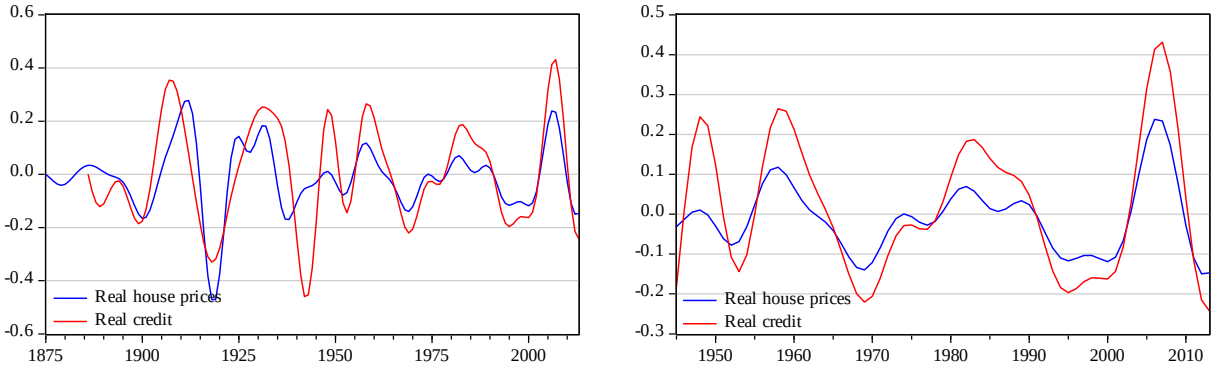
The table gives the contemporaneous correlations of the medium-term cyclical component of the financial variables for three different subsamples. Shaded sells highlight correlation coefficients larger than or equal to 0.7.

Source: Authors' calculations.

As an example, Figure 1 shows how tightly the medium-term cycles in real house prices and real credit (the two financial variables Borio, 2014, argues most parsimoniously describe the financial cycle) have moved together over most of the sample period. Together with the results in Tables 3 and 4, it shows a clear tendency of medium-term cycles in the financial variables to move together over time.[90] Such co-movement is what the financial cycle aims to capture.

[90] A temporary breakdown in the relationship between house prices and credit during WWII, evident in Figure 1, could in part be due to measurement issues as house prices are measured by building costs in these years (see Appendix 1).

Figure 1 Medium-term cycles in house prices and credit
1875-2013 (left) and 1945-2013 (right)



Source: Authors' calculations.

4 The aggregate financial cycle

4.1 Estimating the financial cycle

The results from the previous section suggest that there exists an aggregate financial cycle in Iceland over a sample period spanning more than a century. Similar to Drehmann et al. (2012) and drawing on Borio's (2014) characterisation of the financial cycle as the inherent pro-cyclicality of the financial system, we define this aggregate cycle as the low-frequency (here specified as cycles lasting from 8 to 30 years) cyclical co-movement of a set of financial variables including both quantities and prices. This definition is conceptually similar to the standard approach of defining the business cycle as the recurrent and broad-based co-movement of macroeconomic variables over a frequency typically specified as lasting from just over a year to 8 years (cf. Burns and Mitchell, 1946).

To obtain our estimate of the aggregate financial cycle we simply take a weighted average of the medium-term cycles in the ten financial variables included in our analysis. For this we use principal component analysis where we identify the aggregate financial cycle as the first principal component, i.e. the one that explains most of the combined variability in the medium-term cycles of financial variables. We therefore take a broader approach of measuring the financial cycle than, for example, Aikman et al. (2015) and Schularick and Taylor (2012) (who focus exclusively on the credit cycle) and Drehmann et al. (2012) (who focus on a cycle comprising credit and house prices). Our approach is more akin to that taken in the literature on the "financial conditions index" (although the focus there is more on short-term co-movement in financial variables rather than trying to estimate a lower-frequency composite cycle as we do), cf. Swiston (2008) and Angelopoulou et al. (2013). This approach allows us to attain additional insights into the nature of the financial cycle in such a small open economy by, for instance, exposing the potential feedback mechanisms from one component of the financial cycle to another, working through various linkages, e.g. the interaction of asset prices,

borrower's collateral constraints, and banks' balance sheets, as well as its multifaceted relations with the domestic economy and its external account.[91] Table 5 shows the results.

Table 5 Principal component estimation of the financial cycle

	First principal component				
	Unrestricted	Restricted			
	Total sample	Total sample	1875-1944	1945-2013	1980-2013
Proportion of variance	0.50	0.65	0.60	0.75	0.83
		Normalised factor loadings			
Real house prices	0.15	0.12	0.11	0.15	0.15
Real credit	0.21	0.16	0.18	0.15	0.15
Credit-to-GDP ratio	0.21	0.15	0.18	0.15	0.14
Real M3	-0.07	–	–	–	–
M3-to-GDP ratio	-0.12	–	–	–	–
Credit-to-M3 ratio	0.21	0.14	0.17	0.11	0.12
Assets-to-GDP ratio	0.15	0.13	0.09	0.14	0.15
Bank leverage ratio	-0.12	–	–	–	–
Foreign non-core liabilities	0.16	0.13	0.10	0.15	0.15
Total non-core liabilities	0.22	0.16	0.17	0.15	0.14
Total	1.00	1.00	1.00	1.00	1.00

The table reports the proportion of variance explained by the first principal component of the medium-term cyclical components of the financial variables and the individual factor loadings of each financial variable. Column 2 reports the first principal component for all the ten financial variables, while columns 3-6 report the first principal component for the restricted set of seven financial variables that excludes the three variables that obtain negative loadings in column 2 (the two money measures and the leverage ratio) over the total sample period and three subsamples.

Source: Authors' calculations.

First, we show the unrestricted estimate over the full sample period, i.e. where all the ten financial variables are included. The normalised factor loadings suggest broadly similar weights for all the variables in the aggregate cyclical measure, except for the three found to be weakly correlated to the other variables in Tables 3 and 4 above. While the relatively weak role of money in driving the financial cycle is consistent with the declining role of money in boom-bust financial cycles in the post-WWII period in other industrial countries found by Schularick and Taylor (2012) and Aikman et al. (2015), the limited role of bank leverage found here probably reflects the impact of financial repression in Iceland over a large part of the post-WWII period. Thus, cyclical expansions of the leverage ratio typically reflect depressed financial savings and bank capital through rampant inflation and artificially low interest rates rather than the financial expansions reflected in the other financial variables. As discussed in

[91] For our principal component analysis and the construction of the aggregate financial cycle we normalise all the medium-term cycles so that they have a mean of zero and a standard deviation of unity. We also tried to estimate the aggregate financial cycle using a dynamic factor analysis. The results were broadly the same: most of the cyclical peaks and troughs corresponded to those estimated from the principal component analysis but the dynamic factor analysis produced a cycle with greater short-term fluctuations. Schüler et al. (2015) estimate an aggregate financial cycle for a number of European countries using multivariate spectral analysis that allows for time-varying weights of financial variables that includes credit, house and stock prices, and bond yields. For a discussion of different methods for extracting common financial cycles from a set of financial variables, see also Breitung and Eickmeier (2014).

Einarsson et al. (2015), there are also some measurement issues during the latest episode, with the declining leverage ratio in the run-up to the crisis reflecting the fact that the numerator (bank capital) is measured at book value, whose quality and quantity has since been seriously questioned (Rannsóknarnefnd Althingis, 2010). Hence, the three credit variables, banking system size, and the importance of its wholesale funding seem to perform better at capturing the balance sheet overextension within the financial system than the two money measures and the leverage ratio.

As it is not meaningful in the context of our exercise to include variables with a negative weight in our measure of a common financial cycle, we exclude the three variables with negative loadings in our subsequent analysis of the aggregate cycle (Schüler et al., 2015, use similar arguments). The resulting "restricted" estimate in Table 5 gives roughly identical factor loadings for the remaining variables, while the variability of the aggregate financial data explained by the first principal component rises from 50% in the unrestricted version to 65%. The table also reports the normalised weights estimated over the three subsamples and it is clear from these that the weights remain roughly equal for all the seven variables over the whole sample period, while the proportion of the total variability of the financial data captured by this aggregate measure rises to 75% in the post-WWII period and further to more than 80% in the post-1980 period.[92] This is considerably higher than the proportion of variance explained by aggregate cycles for the post-1970 period in a number of Euro Area countries reported by Hiebert et al. (2014) using a similar approach, which ranges from a third for Italy to roughly half for Ireland.

Figure 2 gives the full-sample estimate of the financial cycle and an approximation of the contribution of individual components to the aggregate cycle calculated using the whole-sample factor loadings from Table 5. To ease the presentation, we summarise the seven individual components into three groups, one denoted the "credit cycle" which contains the contribution of the medium-term cycles in the three credit transformations in our sample (real credit, credit-to-GDP, and credit-to-money), another denoted the "bank balance sheet cycle" which contains the contribution of the medium-term cycles in the three bank balance sheet variables in our sample (bank assets-to-GDP and the two non-core bank liabilities ratios), and the final one is the "house price cycle" which contains the contribution of the medium-term cycle in real house prices to the aggregate cycle.

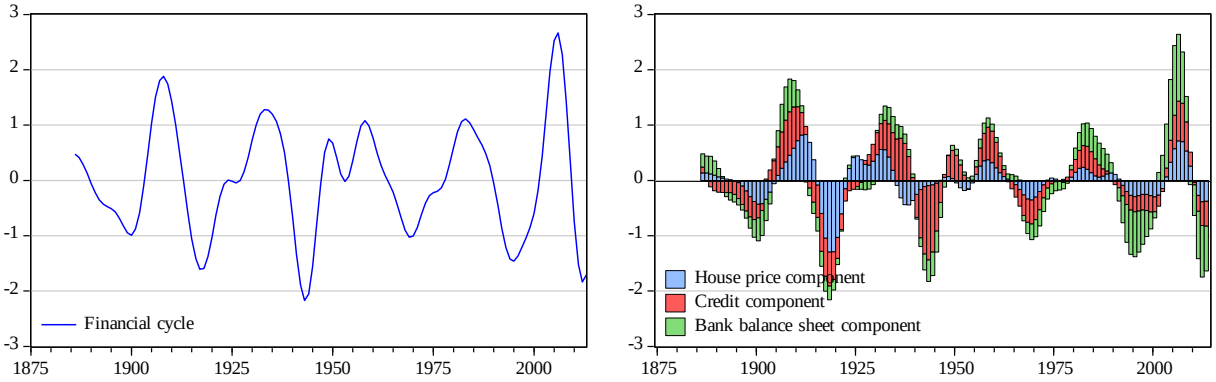
We identify seven cyclical expansions over the whole sample period. There is an expansion around the turn of the century that peaks in 1908, which is mainly driven by credit during the early phase of the expansion, but with a rising contribution of bank balance sheets as the expansion matures, followed by house prices in the final years of the expansion (which in turn play a large role in the cycle's bust phase). There is another expansion that starts at the end of World War I (WWI), breaking off for a short period in the mid-1920s and expanding again until peaking in 1933 (therefore counting as two expansions). Here, house prices play a

[92] Our results are therefore almost identical to using a simple average (as suggested by Drehmann et al., 2012). Our final measure of the financial cycle also appears robust to the information set used to extract it from the data, reflecting the high synchronisation of the medium-term cycle in these variables: for example, it is closely matched by a simple average that only includes house prices and credit (the variables used by Drehmann et al., 2012).

key role during the expansion's initial phase, followed by credit during the second stage of the expansion. The middle of the century is dominated by two relatively short financial expansions, one that peaks in 1949 and follows the large economic shock related to allied occupation in WWII (see Einarsson et al., 2015), and another one that starts in 1953 and peaks in 1958. Both are mainly credit driven, although house prices also play a role in the second cyclical expansion. The next expansionary phase lasts much longer, or fourteen years from 1969 to 1983, and is relatively broadly based. The final expansion starts in 1995 and lasts for eleven years before reversing sharply in 2006. This large expansion is mainly driven by expanding bank balance sheets during the cycle's birth phase, which coincides with the completion of the country's capital account liberalisation and a broad-sweeping privatisation of domestic financial institutes during the latter half of the decade and the first years of the new century. It is only after a few years of balance sheet expansion (much of which took place across borders) that a significant expansion of domestic credit and house prices emerges. During the bust phase of the cycle we see sizeable contributions from all components, but bank balance sheets again play a prominent role. The latest boom-bust cycle therefore highlights how the inclusion of bank balance sheet data in the estimation of the aggregate financial cycle can offer additional insights into its dynamics, due to the important role of financial institutions' balance sheets in driving economy-wide cyclical movements (cf. Adrian and Shin, 2011) by reinforcing the interactions between financing constraints and perceptions of value and risks, operating partly across borders.

Figure 2 The financial cycle and contribution of individual cyclical components

Financial cycle (left) and medium-term components (right)



Financial cycle and contribution of individual cyclical components, weighted with their normalised factor loadings. *House price component* refers to the contribution of the medium-term cycle in real house prices to the financial cycle, *Credit component* refers to the weighted average contribution of medium-term cycles in real credit, credit-to-GDP and credit-to-M3 to the financial cycle, *Bank balance sheet component* refers to the weighted average contribution of medium-term cycles in bank assets-to-GDP, foreign non-core bank liabilities ratio and total non-core liabilities ratio to the financial cycle. The individual components are normalised so that their sum has the same mean and standard deviation as the aggregate cycle.

Source: Authors' calculations.

4.2 Key properties of the financial cycle

Table 6 summarises the key properties of the financial cycle over the whole sample period and the three subsamples. The duration of a complete financial cycle is found to be 16 years on average and to have lengthen over time, as was typically found for individual financial

variables. This is primarily due to the lengthening of the expansionary phase of the cycle, which gradually becomes longer than the contractionary phase. Both phases of the cycle have also become more intense. Although caution is warranted given the relatively small number of cyclical episodes observed, these results are broadly in line with those found by Drehmann et al. (2012) for a sample of seven industrial countries. They also obtain financial cycles of 16 years that seem to have grown longer and more intense as liberalisation progressed since the mid-1980s and macroeconomic conditions became more stable during the run-up to the recent global financial crisis.[93]

Table 6 Key characteristics of the financial cycle

	Total sample	1875-1944	1945-2013	1980-2013
Duration in expansions	7.00	7.00	8.50	12.50
Duration in contractions	9.50	9.50	8.50	9.00
Duration of complete cycle	16.00	16.00	19.50	24.00
Amplitude of expansions	2.14	1.61	2.53	3.13
Amplitude of contractions	-2.34	-2.46	-2.34	-3.54
Slope of expansions	0.23	0.23	0.30	0.26
Slope of contractions	-0.20	-0.22	-0.20	-0.48

The table reports summary statistics for the financial cycle. *Duration* is the number of years between troughs and peaks (for expansions) or peaks and troughs (for contractions). The duration of the full cycle is measured from peak to peak. *Amplitude* is the change from trough to peak (for expansions) or peak to trough (for contractions). *Slope* denotes the ratio between amplitude and duration. Duration, amplitude and slope are in all cases obtained using sample medians.

Source: Authors' calculations.

Table 7 gives the correlation coefficients of medium-term cycles in individual financial and macroeconomic variables with the aggregate financial cycle. Medium-term cycles in most of the financial variables remain highly correlated with the financial cycle throughout the sample period, with correlation coefficients around 0.7 or higher over the whole sample and close to 0.9 in the post-WWII period for all the variables except the two money measures and the bank leverage ratio. This is also borne out by Harding and Pagan's (2006) concordance index reported in Table 7, which measures the fraction of time individual series are in the same cyclical phase as the aggregate financial cycle (see also Appendix 2, which shows the development of the financial cycle and the medium-term cycles in individual series).[94] The index is close to 0.8 for most of the variables over the whole sample period and rises even further in the post-WWII period.

The data therefore clearly shows how different segments of the financial system co-move and have gradually become more and more synchronised over time, presumably reflecting the rising financial sophistication of the Icelandic economy. However, this is not exclusive to the financial variables, as we see that medium-term cycles in some of the macroeconomic variables have also become more closely tied to the financial cycle. This holds

[93] See Einarsson et al. (2015) and Central Bank of Iceland (2016) for discussions of Iceland's varying degree of financial liberalisation.

[94] Two series which are perfectly pro-cyclical (counter-cyclical) would therefore have a concordance index equal to unity (zero). For two series with fully independent cycles (and therefore have a correlation coefficient equal to zero), however, the concordance index would equal 0.5.

particularly true for the cyclical components of economic activity (especially domestic demand) and the trade deficit, which becomes almost completely synchronised with the financial cycle in the post-1980 period. This points to an important interaction between the financial cycle and capital flows with regard to the capacity to finance domestic expenditure, consistent with implications of many of the papers cited in Section 2.2 above. We will return to this theme in our discussion of some of the issues that our analysis give rise to in the next section and in Section 7 below.[95]

Table 7 Co-movement of individual variables with the financial cycle

	Contemporaneous correlations				Concordance index			
	Total sample	1875-1944	1945-2013	1980-2013	Total sample	1875-1944	1945-2013	1980-2013
Real house prices	0.69	0.62	0.88	0.92	0.80	0.74	0.84	0.82
Real credit	0.91	0.95	0.89	0.92	0.84	0.78	0.90	0.88
Credit-to-GDP ratio	0.87	0.91	0.87	0.90	0.80	0.76	0.83	0.79
Real M3	-0.11	-0.39	0.08	0.42	0.50	0.43	0.55	0.59
M3-to-GDP ratio	-0.33	-0.58	-0.15	0.11	0.43	0.48	0.39	0.47
Credit-to-M3 ratio	0.79	0.90	0.69	0.79	0.80	0.79	0.81	0.71
Assets-to-GDP ratio	0.71	0.47	0.87	0.95	0.74	0.69	0.78	0.76
Bank leverage ratio	-0.38	-0.70	0.10	0.54	0.35	0.16	0.51	0.62
Foreign non-core liab.	0.75	0.50	0.91	0.95	0.76	0.60	0.88	0.97
Total non-core liab.	0.91	0.90	0.91	0.93	0.87	0.91	0.83	0.88
Real GDP	0.30	0.20	0.41	0.77	0.60	0.55	0.64	0.62
Real domestic demand	0.28	0.10	0.42	0.89	0.58	0.52	0.64	0.71
Trade deficit-to-GDP	0.25	-0.06	0.49	0.87	0.65	0.60	0.70	0.85
USD exchange rate	-0.03	-0.12	0.01	0.04	0.50	0.43	0.57	0.44
Real exchange rate	-0.12	-0.61	0.24	0.75	0.50	0.41	0.55	0.62
Terms of trade	-0.23	-0.32	-0.13	0.03	0.47	0.41	0.52	0.56
Inflation	-0.17	-0.62	0.43	0.44	0.53	0.36	0.67	0.68
Averages								
Financial variables	0.48	0.36	0.61	0.74	0.69	0.63	0.73	0.75
Macro variables	0.04	-0.20	0.27	0.54	0.55	0.47	0.61	0.64
All variables	0.30	0.13	0.47	0.66	0.63	0.57	0.68	0.70

The table gives the contemporaneous correlations and concordance of the medium-term cyclical component of individual variables with the financial cycle. Shaded sells highlight numbers larger than or equal to 0.7.

Source: Authors' calculations.

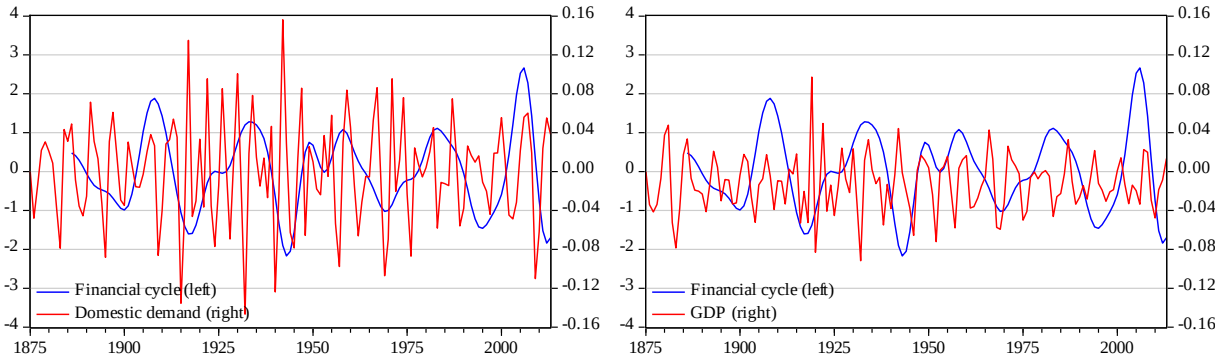
4.3 The financial cycle and economic activity

A comparison of the cyclical properties of the financial cycle in Table 6 with the cyclical properties of GDP and domestic demand in Table 1 shows that the financial cycle is longer than the medium-term cycle in economic activity and has gradually become relatively more drawn out and intense. Figure 3 shows that this also applies when the financial cycle is compared to the short-term cyclical component of output and demand. The figure shows that the financial cycle is clearly longer than the business cycle – as it should be given the way the cyclical

[95] As with individual medium-term cycles in Tables 3 and 4, we find these findings are not sensitive to the inclusion of the latest boom-bust cycle (i.e. the results continue to hold if we end the sample in 2003).

components are defined and constructed. Nevertheless, the difference in the duration of the two cycles is large: over the whole sample period a complete cyclical episode takes 16 years on average for the financial cycle (see Table 6 above), but only 3 years for the business cycle (for GDP but slightly longer, or 4 years, for domestic demand). And the difference increases over time, with cyclical episodes occurring in the post-1980 period taking 24 years to be completed for the financial cycle while it remains roughly unchanged for the business cycle. By the same token, we also see that financial cycle contractions tend to be much more drawn out than business cycle contractions: a typical financial contraction lasts more than 9 years but 2 years for a typical business cycle contraction. The financial cycle has also gradually become more pronounced relative to the business cycle: the relative standard deviation of the financial cycle and the business cycle is almost twice as high in the post-1980 period compared to the 1875-1944 period.

Figure 3 The financial cycle and the business cycle



Source: Authors' calculations.

Finally, in Table 8 we look more closely at economic activity over different phases of the financial cycle. First, we see that there is a marked difference in median demand and output growth over the expansionary and contractionary phases of the financial cycle: over the whole sample period we find that growth is almost three times higher on average during expansionary phases of the financial cycle than during its contractionary phases. This difference is less pronounced with respect to domestic demand in the first subsample period when the financial cycle played a smaller role in affecting macroeconomic developments, but by the post-WWII period we see that growth in GDP and domestic demand is almost four times higher on average during expansions than during contractions. We also find that business cycle contractions that coincide with contractionary phases of the financial cycle tend to be more drawn out than contractions that coincide with expansionary phases of the financial cycle. Together, the results in Table 8 suggest that the financial cycle plays an important role in the boom-bust cycles in the Icelandic economy (especially in the post-WWII period), for example through which enhanced access to credit boosts domestic demand during the boom phase of the financial cycle,

only to curtail it again in the contractionary phase of the cycle. We will return to these linkages in Section 7.[96]

Table 8 Economic activity in different phases of the financial cycle

	Total sample	1875-1944	1945-2013	1980-2013
		Domestic demand		
Growth in expansionary phase	0.053	0.027	0.059	0.058
Growth in contractionary phase	0.021	0.026	0.017	0.015
Relative duration in contractions	2.00	2.00	2.00	2.00
		GDP		
Growth in expansionary phase	0.049	0.049	0.049	0.043
Growth in contractionary phase	0.019	0.020	0.013	0.012
Relative duration in contractions	1.50	1.00	2.00	2.00

The table shows the median growth rate of domestic demand and GDP over the expansionary and contractionary phases of the financial cycle, and the relative duration (in years) of contractions in each series that coincide with contractionary phases of the financial cycle relative to contractionary phases that do not coincide with contractionary phases of the financial cycle. Thus, relative duration above (below) unity indicates that short-term (business cycle) contractions that coincide with contractionary phases of the financial cycle are longer (shorter) than contractions that do not coincide with contractionary phases of the financial cycle.

Source: Authors' calculations.

5 The financial cycle and global spillovers

In Einarsson et al. (2015), we found strong links between global financial crises and financial crises in Iceland: the dates of financial crises were found to correspond remarkably well and our empirical analysis suggested that global crisis episodes typically led to a two- to threefold increase in the probability of a banking or multivariate financial crisis in Iceland (multivariate crises are defined in Appendix 3).

The transmission channels of these global spillovers are relatively well known: financial boom-busts frequently have an important international dimension of some kind, be that due to common sources in a financially integrated global economy, such as the credit and asset price bubbles experienced by many advanced economies in the run-up to the most recent crisis, or due to the transmission of crises from one country (often a global financial centre) to another as a result of cross-border contagion working through both financial and trade channels (see, for example, Kaminsky et al., 2003, Borio, James, and Shin, 2014, Lane and McQuade, 2014, and Avdjiev et al., 2015). Both types of channels were at work in the recent global crisis but they also played a part in many earlier episodes (cf. Bordo and Murshid, 2001).

[96] These results are consistent with the findings in Einarsson et al. (2015) which suggest that recessions tend to be more severe when they coincide with financial crises, which as we show in Section 6 below tend to coincide with peaks in the financial cycle. Our results are also consistent with Claessens et al. (2012) and Drehmann et al. (2012), who find that recessions that coincide with contractionary phases of the financial cycle tend to be longer and more severe. They can also be viewed as being consistent with the findings in Jordà et al. (2013, 2014, 2015), who find that recessions tend to be more severe when they are preceded by periods of strong credit growth, in particular if this is driven by a strong expansion in mortgage credit and interact with abnormal increases in house prices. Borio et al. (2015) emphasise the interaction between sectoral allocation of resources and productivity dynamics across different phases of the financial cycle in explaining these characteristics. Romer and Romer (2015) provide a more sceptical view on the real economic impact of financial crises.

One obvious extension of our analysis of the financial cycle in Iceland is therefore to investigate whether there are links between the domestic financial cycle and financial cycles in other countries. This is also relevant for the growing literature on general spillover effects which mainly focuses on how financial globalisation impacts the capacity of domestic policies to conduct independent monetary and financial policies (cf. Rey, 2013, Schoenmaker, 2013, and Obstfeld, 2015). We begin by analysing potential spillovers from the global financial cycle, which we proxy with the US financial cycle, given its international economic prominence and the fact that the US financial system has long served as a global financial centre. We then move on to look at the potential transmission channels through which the global financial cycle impacts the domestic cycle. Finally, we explore the possibility of additional regional channels by looking at the links between the domestic financial cycle and financial cycles in Denmark and Norway, given their close political, economic, and cultural links with Iceland, especially in the earlier part of the sample. We also look at potential regional spillovers from the financial cycle in the UK, given the long-standing trade and financial links between the two countries (and UKs leading role in global finance in the early part of our sample period).

For the US we use the house price data collected by Shiller (2015), and data from Jordà et al. (2014) for the other variables (with updates until 2013 kindly made available by the authors). Data for the other three countries come from various sources, with Appendix 1 providing the details and graphs of the data for all the four countries. Similarly to our treatment of the Icelandic data, we transform the data to log-differences (except for the US real interest rate, which is transformed using the log-difference of one plus the interest rate) and use the Christiano and Fitzgerald (2003) band-pass filter to identify cycles with periodicity of 8 to 30 years. The final estimate of the medium-term cycles for the individual series is then obtained by cumulating the resulting growth rates.

5.1 Spillover effects from the global financial cycle

We start by reporting the correlations of the Icelandic financial cycle with medium-term cycles of individual US financial series and an aggregate measure of the US financial cycle (explained below). The upper panel of Table 9 shows that there is a high and rising co-movement between the aggregate Icelandic financial cycle and medium-term cycles in many of the individual US series, especially house prices, credit, and the size of the banking system. For example, the Icelandic financial cycle is found to be in the same phase as the medium-term cycle in the US credit-to-GDP ratio close to 75% of the time. This implies that over a period of more than a century, an era covering a number of different policy regimes and varying degree of financial deepening and openness in Iceland, the domestic financial cycle has spent more than ninety years in the same phase as the US credit cycle.

We construct a simple composite measure of the aggregate US financial cycle as the first principal component of the medium-term cyclical components of real house prices and the credit-to-GDP ratio, which are the two financial variables Borio (2014) argues most

parsimoniously capture the aggregate financial cycle in advanced economies.[97] As Table 9 shows, there are remarkably strong links between the Icelandic financial cycle and this simple measure of the global financial cycle: over the whole sample the simple correlation coefficient and concordance index measure above 0.7. Furthermore, both are rising over time: the correlation coefficient rises to almost 0.9 in the post-WWII period while the concordance index rises to 0.8. Thus, the two aggregate cycles are tightly aligned, in particular in the second half of the sample period where the two series spend 80% of the time in the same cyclical phase.

Table 9 Co-movement of US and Icelandic financial cycles

	Contemporaneous correlations				Concordance index			
US financial variables	Total sample	1875-1944	1945-2013	1980-2013	Total sample	1875-1944	1945-2013	1980-2013
Real house prices	0.67	0.47	0.82	0.90	0.57	0.45	0.67	0.74
Real credit	0.58	0.53	0.65	0.63	0.65	0.59	0.70	0.71
Credit-to-GDP ratio	0.67	0.70	0.65	0.63	0.72	0.67	0.75	0.74
Real M3	-0.26	-0.21	-0.32	-0.08	0.39	0.34	0.42	0.56
M3-to-GDP ratio	0.18	0.59	-0.17	-0.22	0.60	0.66	0.55	0.53
Credit-to-M3 ratio	0.66	0.66	0.66	0.81	0.67	0.62	0.72	0.62
Assets-to-GDP ratio	0.51	0.51	0.52	0.52	0.73	0.78	0.70	0.76
Real long-term rate	0.51	0.62	0.38	0.30	0.59	0.64	0.55	0.56
Real stock prices	0.13	0.45	-0.33	-0.33	0.46	0.59	0.36	0.38
Composite fin. cycle	0.78	0.69	0.86	0.87	0.74	0.67	0.80	0.74

Dates of peaks in Icelandic (first line) and US (second line) financial cycles

1886	–	1908	–	1924	1933	–	1949	1958	–	1983	–	2006
1890	1896	1907	1913	–	1931	1937	1949	1956	1964	1980	1988	2006

Dates of troughs in Icelandic (first line) and US (second line) financial cycles

–	1900	–	1917	1926	–	1943	1953	–	1969	–	1995	2012
1892	1901	1909	1919	–	1935	1943	1953	1961	1969	1983	1994	2012

The table gives the contemporaneous correlations and concordance of the medium-term cyclical component of US financial variables with the aggregate Icelandic financial cycle. The US composite financial cycle is obtained as the first principal component of the medium-term cycles in US real house prices and the credit-to-GDP ratio. Shaded sells highlight numbers larger than or equal to 0.7.

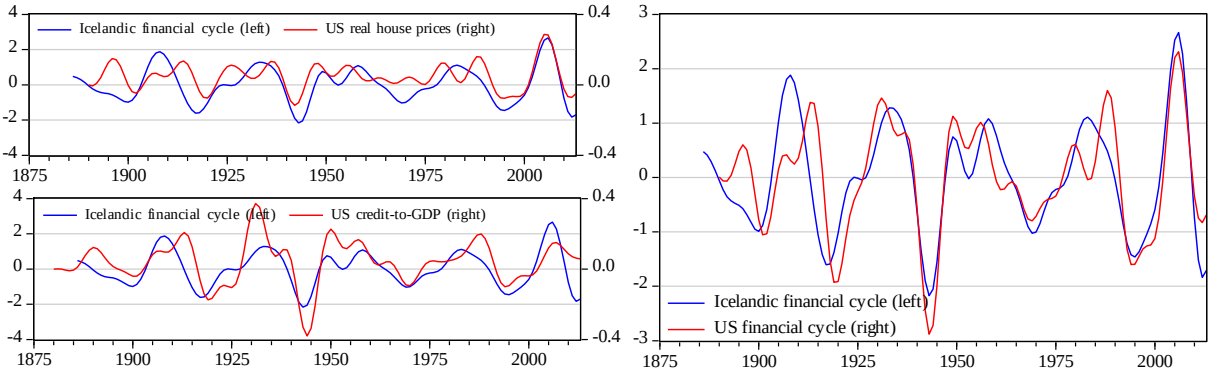
Source: Authors' calculations.

The strong link between the two financial cycles can also be seen in the two lower panels of Table 9, which report the dates of the peaks and troughs in the domestic and US aggregate financial cycles, as well as in Figure 4 which compares the Icelandic aggregate cycle to the medium-term cycles in US credit and house prices on one hand and the composite US cycle on the other hand. There are eight peaks in the aggregate domestic cycle (seven if the first one which coincides with the first observation of the series is excluded) and eight troughs, while the aggregate US cycle has twelve peaks and troughs. Again, the correspondence between the

[97] The aggregate measure explains more than 70% of the total variability in these two variables. We experimented with a number of other variations for the composite indicator (available upon request), e.g. by also including the bank asset-to-GDP ratio, real credit, and the real long-term interest rate, with very similar results. As in Drehmann et al. (2012) we find the medium-term cycle in real stock prices to be relatively weakly synchronised with the cycle in other financial variables. Comparison of our estimate of the aggregate US financial cycle with the one constructed by Drehmann et al. (2012) shows that the estimates are practically identical for the period they estimate the cycle (from 1970).

two cycles is striking: six of the seven domestic peaks since the start of the 20th century correspond to peaks in the US cycle (with the Icelandic cyclical peak typically coinciding with the US peak or lagging it by a year or two). The troughs are also tightly linked, with seven of the eight domestic troughs occurring within a two-year window with troughs in the US.[98]

Figure 4 The US and Icelandic financial cycles



Source: Authors' calculations.

In Table 10 we take a closer look at the possible channels through which the global financial cycle seems to work its way to Iceland. To do this we simply regress the medium-term cycle in each local financial variable on a constant and the composite US financial cycle measure. The table reports significant spillover effects on many of the domestic financial variables, but most clearly through credit and non-core bank liabilities, while there are also strong effects through total bank assets and house prices in the second half of the sample period. This indicates that there may be additional value from looking at the size and composition of the banks' balance sheet instead of just credit and house prices with regard to capturing the transmission of global financial spillovers to the domestic financial cycle and thereby to economic activity (see Section 4.3).

The table also reports the regression results for the aggregate financial cycle, again showing the strong spillover effects reported earlier: the composite US financial cycle explains over 60% of the variation in the Icelandic financial cycle over the whole sample period and, as discussed before, there is clear evidence that these links have been growing stronger over time with the explanatory power rising to almost 75% in the post-WWII period. This close co-movement of the Icelandic financial cycle with its global counterpart stands in stark contrast to earlier studies (such as Gudmundsson et al., 2000, and Einarsson et al., 2013) on the domestic business cycle which have failed to find robust links between the domestic business cycle and

[98] There are four US cyclical peaks in the 20th century that have no corresponding peaks in Iceland: the two peaks leading into the two World Wars, a peak in the mid-1960s and a peak in the late 1980s roughly coinciding with the US Saving & Loans crisis. Interestingly, the short and shallow domestic cyclical reversal in the mid-1920s (the only peak that does not have a corresponding peak in the US) does show up in the US data as a clear slow-down in the cyclical expansion but not enough to temporarily reverse the cycle as happens in the Icelandic case.

the business cycles of other developed economies.[99] We will return to this issue and its policy implications in Section 7 below.

Table 10 Spillover channels from the US financial cycle to financial variables in Iceland

	Total sample		1875-1944		1945-2013		1980-2013	
	R^2	*p*-val.	R^2	*p*-val.	R^2	*p*-val.	R^2	*p*-val.
Real house prices	0.37	0.00	0.31	0.02	0.58	0.00	0.77	0.00
Real credit	0.56	0.00	0.53	0.00	0.59	0.00	0.74	0.00
Credit-to-GDP ratio	0.38	0.00	0.29	0.01	0.57	0.00	0.59	0.00
Real M3	0.00	0.64	0.08	0.21	-0.01	0.75	0.38	0.00
M3-to-GDP ratio	0.15	0.02	0.53	0.00	0.00	0.50	0.09	0.09
Credit-to-M3 ratio	0.42	0.00	0.48	0.00	0.35	0.00	0.20	0.03
Assets-to-GDP ratio	0.33	0.01	0.03	0.20	0.65	0.00	0.83	0.00
Bank leverage ratio	0.11	0.03	0.32	0.00	-0.01	0.81	0.19	0.07
Foreign non-core liab.	0.21	0.01	-0.02	0.89	0.53	0.00	0.58	0.00
Total non-core liab.	0.54	0.00	0.47	0.00	0.61	0.00	0.63	0.00
Aggregate financial cycle	0.61	0.00	0.47	0.00	0.74	0.00	0.76	0.00

The table reports the results from regressing the medium-term cyclical component of the Icelandic financial variables and the aggregate financial cycle, respectively, on a constant and the composite US financial cycle. Reported are the R^2 (degrees of freedom adjusted) and a *p*-value (based on Newey-West adjusted standard errors) for the null hypothesis that the US financial cycle is not statistically significant from zero.

Source: Authors' calculations.

5.2 Potential regional spillovers

The analysis above suggests that there are strong spillover effects from the US financial cycle to the financial cycle in Iceland and a simple regression analysis indicates that similar spillover effects from the financial cycles in Denmark, Norway and the UK to Iceland also exist. But, as the analysis in Appendix 4 shows, these regional spillover effects may simply be reflecting the effects from the US financial cycle working their way indirectly through these countries to Iceland.[100] Thus, to focus on possible additional regional spillover effects, we simply measure the "local" component of the financial cycles in Denmark, Norway and the UK as the residual from a regression of the financial cycle for each of these countries on the US cycle, which by construction captures the component of the financial cycle that is not explained by the US cycle. The importance of these local components of the financial cycle in these three countries for the Icelandic financial cycle is reported in Table 11.

[99] However, our results can be interpreted as being consistent with Obstfeld's (2015) results that Iceland's long-term nominal interest rates correlate strongly with their US counterpart and that the speed of adjustment in Icelandic rates is exceptionally high in international comparison.

[100] The appendix shows that there is strong co-movement between the composite financial cycles in these four countries. A simple regression analysis shows that the composite US financial cycle explains about 40% of the Danish and Norwegian cycles and 50% of the UK cycle (in all cases found to be statistically significant from zero at the 1% critical level). The results with regard to the local UK cycle need to be interpreted with some caution as it rests on the assumption that we can treat the US cycle as exogenous in the regression, which can be questioned in the UK case – especially in the first decades of the period. The appendix also shows that there is a strong coincidence between financial crises in these four countries and that financial cycles have significant predictive power for these episodes.

Overall, we find these additional regional spillovers to be negligible. The global spillovers reported in the previous section therefore mostly stem from the spillover effects of the US financial cycle, with limited additional effects from financial cycles in Scandinavia and the UK. A possible exception is the first half of our sample period, which shows evidence of additional regional spillover effects from the Danish credit cycle and, perhaps to some extent, the UK credit cycle. This would be consistent with the strong political, economic and cultural ties between Iceland and Denmark in this period (with Iceland a part of the Danish Kingdom until 1944) and the strong financial links between the two countries as reflected, for instance, in Danish ownership of one of the two principal commercial banks in Iceland and the fact that Danish banks were a chief source of external financing for the Icelandic banking system, Treasury, and key industries. The same applies to the UK, which in addition to strong trade links, was also a prominent source of financing for Icelandic entities in the latter half of that period (see Einarsson et al., 2015, for more detail). For the post-WWII period we see, however, that these additional regional effects all but disappear.

Table 11 Additional spillover effects from local components of regional financial cycles

	Total sample		1875-1944		1945-2013		1980-2013	
	Corr.	Con.	Corr.	Con.	Corr.	Con.	Corr.	Con.
Danish credit-to-GDP	0.02	0.53	0.56	0.76	-0.43	0.33	-0.37	0.35
Danish real house prices	0.01	0.55	0.09	0.55	-0.03	0.55	0.22	0.53
Danish financial cycle	0.03	0.55	0.49	0.67	-0.28	0.45	-0.13	0.41
Norw. credit-to-GDP	0.07	0.52	0.18	0.57	0.00	0.48	0.02	0.59
Norw. real house prices	-0.09	0.45	0.05	0.48	-0.18	0.42	-0.20	0.44
Norwegian financial cycle	0.00	0.45	0.18	0.53	-0.09	0.38	-0.08	0.50
UK credit-to-GDP	0.05	0.52	0.67	0.64	-0.49	0.42	-0.68	0.32
UK real house prices	-0.11	0.51	-0.23	0.47	-0.06	0.55	0.26	0.68
UK financial cycle	-0.04	0.51	0.41	0.55	-0.28	0.48	-0.31	0.47

The table reports the contemporaneous correlation and concordance index for the aggregate Icelandic financial cycle and the local component of the medium-term cyclical components of the credit-to-GDP ratio and real house prices, and the composite financial cycle, respectively, in Denmark, Norway and the UK. The local cyclical components are obtained as the residual from regressing the original cyclical components on a constant and the composite US financial cycle. Shaded sells highlight numbers larger than or equal to 0.7.

Source: Authors' calculations.

6 The financial cycle and financial crises

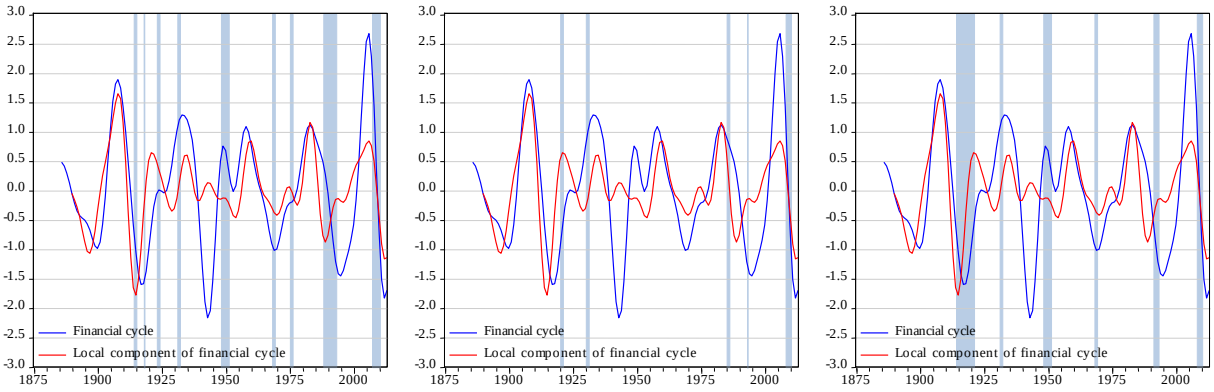
The analysis in Section 4.3 showed that median GDP and domestic demand growth is markedly higher during expansionary phases of the financial cycle than during its contractionary phases, and that recessions coinciding with financial cycle contractions are typically longer than other recessions. This suggests an important role of the financial cycle in facilitating real economy expansions and triggering its subsequent downturns. This can also be seen from the left-hand panel of Figure 5 which shows the tight connection between the financial cycle and its local component on the one hand, and particularly nasty real economy episodes on the other hand which we define as "demand disasters" in the spirit of Barro's and Ursúa's (2008) specification

of "consumption disasters" (i.e. episodes where per capita domestic demand contracts by more than 10% from peak to trough).[101]

One important manifestation of this co-movement of the financial cycle and excessive fluctuations in economic activity is through possible financial disruptions during the final stages of the cycle's expansionary phase, for example when balance sheets become overextended and asset price overvaluations peak. Many studies (including ours, see Section 5 in Einarsson et al., 2015) have indeed found that financial distresses are typically associated with more severe economic recessions. What remains to close the circle is therefore to consider whether there are close links between different phases of the financial cycle and the timing and incidence of these financial disruptions. Again, and consistent with the findings in Drehmann et al. (2012) and Aikman et al. (2015) for other industrial countries, we find a clear link: Figure 5 clearly shows that financial crises, whether they are banking crises or full-blown multiple financial crises (see Appendix 3 for a summary of financial crises dates), are closely aligned with peaks in the financial cycle, both the aggregate cycle and its local component.

Figure 5 The financial cycle, demand disasters and financial crises

Demand disasters (left), banking crises (centre), and multiple financial crises (right) shown as shaded areas



Sources: Einarsson et al. (2015) and authors' calculations.

The close links between the financial cycle and excessive financial turmoil can also be seen in Table 12, which shows that almost all the identified cyclical peaks coincide with some kind of a financial distress at a similar date (about 80% of the peaks in the aggregate and local cycles have some type of a financial crisis within a three year window).[102] Some of the crises

[101] We use domestic demand instead of private consumption as consumption data is not available prior to 1945. This criteria gives us nine disaster episodes that occur on average every 12 years and last for almost 3 years (1914-15, 1918, 1923-24, 1931-32, 1948-51, 1968-69, 1975-76, 1988-93, and 2007-10). See Einarsson et al. (2015) for more detail.

[102] We use the same window size as Drehmann et al. (2012), disregarding the first peak of both cycles as they merely reflect the first observation of the series. A peak in the domestic cycle in 1886 would, however, be consistent with peaks in the Danish, Norwegian, and British cycles in 1885-86 (see Figure A.4.1 in Appendix 4). The only cyclical expansion in the table that does not have a financial crisis at a similar date is the one peaking in 1908 which is not associated with any type of financial crisis in Iceland. However, as we discuss in Einarsson et al. (2015), this episode did coincide with some strain on the domestic financial system following the global banking panic in 1907 (starting in the US following the San Francisco earthquake in 1906 and the collapse of copper prices in 1907), which led to some loss of access to foreign funding for Icelandic financial institutions.

occur soon after the cycle turns, but as in Drehmann et al. (2012) who focus on systemic banking crises in the period from 1970 and onwards, we also find cases where the cycle continues to expand for some time after the crisis occurs. This applies to the first two systemic banking crises in the early 1920s and 1930s, and may reflect a slower and somewhat more muted propagation mechanism between the financial system and the real economy at the prevailing degree of financial development compared to that existing in the post-WWII period. For example, in the last episode we find that the cyclical peak leads the crisis by two years.

Table 12 Peaks in the financial cycle and financial distresses

Cyclical peaks

Aggregate cycle	Local component	Financial distresses at similar dates
1908	1908	No financial crisis identified but there was a sharp deterioration of access to foreign funding for local banks following the global banking panic in 1907
1924	1921	A currency crisis in 1919-20 and a systemic banking crisis in 1920 (part of a multiple financial crisis lasting from 1914 to 1921)
1933	1935	A systemic banking crisis in 1930-31 and a currency crisis in 1932 (part of a multiple financial crisis lasting from 1931 to 1932)
–	1943	No currency or banking crisis but an inflation crisis in 1940-43
1949	1949	A currency crisis in 1950, followed by an inflation crisis in 1950-51 (part of a multiple financial crisis lasting from 1948 to 1951)
1958	1960	A currency crisis in 1960
–	1975	Inflation and currency crises lasting from 1973-89 and 1974-85, respectively
1983	1983	Coincides with the ongoing inflation and currency crises from above and a non-systemic banking crisis in 1985-86
–	1994	A twin currency and (non-systemic) banking crisis in 1993 (part of a multiple financial crisis lasting from 1991-93)
2006	2006	Currency and banking crises from in 2008-9 and 2008-10, respectively (part of a multiple financial crisis lasting from 2008 to 2010)

The table gives the dates of peaks in the aggregate financial cycle in Iceland and its local component. These dates are compared to periods of financial turmoil at similar dates (see Appendix 3 for further detail).

Sources: Einarsson et al. (2015) and authors' calculations.

The chronology in Table 12, together with our previous analysis, suggests that financial booms may fuel the economic expansion and increase the risks of overheating and overextension in the financial system and therefore sow the seeds of the subsequent bust. This raises the question whether expansions of the financial cycle may provide a robust early-warning signal for financial crises. Indeed, this is what we find. As Table 13 shows, a financial cycle expansion is within three years followed by a banking crisis in almost 60% of all expansionary phases and by a multiple financial crisis in just under 50% of all expansionary phases. Not all cyclical peaks are followed by a financial crisis, however: just under 30% of expansions are not followed by a banking crisis and roughly 15% of the expansions are not followed by a multiple financial crisis.

As the table shows, this compares favourably with the early warning capacity of the individual financial and macroeconomic variables (and the local component of the aggregate cycle as well): the fraction of expansions that are followed by a crisis tends to be higher for the

aggregate cycle and the fraction of expansions that are not followed by a crisis lower. The ratio between the "good" and "bad" signals can be interpreted as a "noise-signal" ratio, and we see that the aggregate financial cycle outperforms the individual variables and its local component.[103] This suggests that by combining information from different financial variables and highlighting their important interaction in amplifying financial imbalances, the aggregate financial cycle can provide a better signal of future financial distresses than individual financial variable considered in isolation (see also Claessens et al., 2011, Borio, 2014, and Schüler et al., 2015).

Table 13 Cyclical expansions and financial crises

	Banking crises			Multiple financial crises		
	Expansions close to crises	Expansions not close to crises	Noise-signal ratio	Expansions close to crises	Expansions not close to crises	Noise-signal ratio
Real house prices	0.36	0.55	1.50	0.45	0.45	1.00
Real credit	0.44	0.44	1.00	0.33	0.33	1.00
Credit-to-GDP ratio	0.44	0.44	1.00	0.33	0.33	1.00
Real M3	0.20	0.50	2.50	0.40	0.40	1.00
M3-to-GDP ratio	0.44	0.44	1.00	0.44	0.33	0.75
Credit-to-M3 ratio	0.57	0.29	0.50	0.43	0.14	0.33
Assets-to-GDP ratio	0.40	0.50	1.25	0.30	0.40	1.33
Bank leverage ratio	0.30	0.50	1.67	0.30	0.40	1.33
Foreign non-core liabilities	0.33	0.44	1.33	0.22	0.33	1.50
Total non-core liabilities	0.40	0.50	1.25	0.30	0.40	1.33
Real GDP	0.18	0.55	3.00	0.55	0.45	0.83
Real domestic demand	0.18	0.55	3.00	0.55	0.45	0.83
Trade deficit-to-GDP ratio	0.31	0.62	2.00	0.38	0.54	1.40
USD exchange rate	0.23	0.62	2.67	0.46	0.54	1.17
Real exchange rate	0.31	0.62	2.00	0.38	0.54	1.40
Terms of trade	0.14	0.64	4.50	0.29	0.57	2.00
Inflation	0.36	0.64	1.80	0.29	0.57	2.00
			Averages			
Financial variables	0.39	0.46	1.30	0.35	0.35	1.06
Macro variables	0.24	0.60	2.71	0.41	0.52	1.38
All variables	0.33	0.52	1.88	0.38	0.42	1.19
			Financial cycle			
Financial cycle	0.57	0.29	0.50	0.43	0.14	0.33
Fin. cycle (local comp.)	0.40	0.50	1.25	0.30	0.40	1.33

Expansions (not) close to crises gives the fraction of medium-term cyclical expansions that are (not) followed by a financial crises within a 3 year window. The *noise-signal ratio* gives the ratio between the two fractions.

Sources: Authors' calculations.

[103] This is a slightly different approach to the early-warning exercise in Einarsson et al. (2015), where we measure the signalling properties of individual variables based on deviations that exceed 1.5 standard deviations from a smooth Hodrick-Prescott trend. There we find that individual variables do not provide robust enough early-warnings for ensuing financial crises.

7 Discussion and some policy implications

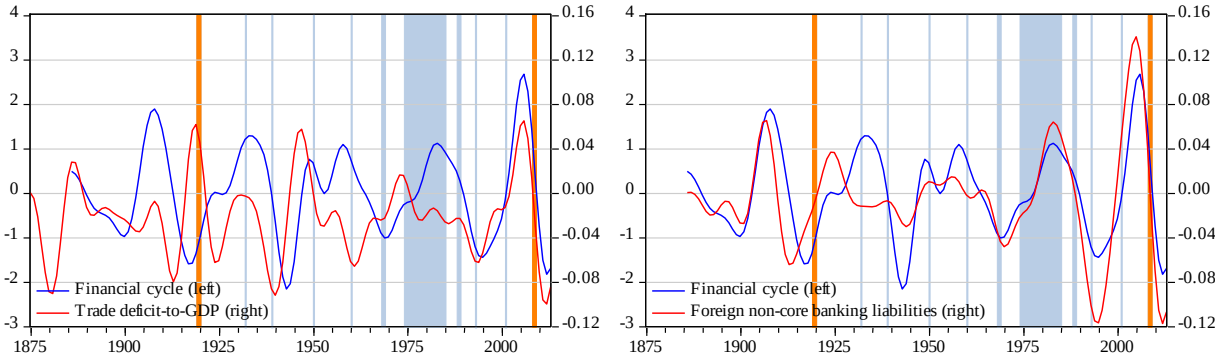
The existence of a clearly defined financial cycle in Iceland and the strong interaction of the cycle with real economic activity on the one hand, and the global financial cycle on the other hand, raises some fundamental issues with important policy implications, while also providing important new insights into a number of prevalent issues in the domestic economic debate. In this section, we touch upon several of these issues and highlight some of the key policy implications, but this can only be viewed as a first attempt. Further analysis is likely to be needed to explore the full implications of our findings.

7.1 The financial cycle, capital flows and sudden stops

Our previous analysis in Table 7 shows that the medium-term cycle in the trade deficit closely co-moves with the aggregate financial cycle and that this co-movement has strengthened over time. Thus, a financial cycle expansion tends to coincide with an expansion in the lower-frequency component of the trade deficit, consistent with a trade deficit building up in the expansionary phase of the financial cycle and reversing at roughly the same time as the aggregate cycle turns.

Figure 6 The financial cycle, capital flows and sudden stops

Currency crises (grey) and sudden stops (orange) shown as shaded areas



Financial cycle and medium-term cycles in the trade deficit-to-GDP ratio and the ratio of foreign non-core bank liabilities to total liabilities, respectively. Currency crises are denoted as shaded grey areas and currency crises that coincide with sudden stop of capital inflows as orange shaded areas (see Table A.3.1 in Appendix 3 for details on currency crisis dates).

Sources: Einarsson et al. (2015) and authors' calculations.

This is consistent with the analysis in Einarsson et al. (2015), which also shows that large trade reversals tend to coincide with currency crises, and is also evident from Figure 6, which shows that cyclical peaks in the trade deficit are frequently followed by a currency crisis and that the timing of these crises typically coincides with the cyclical trough. The same is also apparent when looking at the medium-term cycles in the ratio of foreign non-core funding of domestic banks, especially during the first period of relatively free capital movements up until 1930 and again from 1970 and onwards when domestic banks' access to foreign credit improved again. The figure also shows that two of the more dramatic cyclical reversals, in the early 1920s and in 2008, which show a large trade balance reversal coinciding with a sharp exchange rate

depreciation, also coincide with a sudden stop crisis and the introduction of widespread capital controls.[104] Figure 6 therefore clearly points to an important link through which the expansionary phase of the financial cycle facilitates the build-up of external imbalances and forces a sharp reversal in capital flows, even resulting in currency crises, once the cycle turns.

7.2 The financial cycle and the consumption boom-bust cycle

Einarsson et al. (2013) show that private consumption is more volatile in Iceland than in other industrial countries and that this high volatility cannot be accounted for by more volatile external macroeconomic conditions (either export volumes or terms of trade). They also find that private consumption is more volatile than income, a common finding among emerging market economies but an unusual feature among advanced economies (cf. Aguiar and Gopinath, 2007). This unusually high consumption volatility is also consistent with Barro and Ursúa's (2008) finding that the frequency of consumption disasters is by far the highest in Iceland among advanced economies in the post-WWII period (and even in the higher region among the emerging market economies in their sample).

Einarsson et al. (2013) also document the cyclical volatility (at business cycle frequency) in several sub-components of private consumption, showing that a notable feature of the consumption cycle in Iceland is the high volatility of durable goods consumption, and that this volatility is strongly correlated with fluctuations in the exchange rate. They also find that as the volatility of the exchange rate increased following the move to a more flexible exchange rate regime in 2001, so did short-term fluctuations in total consumption, and durable consumption in particular. One possible explanation offered by Einarsson et al. (2013) is that this reflects the high import content of durable goods in Iceland, which in turn reflects the country's relatively small manufacturing sector and its narrow production structure. But this could also reflect effects of the financial cycle, with rising asset prices and easing credit conditions during the expansionary phase of the cycle (which tend to coincide with the expansionary phase of the real exchange rate cycle as shown in Table 7 above), working to reduce financial constraints and make leveraged consumption spending easier. As the cycle subsequently reverses, so do financial conditions.

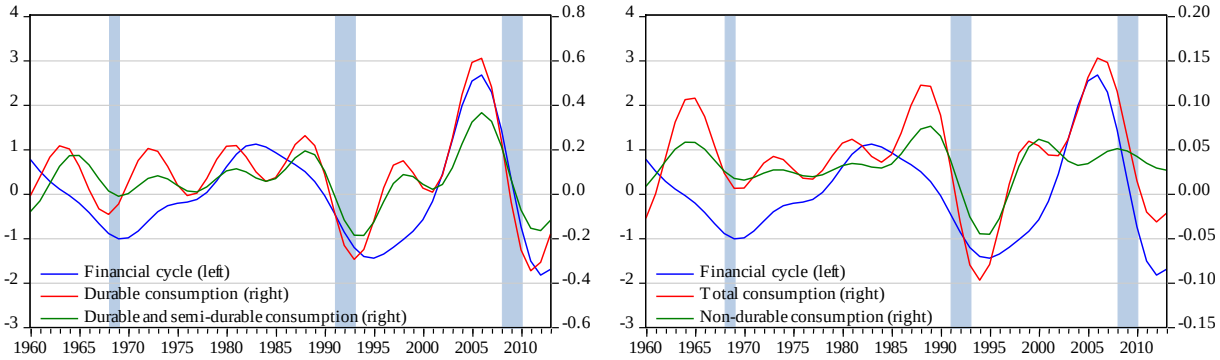
Figure 7 therefore compares the financial cycle with the medium-term cycles in total private consumption and its key subcomponents from 1960 to 2013. There seems to be a strong link between the financial cycle and the medium-term cyclical component in consumption of semi-durable and durable goods, which appears to have become even stronger since the late 1980s consistent with the increasing financial deepening and liberalisation discussed earlier (cf. Juselius and Drehmann, 2015). Not surprisingly, these links are less apparent in non-durable

[104] Sudden stop crises are episodes where financing a large current account deficit suddenly becomes more difficult and capital inflows reverse, typically forcing a sharp narrowing of the current account deficit and a currency depreciation. We follow Calvo et al. (2008) and Forbes and Warnock (2012) in defining sudden stop crises as episodes where reversals in the trade deficit that exceed two standard deviations coincide with output contractions. This gives us two episodes: 1919-20 and 2008-9, both of which saw very large currency depreciations and a reversal of trade balance amounting to 20-30% of GDP from peak to trough. Widespread capital controls were also introduced in 1931 but this episodes falls short of the sudden stop criteria used here. See Central Bank of Iceland (2016) for a discussion of capital controls in Iceland.

consumption shown in the second figure (note the different scale of the two figures). This suggests that the financial cycle may be an important source of consumption volatility in Iceland which is an issue that needs further exploring, including its relation to capital flows and exchange rate movements discussed above, and fiscal policy discussed in the following section.

Figure 7 The financial cycle and consumption

Multiple financial crises shown as shaded areas



Financial cycle and medium-term cycles in total consumption and its subcomponents. Shaded areas denote multiple financial crises (see Table A.3.1 in Appendix 3 for details on crisis dates).

Sources: Authors' calculations.

7.3 The financial cycle and fiscal policy

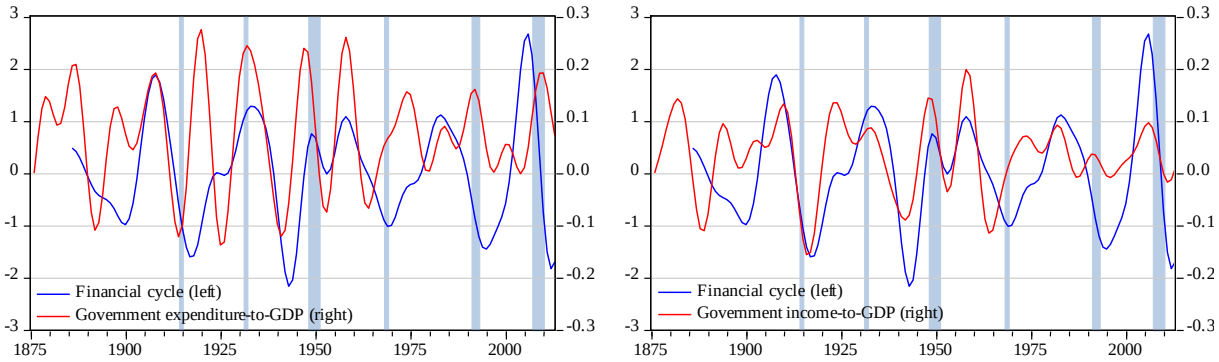
Einarsson et al. (2013) find evidence that government expenditure in Iceland tends to be positively correlated with the business cycle and a Central Bank of Iceland (2012) report documents strong pro-cyclicality of both government spending and tax policy in the lead-up to the financial crisis in 2008. There was a strong pick-up in government revenue in the run-up to the crisis as the asset price bubble and the enormous expansion of credit and balance sheets (cf. Table 7.c in Einarsson et al., 2015) led to rising income from taxes (on income, consumption, property and capital gains), import tariffs, excise and stamp duties. The government seemed to interpret this windfall income as being permanent (cf. Aguiar and Gopinath, 2007, and Reinhart and Rogoff, 2009) and thus went on a spending spree and cut taxes substantially at the same time. This could suggest an important role for the financial cycle in explaining the pro-cyclicality of fiscal policy in Iceland, which indeed seems to be supported by the data (the importance of the financial cycle for fiscal policy is also discussed in Bénétrix and Lane, 2011, Poghosyan, 2015, Budina et al., 2015, and Borio et al., 2016).

Figure 8 shows the financial cycle together with the medium-term cycles in current spending and income of the Treasury. Both spending and income tend to co-move with the financial cycle (with a whole-sample concordance index above 0.6 for spending and above 0.7 for income). The data show, however, that the strong co-movement of cyclical income and the financial cycle has been rising over time while the opposite is true for cyclical spending: the concordance index for income rises from 0.72 in the 1875-2013 period to 0.79 in the post-1980 period, while it falls from 0.66 to 0.47 for expenditure. Government income therefore seems highly sensitive to the financial cycle and the co-movement between the two has strengthened

over time, presumably in part reflecting the increasing financial deepening, and the rising homeownership and financial wealth in the economy. Fluctuations in the financial cycle have also crept into current government spending, and although the concurrent co-movement between the two seems to have declined over time, a significant link between the financial cycle and lagged spending remains. The latest boom-bust cycle is a clear example, with the expansion of the financial cycle followed by a strong cyclical expansion in current spending. This suggests an additional channel through which the financial cycle reinforces the boom-bust dynamics of the Icelandic economy and at the same time strengthening even further the interlinkages between the financial cycle, capital flows, and domestic demand, as discussed above.

Figure 8 The financial cycle and fiscal policy

Multiple financial crises shown as shaded areas



Financial cycle and medium-term cycles in the government expenditure and income ratios to nominal GDP. Shaded areas denote multiple financial crises (see Table A.3.1 in Appendix 3 for details on crisis dates).

Sources: Authors' calculations.

7.4 Some policy implications

Our uncovering of the financial cycle in Iceland and its main characteristics raises a number of issues for domestic policymakers, highlights the importance of financial factors in many of the challenges that economic policy has failed to overcome throughout the country's economic history, and contributes to the rapidly expanding literature on the financial cycle, especially with regard to portraying its salient features in small open economies.

Our findings suggest that the financial cycle plays a pivotal role in fuelling the characteristic boom-bust behaviour of the Icelandic economy, while at the same time revealing strikingly strong spillovers from the global financial cycle. The key underlying macro-financial amplifying mechanism shows up in the expansionary phase of the cycle when easing financial constraints facilitate domestic demand growth, especially credit-financed expenditure, with the global financial cycle serving a further amplifying role by supporting a domestic bank balance sheet expansion and credit extension. As the boom progresses, macro-financial fragilities build up in the form of balance sheet overextensions, asset price overvaluations, and external imbalances, ultimately leading to the expansionary phase of the financial cycle giving way to a contraction with a resulting economic recession, external adjustment, and, in many cases, a financial crisis.

This implies that to obtain better economic policy outcomes, the financial cycle and its associated macro-financial linkages need to be taken into account in the design of the overall policy framework and in implementation across different policy areas. The recent reform of the policy framework in Iceland represents a step in that direction as it entails a broader view of monetary and financial stability, greater awareness of the systemic risk associated with the build-up of macro-financial imbalances, and the introduction of new policy tools to strengthen the resilience of the financial system and, hopefully, constrain to some extent the boom-bust dynamics that have been so prominent (Central Bank of Iceland, 2016). However, it remains to be seen how effective these reforms will be.

Our results also indicate that further reforms are desirable to increase the authorities' capacity to safeguard macroeconomic and financial stability. First, more coordinated and robust policy anchors are needed for the monetary, financial, and fiscal policy spheres, so that no single policy authority becomes overburdened. The financial cycle entails powerful, pro-cyclical, and long-lasting forces, which to a significant degree originate outside the domestic economy domain, increasing the negative effects of pro-cyclical policy behaviour. Hence, a firm, wide-reaching, and robust commitment to counter-cyclical stabilisation becomes even more important. This holds particularly true now, as the economy re-opens its capital account and again faces possible global headwinds in its conduct of independent monetary policy with relatively illiquid domestic financial markets and exceptional global conditions.

Second, capital flow management measures may need to be considered to complement other stabilisation policies in light of the important role played by cross-border capital flows in the aforementioned macro-financial linkages. However, as our results clearly demonstrate, international spillovers do not necessarily cease when the capital account is heavily controlled. Hence, expectations should be kept in check with regard to what such measures can hope to accomplish. On the other hand, Iceland's experience does not rule out that the use of capital flow management measures, as an addition to an otherwise comprehensive, coordinated and credible stabilisation policy, would be able to moderate to a greater extent the domestic impact of the global financial cycle and the entrenched boom-bust characteristic of the economy.

Third, our results highlight the need to strengthen the analytical foundations for policy making within small open and financially integrated economies. This implies further research into the strong spillover dynamics from the global financial cycle to its domestic counterpart, which in the case of Iceland could challenge the prevalent view of relatively weak links between the domestic and global business cycle (Gudmundsson et al., 2000, and Einarsson et al., 2013), which has been an important argument in the debate on the country's currency and exchange rate regime (Central Bank of Iceland, 2012). Our results can also only be taken as a first step in analysing the capacity of financial cycle developments to function as an early warning for risks of financial distress. Further work is also needed into mapping and modelling the important role played by financial factors in affecting macroeconomic developments. This includes uncovering the underlying financial sector externalities at work (cf. Korinek, 2011, and De Nicolò et al., 2012) and taking financial factors into account in assessment of key policy-relevant unobservables, such as the output gap, the neutral rate of interest, and the equilibrium real exchange rate (Borio, Disyatat, and Juselius, 2014, and Berger et al., 2015).

Fourth, the fact that the duration of the contractionary phase of the latest financial cycle episode was shorter than on average over the whole sample, may be interpreted as evidence of a more successful crisis management and resolution this time around compared to earlier episodes, especially given the exceptional size of pre-crisis macro-financial imbalances (Einarsson et al., 2015). Although further evidence is needed, it seems clear that bank resurrection and private sector debt restructuring was more comprehensive in the aftermath of the 2008 financial crisis than in earlier episodes, in addition to being supported by wide-reaching resource reallocation in the real economy and policy improvements (Central Bank of Iceland, 2016).

Finally, it is clear that the features of the financial cycle in Iceland, especially the presence of strong global spillovers and a prominent boom-bust interaction between credit, capital flows, and domestic demand are likely to apply to other small open economies. This holds particularly true for small open emerging market economies, many of which have already attained certain experience in adjusting their policy frameworks to lean against global spillovers and increase capacity for domestic stabilisation. The jury is still out, however, with regard to how successful they will be. As in the case of Iceland, efforts to understand and tame the financial cycle are likely to offer serious policy challenges for years to come.

8 Conclusions

In an earlier study of financial booms and busts in Iceland (Einarsson et al., 2015), we identified and dated different types of financial crises over a period spanning more than a century and analysed the main properties of these episodes and the development of key macroeconomic and financial variables in the run-up to these crises and in the period when they unfold. Here, we take the analysis a step further and attempt to capture the low-frequency co-movement of a number of financial variables in a single and well-defined financial cycle.

Our findings suggest that indeed there exists such a financial cycle in Iceland and that it has gradually become more prominent as the financial deepening and sophistication of the Icelandic economy has increased. The aggregate cycle is much longer than the typical business cycle, with a median duration of sixteen years, and seems to be getting longer and more intense over time. The underlying cycles in most of the individual financial variables are also becoming more tightly aligned with the aggregate cycle over time and the proportion of variability in the underlying individual cycles captured by the aggregate cycle is growing ever larger, reaching 75% in the post-WWII period and exceeding 80% in the post-1980 period.

We find that there is a large difference in economic performance over different phases of the financial cycle: the average growth rate of output and domestic demand is almost three times higher in expansionary phases of the financial cycle than in its contractionary phases (rising to almost four times higher in the post-WWII period). We also find that economic recessions that coincide with the contractionary phases of the financial cycle tend to be more drawn out than recessions that do not coincide with the contractionary phases of the cycle. The financial cycle therefore seems to have played a prominent role in the country's macroeconomic development over a period spanning more than a century. In fact, we find that almost all of the

peaks in the financial cycle coincide with some type of a financial crisis and that cyclical expansions provide a robust early-warning signal for subsequent crises. Furthermore, our results show that the aggregate cycle provides an improvement over the capacity of individual financial and macroeconomic variables to signal ensuing financial crises, highlighting the importance of the interaction of different financial variables in amplifying financial imbalances.

We find strikingly strong ties between the Icelandic financial cycle and its global counterpart, which is proxied with the US financial cycle (captured by a composite measure of medium-term cycles in credit and house prices): over the whole sample period these two financial cycles spend close to 75% of the time in the same cyclical phase and almost all of the cyclical peaks in the Icelandic financial cycle occur close to peaks in the global cycle, with the peaks usually coinciding or the Icelandic cyclical peak lagging by a year or two. There is also evidence that these spillover effects have been growing stronger over time. There is limited evidence, however, of additional regional spillover effects from Scandinavia and the UK, although there is some evidence of important regional spillover effects from the Danish credit cycle in the first half of the 20th century consistent with the prominent role of Danish financing of the domestic financial system during that period.

This tight link between the domestic and global financial cycles highlights the importance of accounting for the financial channel through which global developments penetrate the Icelandic economy and may call the prevalent view of the Icelandic business cycle being dominated by idiosyncratic supply shocks into question. Our results also suggest that understanding fluctuations in capital flows, the surprisingly high volatility of private consumption in Iceland, and fiscal policy dynamics, to name only three important issues in the domestic economic debate, is hard without understanding the financial cycle. We conclude the paper with a first attempt at exploring some of the policy questions that our findings raise.

Appendix 1 The data

Icelandic data

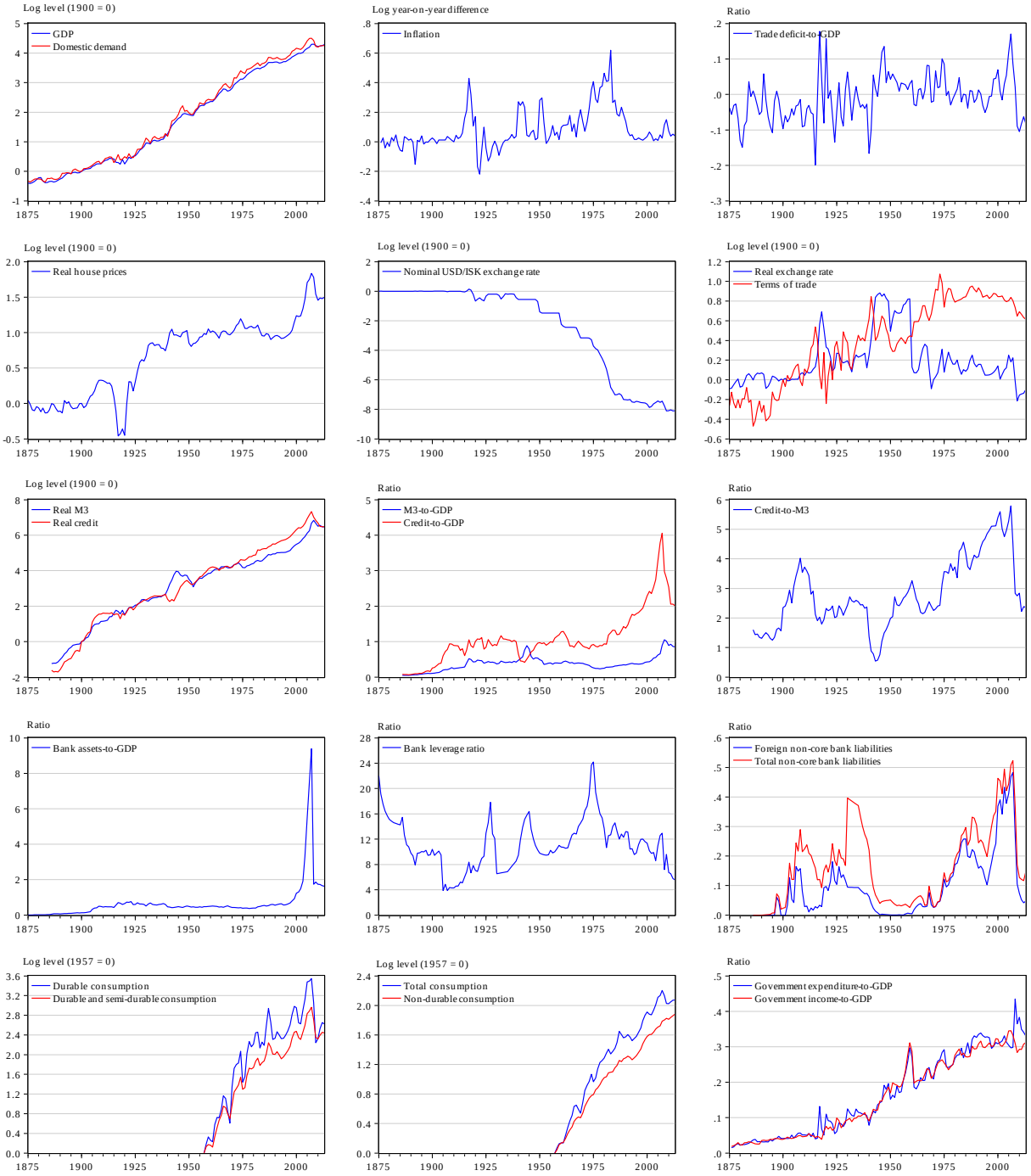
The data used in this paper is obtained from various sources. All of the data span the period 1875-2013, except for money, credit, and non-core banking liabilities which date back to 1886, and the data on private consumption which dates back to 1957 (for the consumption subcomponents, although data on total consumption is available from 1945). Table A.1.1 summarises the key data sources, while Figure A.1.1 shows the data.

Table A.1.1 The data and sources

Variable	Source
Banking system assets	*Hagskinna*: *Icelandic Historical Statistics* (Tables 13.2, 13.3, 13.6a-c, and 13.7), Björnsson (1961, p. 126-127), Björnsson (1981, p. 106, 119, and 129), Financial Supervisory Authority, and Central Bank of Iceland (*Annual Reports*, various years)
Banking system equity	*Hagskinna*: *Icelandic Historical Statistics* (Tables 13.2, 13.3, 13.6a-c, and 13.7), *Fjármálatíðindi* (p. 186), Gudnason (1972), Financial Supervisory Authority, and Central Bank of Iceland (*Annual Reports*, various years)
Banking system non-core liabilities	*Hagskinna*: *Icelandic Historical Statistics* (Tables 13.2, 13.3, 13.6a-c, and 13.7), Björnsson (1961, p. 126-127), Björnsson (1981, p. 106, 119, and 129), and Central Bank of Iceland
Broad money (M3)	*Hagskinna*: *Icelandic Historical Statistics* (Table 13.1) and Central Bank of Iceland (Website and *Annual Report*, 2007)
Private consumption	Statistics Iceland (with data on consumption subcomponents constructed from historical data on consumption by items)
Credit	*Hagskinna*: *Icelandic Historical Statistics* (Tables 13.9 and 13.12), and Central Bank of Iceland
Domestic price level	*Hagskinna*: *Icelandic Historical Statistics* (Table 12.25), and Statistics Iceland
Domestic demand	Jónsson (1999, Tables V.14.6 and V.15.4), and Statistics Iceland
GDP	Jónsson (1999, Table V.14.6), and Statistics Iceland
Government expenditure and income	*Hagskinna*: *Icelandic Historical Statistics* (Table 15.3), and Statistics Iceland
House prices	*Árbók Reykjavíkurbæjar 1940*, (p. 38-39), and Statistics Iceland
Nominal exchange rate	Abildgren (2004), *Hagskinna*: *Icelandic Historical Statistics* (Table 13.16), and Central Bank of Iceland
Real exchange rate	Abildgren (2004), *Hagskinna*: *Icelandic Historical Statistics* (Table 13.16), Statistics Iceland, and Central Bank of Iceland
Terms of trade	*Hagskinna*: *Icelandic Historical Statistics* (Table 10.23), and Statistics Iceland
Trade balance	Jónsson (1999, Tables V.14.6 and V.15.4), and Statistics Iceland

All the data, except the data on government expenditure and income, private consumption and house prices, is obtained from Einarsson et al. (2015) and further detail on how the data was constructed can be found there. The house price data for the early part of the sample period (up to 1940) has been updated from the previous version of the series (and now starts in 1875 instead of 1900). The current series is based on payed fire insurance premiums for housing in the Reykjavík area for the period 1875-1939 (*Árbók Reykjavíkurbæjar 1940*, p. 38-39), the building cost index from Statistics Iceland for the period 1940-1945, and the implicit housing stock price deflator from Statistics Iceland for the period 1945-2013.

Figure A.1.1 The data for Iceland



Source: See Table A.1.1 for details.

International data

United States

For all the series except house prices we use data from Jordà et al. (2014), which covers the period 1870-2011, with an updated dataset to 2013 kindly made available by the authors (this dataset is an update of an earlier version of the data from Schularick and Taylor, 2012). There is a gap in the Jordà et al. credit series in 1941-44 which we fill using log-linear interpolation. For house prices we use Shiller (2015) with updates from the author available from (http://irrationalexuberance.com/main.html?src=%2F).

Denmark

For the credit-to-GDP ratio we use data on the ratio of loans from banks and mortgage-credit institutes to GDP from Abildgren (2006) for the period 1875-1965 (Tables A.2, A.3 and A.9) combined with data on the ratio to GDP using total credit from banks to the private non-financial sector from the BIS' *Total Credit Statistics* database from 1966-2013 (http://www.bis.org/statistics/totcredit.htm?m=6%7C326). For house prices we use data from Abildgren (2006) on prices for one-family houses from 1938-69; combined with prices for farms from 1875-1937 (Table A.16). These series are combined with data on residential property prices from the BIS' *Residential Property Price* database from 1970-2013 (http://www.bis.org/statistics/pp.htm?m=6%7C288). Data on domestic consumer prices are from Abildgren (2006) for the period 1875-2005 (Table A.10) and the IMF *World Economic Outlook* database for 2006-13.

Norway

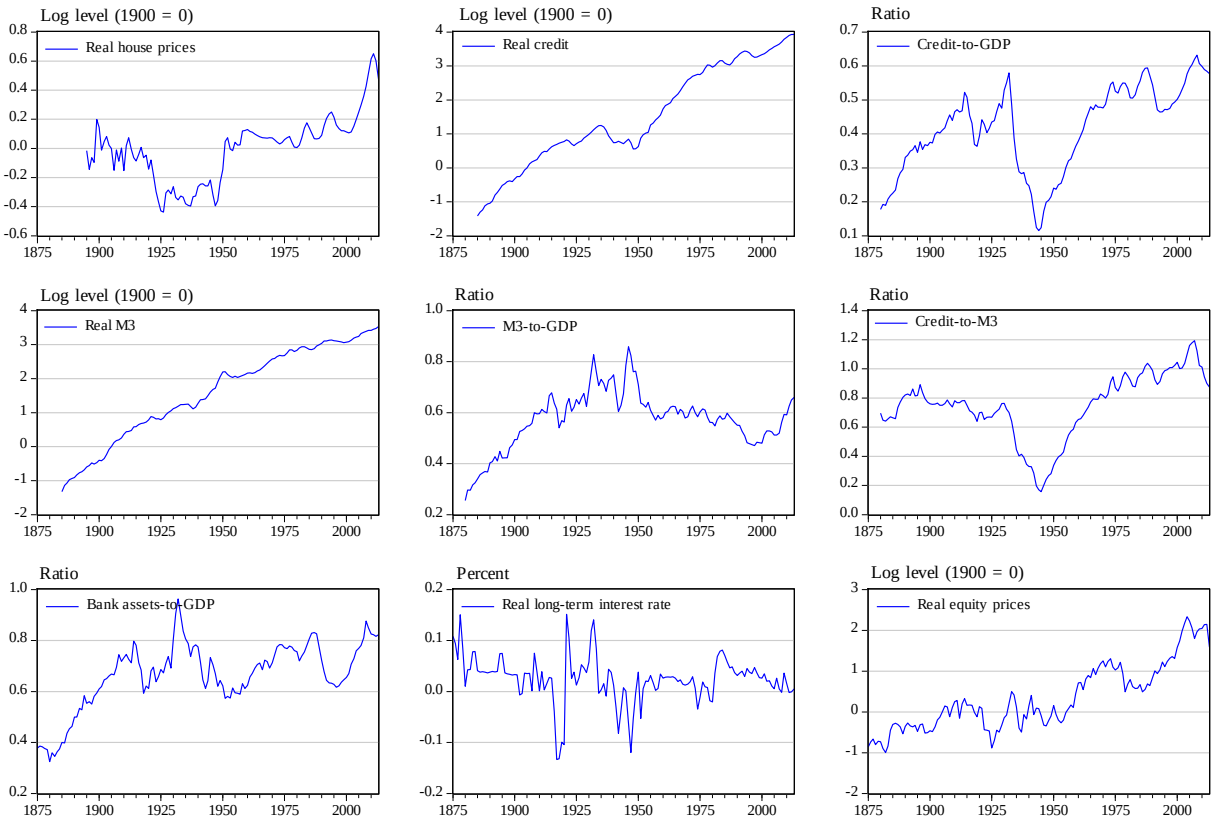
We use Eitrheim et al. (2004, 2007), with updates from the Norges Bank *Historical Database* as a source for credit (total credit private banks), nominal GDP, house prices (country-wide prices), and domestic consumer prices (consumer price index). There is a gap in the GDP series from 1940-45 and linear interpolation is therefore used to provide data for the credit-to-GDP series for that period.
http://www.norges-bank.no/en/Statistics/Historical-monetary-statistics/.

United Kingdom

We use the Bank of England historical dataset (*Three Centuries of Macroeconomic Data*, Version 2.2) as a source for credit (total stock of bank and building society lending), nominal GDP, house prices (property prices) and domestic consumer prices (consumer price index).
http://www.bankofengland.co.uk/research/Pages/onebank/threecenturies.aspx.

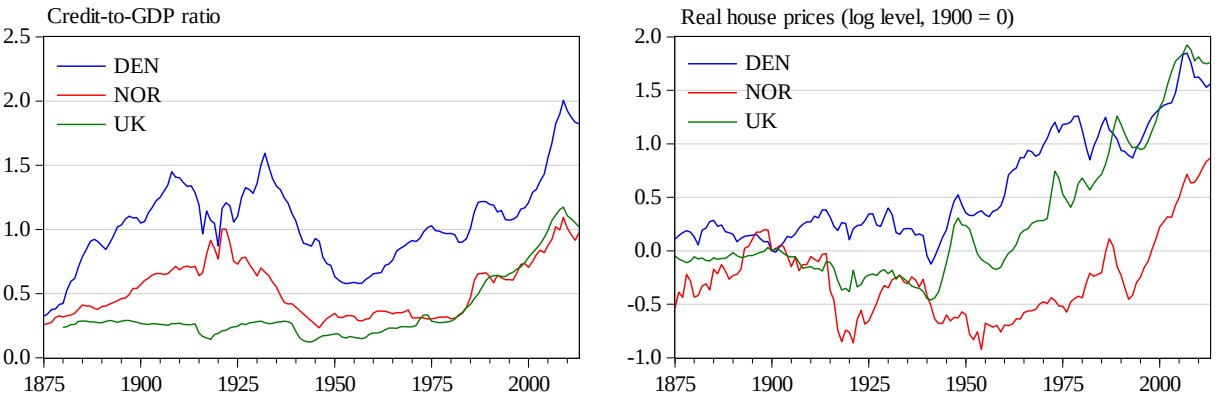
The following figures show the data: first Figure A.1.2 for the nine US variables used, followed by Figure A.1.3 for the credit-to-GDP ratio and real house prices for Denmark, Norway and the UK.

Figure A.1.2 The data for the US



Sources: Jordà et al. (2014) and Shiller (2015).

Figure A.1.3 The data for Denmark, Norway and the UK

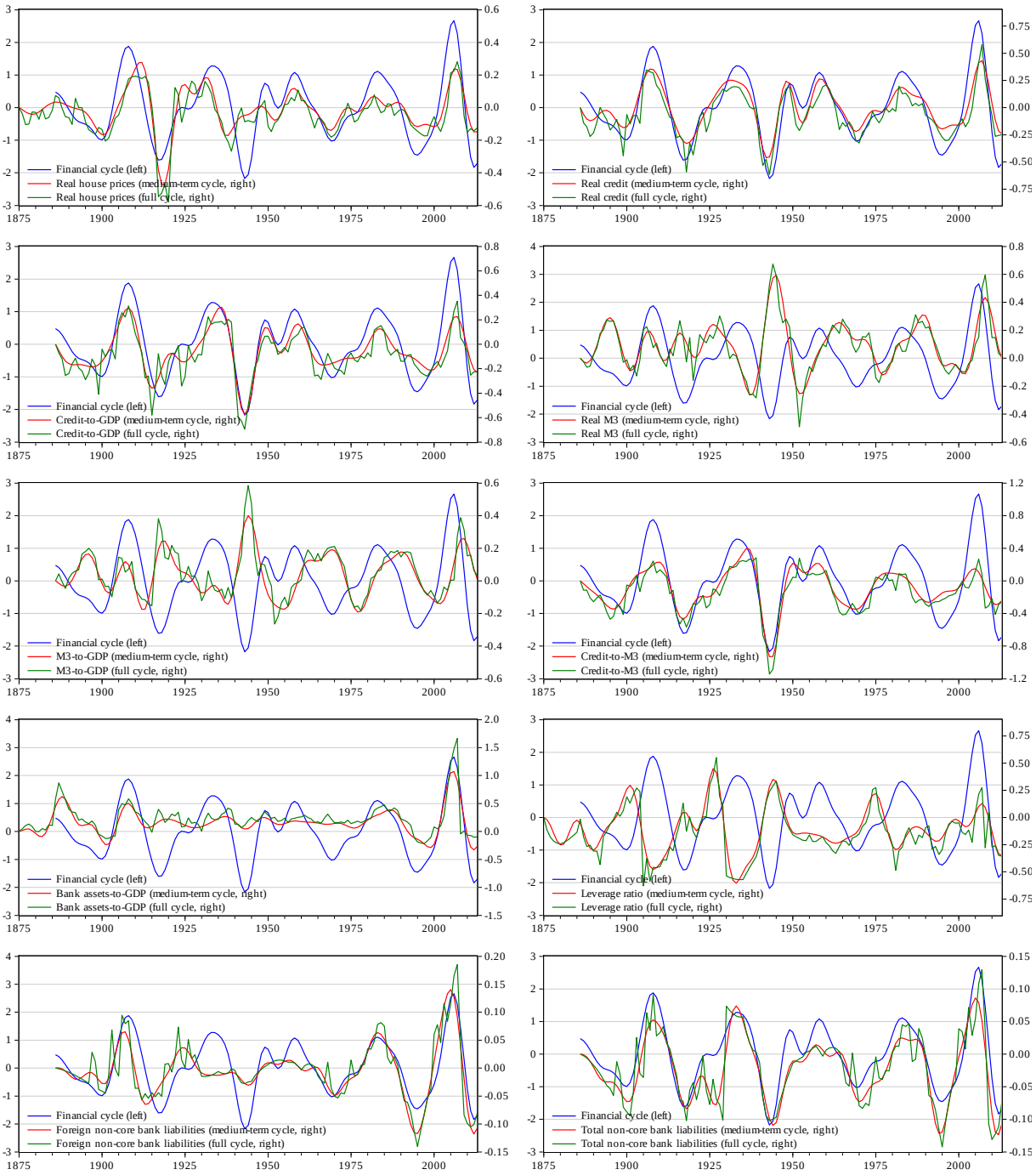


Sources: Abildgren (2006), Bank of England, Bank for International Settlements, Eitrheim et al. (2004, 2007), International Monetary Fund, and Norges Bank.

Appendix 2 Cyclical components of the domestic data

This Appendix shows the medium-term (8 to 30 year) and complete (2-30 year) cycles of individual domestic financial (Figure A.2.1) and macroeconomic (Figure A.2.2) variables together with the composite measure of the aggregate financial cycle.

Figure A.2.1 The financial cycle and cycles in individual financial variables

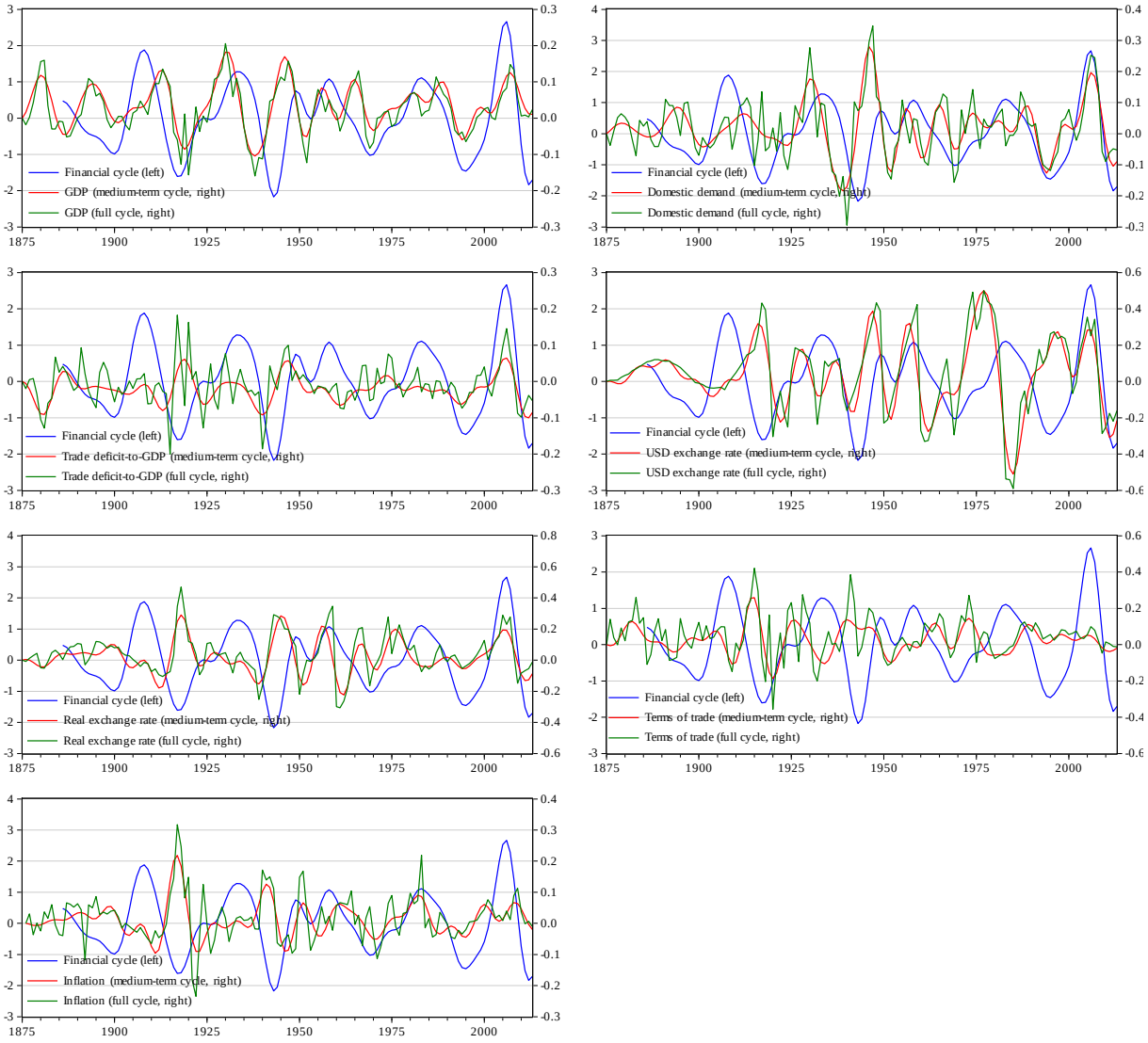


Financial cycle, medium-term (8 to 30 year) and full (2-30 year) cycles in individual financial variables.

Source: Authors' calculations.

The figures show how most of the variables are dominated by their medium-term cyclical components and how closely most of these medium-term cycles coincide with the aggregate financial cycle.

Figure A.2.2 The financial cycle and cycles in individual macroeconomic variables



Financial cycle, medium-term (8 to 30 year) and full (2-30 year) cycles in individual macroeconomic variables.

Source: Authors' calculations.

Appendix 3 Financial crises in Iceland

In this Appendix we summarise the dates of different types of financial crises in Iceland over the period 1875-2013 and give a short description of the criteria used to date these episodes. For a detailed description and analysis, see Einarsson et al. (2015).

Currency and inflation crises

Table A.3.1 shows the dates of different types of financial crises in Iceland over the period 1875-2013. Currency and inflation crises are identified using the numerical threshold suggested by Reinhart and Rogoff (2009, 2011) (15% per annum for annual currency depreciations and 20% per annum for annual inflation).[105] This gives us eleven currency crises and five inflation crises with an average duration of 2.4 and 5.4 years, respectively. Not surprisingly, the two types of crises are closely connected with all the inflation crises coinciding with currency crisis episodes, with the temporal sequence usually from a currency crisis to an inflation crisis. One episode stands out in terms of its longevity: the currency and inflation crisis starting in the mid-1970s which lasts for more than a decade with a cumulative depreciation amounting to almost 98% and inflation averaging at almost 40% per year. Some of the shorter currency crisis episodes are also nastier than others: the crises in the early 1920s, in 1950, the two crises in the 1960s, and the latest one, all saw the currency collapsing by close to 50%. As discussed in Einarsson et al. (2015), two of these episodes (the first and the last) also coincided with a full-blown sudden stop crisis that eventually led to the introduction of capital controls.[106]

Banking crises

For dating banking crises, we follow the standard practice in the literature in basing our event criteria on identifying dates where there are significant signs of financial distress in the banking system, as reflected in large-scale bank runs (be that a conventional run on deposits or a more "modern" run on wholesale funding) that lead to the closure, merging, or public sector takeover of a significant share of the banking system (see e.g. Reinhart and Rogoff, 2009, and Laeven and Valencia, 2013).

This gives us five banking crisis episodes, occurring every 22 years and lasting for 2 years on average. Three of these episodes are defined as systemic: the two early episodes in the early 1920s and 1930s, and the latest episode starting in 2008. All three would register as serious on any banking crisis barometer (although the latest one beats them all, hands down): all involved between two-thirds to more than 90% of the banking system and coincided with a contraction in real credit that amounted to 10-20% in the first two episodes to more than 80% in the latest one. The two other episodes (in the mid-1980s and early 1990s) are smaller, non-systemic crises that only involved one, albeit important, financial institution in distress.

[105] There are a few exemptions explained in Einarsson et al. (2015).

[106] The currency crisis in the early 1930s also led to an introduction of capital controls but this episode falls short of the criteria for identifying sudden stop crises used (a trade balance reversal exceeding two standard deviations and coinciding with collapsing output; cf. Calvo et al., 2008, and Forbes and Warnock, 2012).

Table A.3.1 Financial crises in Iceland 1875-2013

Currency crises	Inflation crises	Banking crises	Multiple financial crises
1919-20	1916-18	1920-21	1914-21
1932	–	1930-31	1931-32
1939	1940-43	–	–
1950	1950-51	–	1948-51
1960	–	–	–
1968-69	1969	–	1968-69
1974-85	1973-89	–	–
1988-89	–	1985-86	–
1993	–	1993	1991-93
2001	–	–	–
2008-9	–	2008-10	2008-10

The dates of currency and inflation crises as identified by the numerical thresholds suggested by Reinhart and Rogoff (2009, 2011): exchange rate crises are defined as episodes where annual depreciations is greater than 15% per annum and inflation crises as episodes where annual inflation is in excess of 20% per annum. The dates identified for the 1985-86 and 1993 banking crises are obtained from Caprio and Klingebiel (2003) (also used by Reinhart and Rogoff, 2009, 2011), while we use Laeven and Valencia (2013) to date the start of the latest banking crisis. The dating of the two pre-WWII banking crises is based on archived documentation. Identification of multiple financial crises is based on the Harding and Pagan (2006) non-parametric common cycle algorithm.

Source: Einarsson et al. (2015).

Multiple financial crises

To capture the clustering nature of the financial crises in Iceland, we also apply a version of Harding and Pagan's (2006) non-parametric common cycle algorithm to identify the more serious multiple financial crisis episodes. This gives us six multiple crises occurring every 15½ years on average. The first two episodes occur during the early 1900s: the first coincided with the WWI and lasted into the early 1920s, when a sharp collapse in economic activity led to an inflation crisis that was followed by a sudden stop and a currency crisis and eventually by a systemic banking crisis; while the second crisis coincided with the outbreak of the Great Depression in the early 1930s when another systemic banking crisis followed a recession and morphed into a currency crisis in 1932. There are two further episodes occurring at the end of the 1940s and in the late 1960s that are related to a serious deterioration of external conditions, in both cases leading to currency and inflation crises: the first followed a sharp deterioration of terms of trade and a contraction in economic activity; the second of these episodes following a collapse in fish catch, a major export item. The fifth episode occurs during the early 1990s when falling economic activity, following attempts to rein in the chronic inflation of the 1970s and the 1980s, led to a twin currency and (non-systemic) banking crisis in 1993. The final episode is the most recent one when a build-up of large imbalances in the run-up to the crisis were followed by a sudden stop and a twin currency and banking crisis in 2008.

Appendix 4 Global financial cycles and crises

Figure A.4.1 shows the estimated aggregate financial cycles from 1875 to 2013 for the four countries used to analyse global and regional spillovers to Iceland and the dates of banking and general financial crises in these countries, as identified by Reinhart and Rogoff (2011).[107] The figure shows that peaks in our measure of the US financial cycle closely coincide with the dates of banking crises in the US. From 1890 (the first observation of the composite US financial cycle), Reinhart and Rogoff identify seven banking crises in the US: in 1890, 1893, 1907, 1914, 1929-33, 1984-91, and 2007-10, and our composite financial cycle peaks within a three year window of the start of six of these episodes – it is only in the mid-1980s that the cyclical peak falls outside this three year window (occurring four years after the start of the crisis). There are also cyclical peaks that do not coincide with a banking crisis, but some of them coincide with other types of financial crises, such as the currency crisis in 1947. The broader defined measure of financial crises gives a greater number of crises, but again we find that a significant number of those coincide with peaks in the financial cycle (ten of the total of seventeen).

For the other three countries, the same results emerge: most of the financial crises identified by Reinhart and Rogoff (2011) coincide with a cyclical peak in our composite measure of their respective financial cycles. In fact, for the four countries we find that almost 80% of the banking crises identified coincide with a cyclical peak within a three year window. The number of general crises coinciding with cyclical peaks is lower but is still as high as 58%.

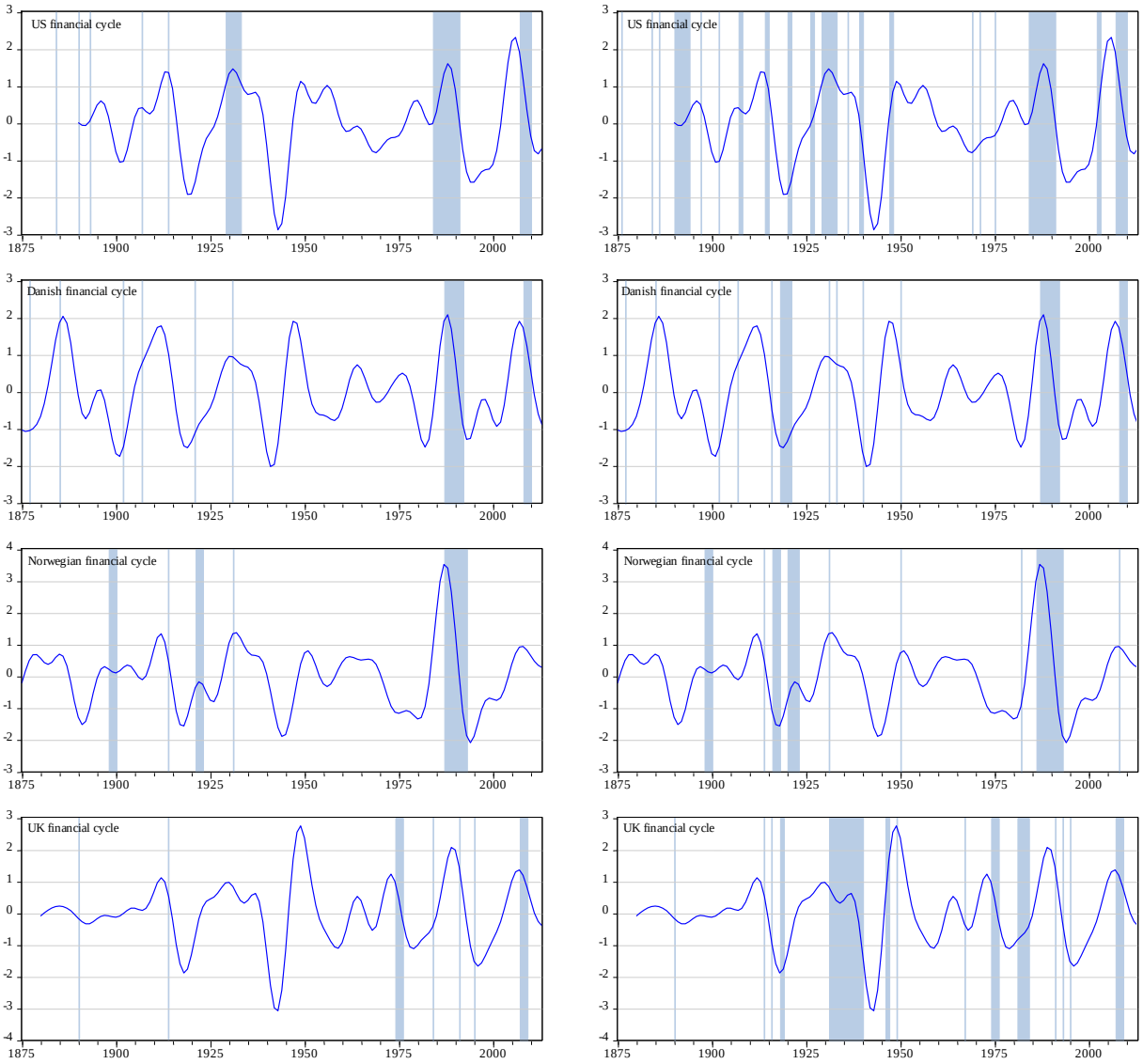
Inspection of the figure suggests that the cycles across these four countries tend to move together over time, with peaks and troughs more often than not coinciding. This visual perception is confirmed by the concordance index which suggests that over the whole sample period the four cycles tend to be in the same phase from almost 60% (the US and Norwegian cycles) to close to 80% (the Danish and the US and UK cycles) of the time. The financial crises identified here also show a strong common global component: the concordance index suggests that the four countries are roughly 70-90% of the time in the same financial state. Finally, panel probit regressions show that the composite financial cycle has a statistically significant predictive power for impending financial crises and that cyclical expansions significantly increase the probability of a financial crisis: for example, a lagged binary indicator that equals unity at cyclical peaks and zero otherwise is found to be statistically significant (*p*-values equal to 0.002 and 0.012 for banking and general financial crises, respectively) and suggests that a peak in the financial cycle coincides with roughly two- to almost threefold increase in the probability of a financial crises two years after the cyclical peak.[108]

[107] General financial crises corresponds to dates when Reinhart and Rogoff's (2011) BCDI index signals two or more crisis episodes (i.e. at least two of banking, currency, external sovereign debt, or inflation crises).

[108] The regressions include a constant and time-invariant country-specific effects. Using cross-country averages, the empirical results suggest that the probability of a banking crisis rises from roughly 10% to 28%, whereas the probability of general financial crisis rises from 22% to 40%. The results for individual countries are very similar.

Figure A.4.1 Financial cycles and crises in the US, Denmark, Norway, and the UK

Banking crises (left) and general financial crises (right) shown as shaded areas



Financial cycle, estimated as the first principal component of the medium-term cycle of the credit-to-GDP ratio and real house prices for each country. Dates for financial crises are from Reinhart and Rogoff (2011). General financial crises are defined as years when there are two or more crisis episodes involving either a banking, currency, external sovereign debt or inflation crises identified by Reinhart and Rogoff (2011).

Sources: Reinhart and Rogoff (2011) and authors' calculations.

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CHAPTER 4

HOUSEHOLDS' POSITION IN THE FINANCIAL CRISIS IN ICELAND

Analysis based on a nationwide household-level database

Households' position in the financial crisis in Iceland

Analysis based on a nationwide household-level database*

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Abstract

We analyse households' position in the financial crisis in Iceland using a unique nationwide household-level database. The main focus of our analysis is to assess how the share of indebted households in financial distress evolved and how it was affected by debt restructuring measures and court decisions. We also analyse the share of indebted homeowners in negative housing equity and those in the highly vulnerable situation of being simultaneously in distress and negative housing equity. We find that the degree of financial distress more than doubled between January 2007 and its peak in October 2009, but decreased to 20 per cent in December 2010. Financial distress is inversely related to income. Distress is higher among families with children and those with foreign-denominated debt than among childless households and those with ISK-denominated loans only. Parents of every fifth child in Iceland were in distress at year-end 2010. The share of indebted homeowners in negative housing equity increased from 6 to 37 per cent. Negative housing equity is more widespread among high-income than low-income households. Roughly 10 per cent were simultaneously in distress and negative equity in December 2010. Middle-income families with children, most of which had foreign-denominated loans, and low-income singles seem especially vulnerable.

Keywords: household debt, financial distress, financial crisis, microdata, debt restructuring, deleveraging

JEL classification: D10, D12, D31, G21

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1 Introduction

Household debt played a pivotal role in starting the global financial crisis. What seemed initially to be an increased incidence of arrears in a small subsection of the vast US mortgage market metamorphosed into the worst global financial crisis since the Great Depression. Households in advanced countries have felt the impact of the crisis, most notably through increased unemployment and loss of wealth, which has prompted them to increase savings by cutting back on spending and paying down debt. The macroeconomic effects of changed household behaviour have been widely felt. Icelandic households were among the hardest hit by the global financial crisis, as is reflected in one of the largest contractions in private consumption experienced in any medium- to high-income country. This is not surprising, given that Icelandic households were among the most indebted household sectors in the run-up to the crisis and were the only households with widespread borrowing in foreign currency to experience a currency crisis on top of a banking system collapse leading to a dramatic increase in debt levels and debt service (Ólafsson and Pétursson, 2011). Nominal debt levels rose even further, as the majority of mortgages in Iceland are indexed to consumer price inflation, which rose steeply due to the massive depreciation of the currency.

This paper aims to portray how the state of Icelandic households' finances evolved in the run-up to and aftermath of the financial crisis in Iceland. Our analysis builds on a unique nationwide household-level database designed and compiled by the Central Bank of Iceland. It combines a comprehensive loan-level dataset including detailed information on each individual loan for nearly all indebted households in Iceland with a household-level dataset covering information on income levels and various demographic characteristics for each individual household; e.g., family type, age, and place of residence. Hence our database contains detailed information on each individual loan and household for an entire country's population of indebted households at a time of unexpected adverse shocks in the form of a banking system collapse and a currency crisis of exceptional magnitude.

Our analysis of households' position centres on the following issues. First, we assess how the share of indebted households in financial distress evolved over the four-year period from 2007-2010. Households are defined to be in financial distress if they have a negative financial margin such that their disposable income is insufficient to cover both debt service and necessary minimum living expenses. Second, we analyse the development in homeowners' housing equity with particular focus on the incidence of negative housing equity; i.e., where the outstanding mortgage balance exceeds the value of the underlying property. Third, we analyse the size of the highly vulnerable group of households simultaneously in distress and negative housing equity. Fourth, we shed light on the main characteristics of vulnerable households in order to support policy-making in this field. Fifth, we analyse the effects of debt restructuring measures, as well as court judgements declaring widely used exchange rate-linked loans illegal and in need of recalculation. Throughout, we provide a breakdown of results for various groups based on factors such as income, currency-denomination of debt, and family type.

The remainder of the paper is organised as follows: Section 2 presents the data and describes our construction of payment, income, cost of living, and housing wealth profiles. Our

empirical results on the evolution of financial distress and negative housing equity are presented in Section 3. Furthermore, we analyse the characteristics of vulnerable households and offer some international comparison. In Section 4, we interpret the main economic and policy findings. Section 5 concludes.

2 The data and construction of profiles

This section describes the data analysed in this paper and introduces the profiles constructed for payments for each individual loan, income and living expenses for each household, and housing wealth profiles for each homeowner.[109]

Traditionally, shortfalls of household-level data limit analysis of households' financial position to aggregate data, surveys, or small samples of micro data. This can be a drawback. Aggregate data measures contain income and assets from debt-free households, and they provide limited information on the distribution of debt – across income groups, for instance – and the size of debt held by households in distress. Hence aggregate data can understate the degree of indebtedness and the vulnerability of debtors. Survey data is usually the main source of household sector analyses, but they allow limited guidance on the effects of debt restructuring measures, and results are associated with sampling uncertainty, interpretations difficulties, and delay.

The Central Bank of Iceland began preparations for extensive data gathering on households shortly after the collapse of the banking system in late 2008. Over the course of 2009, a small working group within the Central Bank designed a data request and subsequently collected detailed data on individuals and households from financial institutions, the tax authorities, and the Directorate of Labour. Data were gathered by permission from the Icelandic Data Protection Authority (2009), which set strict rules of procedure. The analysis was conducted using coded and anonymous data and the encryption key subsequently destroyed in accordance with the permission, obstructing the possibility of adding new data to the database at a later date.

This database was unprecedented for a country that has experienced a financial crisis at the time of its compilation. Efforts have been made to build similar databases in some countries, especially in Ireland, but we are not aware of any household-level database covering a whole nation or any work using a household-level database to build payment profiles for each individual loan on the scale that we do in this paper.

The data can be categorised into the following groups. The first group consists of three encrypted variables used for *identification* of individuals, households, and loans.[110] This allows for combining information on loans, individuals, and households from different data sources in order to obtain an overview of households' financial position at the household level. Each

[109] A more detailed description of the data can be found in Ólafsson and Vignisdóttir (2012).

[110] A household is defined as individuals with the same (coded) family number, which is equal to the (coded) social security number of the oldest family member. The disadvantage of defining a household in this manner is that individuals receive their own family number when they reach 18 years of age.

individual's social security and family number is encrypted, as is each loan's identification number.

The second group of data consists of 21 variables describing *terms, conditions, and loan amounts* for each individual loan, including date of issuance, type of loan, maturity, debt service method, currency composition, interest rate level, interest premium level, number of payment dates per year, type of interest rate (fixed/floating), original loan amount, and outstanding balance on 31 December 2008.

The third group of data consists of information regarding *assets and collateral*. Commercial banks and savings banks provided data on each individual's deposits by type as of 31 December 2008, and pension funds supplied available data on each individual's pension savings assets. Financial institutions also provided data on the official December 2008 Land Registry value of each property used as collateral, which is used as a reference point of homeowners' housing wealth.

The fourth group of data consists of information on household *income*. Annual tax returns provide the best possible overview of household income in Iceland, but the most recent data available from this source at the time of the data gathering was for the year 2007. It was clear from the outset that, in many cases, this would provide a poor representation of household income after the banks' collapse. Therefore, we opted to supplement tax return data on each individual's annual income in 2007 with income data from tax withholding records. The tax authorities provided data on each individual's income according to tax withholding records for February 2009, the most recent data available at the time of data gathering, as well as a year earlier; i.e., February 2008.

The final group of data consists of indicator variables on *demographics*. First, there is an age indicator variable for each individual's age interval, which permits analysis for different age groups. Second, there is an indicator variable for each individual's place of residence. We also constructed an indicator variable for family type, using the number of individuals with the same family number, which enabled us to analyse households' financial position for different family types; i.e., singles, single parents with children, couples without children, and couples with children.

We have information on the debt position of 120,745 indebted households in our database. Debt-free households are excluded from the analysis. Our results show that the currency-denomination of debt has an important effect on households' financial position. Foreign-denominated borrowing was far more widespread among households with motor vehicle debt than among those with mortgage debt.[111] Roughly 80 per cent of households with motor vehicle debt had at least some portion of that debt denominated in foreign currency, while the same applies to only approximately 10 per cent of mortgagors.

The main strength of our approach lies in the construction of various profiles, which enables us to capture the crisis dynamics and provide an assessment of our specified topics of interest. First, we utilise our detailed database to construct payment profiles for each of the roughly 424 thousand individual loans in our database which allows us to combine debt

[111] We define all loans backed by real estate as mortgages, as it is problematic to distinguish between loans taken for real estate purchases and mortgage equity withdrawals.

payments and outstanding balances for each household so as to assess how their debt service burden and debt level develop over time. In this manner, we transform our loan-level database from merely providing information on each loan at a particular point in time to a dataset portraying how debt service and debt levels evolve over time; i.e., from cross-sectional data to panel data.[112] We can compare the evolution of financial distress with and without various debt restructuring measures and legal interventions by constructing both payment profiles with these measures (our baseline scenario) and a counterfactual scenario without them (our alternative scenario).

Second, we use individual income data and information on family type to assess each household's disposable income and necessary minimum living costs. Our measure for living expenses is based on the Debtors' Ombudsman's consumer guidelines for minimum living expenses for different family types, but we add a 60 per cent buffer to cover factors not included in the consumer guidelines.[113] We also add the cost of motor vehicle operation for households with motor vehicle loans. We extrapolate the wage income information in the database to provide an income profile for our four-year period. Income for the year 2007 is given by income according to tax returns but is distributed throughout the year such that it develops according to the Statistics Iceland wage index. Income for 2008 is estimated in terms of reported income in February 2008 and extrapolated in line with the wage index. Household income from January 2009 through December 2010 is estimated in terms of reported income in February 2009 and extrapolated in line with the wage index. Consideration is given to changes in taxes and personal tax deductions, and mortgage interest subsidies and child benefits are calculated for each household. Thus we obtain a profile for disposable income for each household for the entire reference period for which we have wage information for all the data points (i.e., for the year 2007, February 2008 and February 2009).[114]

Third, we construct a housing wealth profile for each homeowner based on the official Land Registry value and the evolution of house prices in the various districts around the country. This, alongside the payment profiles, allows us to assess developments in housing equity. Our housing wealth measure is based on the value of each dwelling according to official Land Registry value in December 2008 for all residential properties used as mortgage collateral. The official Land Registry value should broadly reflect the market value of each residential property in February 2008, and we extrapolate this measure of housing wealth by allowing it to

[112] The detailed loan-level data provide most of the information necessary to build payment profiles for each individual loan. Some assumptions are nevertheless necessary, especially with regard to interest rate and interest rate premium developments for loans with floating rates, for which we only have information on at the time of the data gathering. Fortunately, 80 per cent of indexed ISK-denominated mortgages in our database have fixed (real) interest rates for which we have information for individual indexed mortgages. A detailed account of the assumptions used is available in Ólafsson and Vignisdóttir (2012).

[113] This includes a variety of fixed expenses, such as telephone services, subscriptions, property taxes, insurance, and day-care. The Debtors' Ombudsman's consumption guidelines are updated in January and August each year. The analysis of households' position is based on a linear approach so that living costs rise month-on-month instead of increasing in stages each January and August. In Ólafsson and Vignisdóttir (2012) we assess the robustness of our results on distress by using a 50-70 per cent buffer on the consumer guidelines.

[114] We exclude some households for which we only have information for the year 2007 from tax returns to prevent the fact that many low-income singles included in the 2007 income data are not included in the 2008 data from disturbing the interpretation of our analysis. Hence, our reference group includes 111,592 households.

evolve in accordance with our constructed house price index for each district over the period from January 2007 to December 2010. The index is based on the development of average purchasing price per m2 for each district according to data from Registers Iceland.

When profiles have been prepared for payments on each loan, as well as profiles for living expenses and disposable income for each indebted household, then it is possible to assess how households' ability to service debt and cover living expenses has developed. Furthermore, we can assess households' housing equity using the outstanding balances according to the payment profiles for mortgages, and housing wealth according to the constructed housing wealth profiles.

3 Results

In this section, we report the main findings of our analysis of households' financial position. Section 3.1 presents the results of the financial margin analysis, which builds on the constructed payment, income and living cost profiles. Its main aim is to assess the share of households in financial distress and how that share evolved over the four-year period from January 2007 to December 2010. In Section 3.2 we assess the balance between household's mortgage debt and housing wealth and estimate the share of homeowners in negative housing equity. In Section 3.3 we analyse how the share of homeowners in the especially vulnerable position of being both in financial distress and negative housing equity evolved over the four-year period. We analyse the main characteristics of vulnerable households in Section 3.4 and provide some international comparison of our results in Section 3.5. The economic and policy interpretations of our findings are mostly contained in Section 4.

3.1 Results on financial distress from the financial margin analysis

Our preferred method of assessing the share of households in financial distress is based on each household's financial margin. We calculate each indebted household's *financial margin* by subtracting total debt service payments and minimum necessary living expenses (based on the Debtors' Ombudsman's consumer guidelines with a 60 per cent buffer) from the household's disposable income. We define households in *financial distress* as all households with a negative financial margin. The main focus of our analysis is to assess how the share of indebted households in financial distress evolved in the run-up to and aftermath of the banking and currency collapse and how it has been affected by various policy measures and legal rulings.

It is important to note that financial distress does not necessarily lead households to default on their debt payments. Households whose total spending on debt service and necessary living expenses exceeds their disposable income have various ways to defer default. They can liquidate some of their assets such as deposits, bonds, motor vehicles, housing, or even pension fund assets, as was made possible in the aftermath of the crisis. They can also increase their overdraft debt, restructure their debt – for instance, take on mortgage equity loans and pay down short-term debt – reduce consumption or increase labour participation or hours worked (some

of which could even take place outside the organised labour market).[115] Thus it is likely that households can navigate through temporary periods of distress without defaulting. On the other hand, persistent payment problems are likely to lead to default.

An important factor determining households' possibility of escaping financial distress by liquidating assets or restructuring debt is their equity position, particularly their housing equity. Households' housing wealth in excess of their mortgage debt is important, as it affects both borrowers' opportunity to offer collateral for more favourable loans and thereby restructure their debt and lenders' incentive to push for foreclosure in the event of payment problems. Hence we are interested in assessing the share of households that are both in financial distress and negative housing equity (Section 3.3).

The results of the financial margin analysis indicate that roughly 12½ per cent of indebted households were already likely to be in financial distress in January 2007. The share of households in distress rose gradually over the course of 2007. The effects of the outbreak of the global financial crisis are evident in August 2007 when the monthly currency depreciation measured roughly 8 per cent using our household debt exchange rate index.[116] The share in distress is assessed to have been roughly 17 per cent at year-end 2007, but households' financial position deteriorated rapidly thereafter as the currency depreciated and inflation rose. The share of households in distress is estimated to have been 23½ per cent on the eve of the banking system collapse in autumn 2008, when the annual drop in our constructed household debt exchange rate index measured 50 per cent and annual inflation was just shy of 16 per cent (Figure 1). This represents a roughly 96 per cent increase in the number of households in distress from January 2007 and reflects that the lion's share of the shocks to the households' balance sheet had already taken place when the banking system collapsed.

The freezing of payments on the majority of foreign-denominated loans prevented the share in distress from rising to 27 per cent in the immediate aftermath of the crisis.[117] Instead it fell to roughly a fifth, but of course these forbearance efforts only provided short-term breathing space in the aftermath of the banks' collapse and increased the indebtedness of the households that made use of this option, as their interest and principal payments were merely postponed and therefore added to the outstanding balance of their loans.

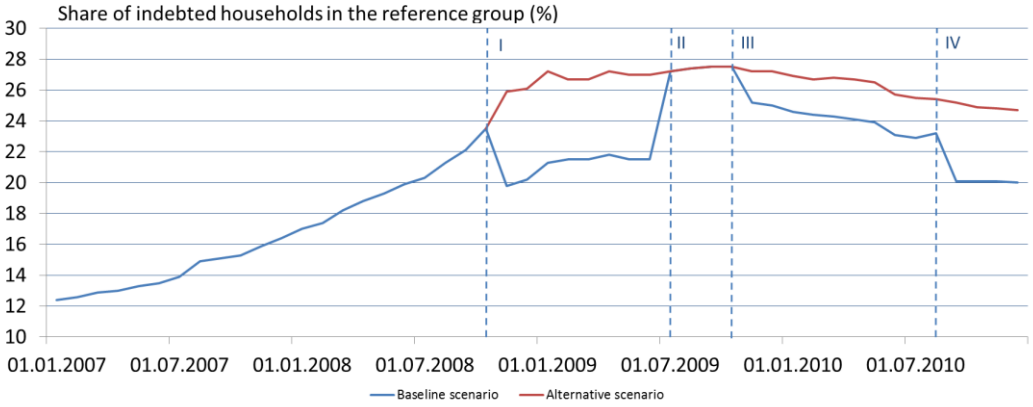
[115] For some households found to be in financial distress, it may be that the imbalance between total spending and disposable income is mitigated by financial income, which is not included in our analysis as we only have data on financial income for 2007. A rough assessment of the importance of financial income in 2007 indicates that the share of indebted households in distress may be overestimated by roughly 1.3-1.5 percentage points that year due to this factor. However, this problem is probably smaller in the following years as total financial income decreased by over 70 per cent between 2007 and 2010. Financial income is very unevenly distributed and, for instance, roughly 2,200 households held 78 per cent of the total financial income held by indebted households in 2007.

[116] We construct a household debt exchange rate index where currencies are weighted according to their share in households' foreign-denominated loans

[117] After the collapse of the banking system, households were able to freeze payments on foreign-denominated loans because the domestic currency depreciated rapidly and the foreign exchange market was highly unstable. We base our analysis on our collected information on which loans were frozen at the time of data submittal in the beginning of 2009, and we assume that all loans that were frozen at that time were frozen from November 2008 until mid-2009, while debt payments on other loans were serviced as usual.

Figure 1

Share of indebted households in distress in the baseline and alternative scenario[1]



1. Share of households in the reference group with negative margin taking the 60 per cent buffer on the minimum living expenses into account. I: Freezing of many foreign-denominated loans begins, II. freezing ends and payment smoothing of foreign-denominated mortgages begins, III. payment smoothing of indexed ISK mortgages begins, IV: recalculation of foreign-denominated loans takes place.

Source: Ólafsson, T. T. and K. Á. Vignisdóttir (2012). Households' position in the financial crisis in Iceland: Analysis based on a nationwide household-

We assume that full payments resumed on frozen foreign-denominated loans in July 2009. Some payments actually remained frozen for a longer period, but our assessment is based roughly on when the bulk of debt payment freezing ended. Hence the share of households in distress increased dramatically when the freezing ended, despite the introduction of payment smoothing on foreign-denominated mortgages, which affected relatively few households.[118] The share in distress is assessed to have peaked at 27½ per cent in October 2009. Debt rescheduling through payment smoothing of indexed ISK mortgages[119] is assumed to have begun in November 2009, and it affected a large number of households. The share in financial distress continued to decline gradually over the course of 2010, reaching just shy of 23½ per cent in August 2010.

Our analysis assumes that all foreign-denominated and mixed loans were recalculated at the end of August 2010, following the Supreme Court rulings. After recalculation, the share of households in distress dropped from 23½ per cent of households to 20 per cent. In December 2010, an estimated 21,000 indebted households were likely to be in financial distress. In all, this group of households in distress included roughly 47,660 individuals. Therefore,

[118] This method involves setting the original payment at the level (in ISK) that applied in May 2008, or at the level of the first instalment if the loan was taken after that date. Subsequent payments change in accordance with the modified mortgage payment index, as calculated by Statistics Iceland. The modified mortgage payment index weighs together developments in wages and employment levels. We base our analysis on the assumption that all foreign-denominated mortgages were subjected to payment smoothing from mid-2009 until August 2010, when all foreign-denominated loans were recalculated due to the Supreme Court ruling.

[119] This is a means of temporarily lightening the burden of regular loan instalments by linking them to the modified mortgage payment index instead of the consumer price index. The difference between actual and implicit payments is posted to a special account and paid at the end of the loan period, so that the duration of the loan is extended and the number of payments is increased. The duration of the loan is never lengthened by more than three years, however, according to the terms and conditions, as a ceiling is placed on the extension of the maturity date. In order to estimate what this measure could achieve, it is assumed that all index-linked mortgages were subjected to payment smoothing in November 2009 when it became an opt-out option. In reality, approximately 50 per cent were subjected to this measure.

approximately 15 per cent of all individuals (indebted and debt-free) in Iceland are estimated to have been in distress at year-end 2010.

Out of the group of households in distress in December 2010, roughly 67 per cent were not in financial distress in January 2007; 52 per cent were not in distress in January 2008, when the currency depreciation started to gain momentum; and roughly 42 per cent were not in distress when the banks' collapsed in October 2008. This is a certain indication of the scope of the consequences of the banking and currency collapse for households' capacity to service debt and cover minimum necessary living expenses.

The results above represent our baseline scenario, which allows for explicit debt restructuring measures and recalculation of foreign-denominated and mixed loans. However, it is interesting to assess how the scope of households' financial difficulties would likely have developed if there had not been any explicit policy measures taken to reduce households' debt service burden and foreign-denominated loans had not been deemed illegal. This is done in our alternative scenario. In that counterfactual scenario, the share of households in financial distress would have continued to rise following the collapse of the banking system, instead of declining sharply due to freezing of payments. The share would have measured roughly 27 per cent in January 2009 (approximately 6 percentage points higher than in the baseline scenario) and would have peaked at 27½ per cent in September 2009. Thereafter, it would have declined gradually to about 24½ per cent in December 2010. This is a 4½ percentage point higher share than in the baseline scenario.

Now we return to our baseline scenario and analyse how the extent of financial distress varies across different groups of households; for instance, according to income, currency denomination of debt, and family type.

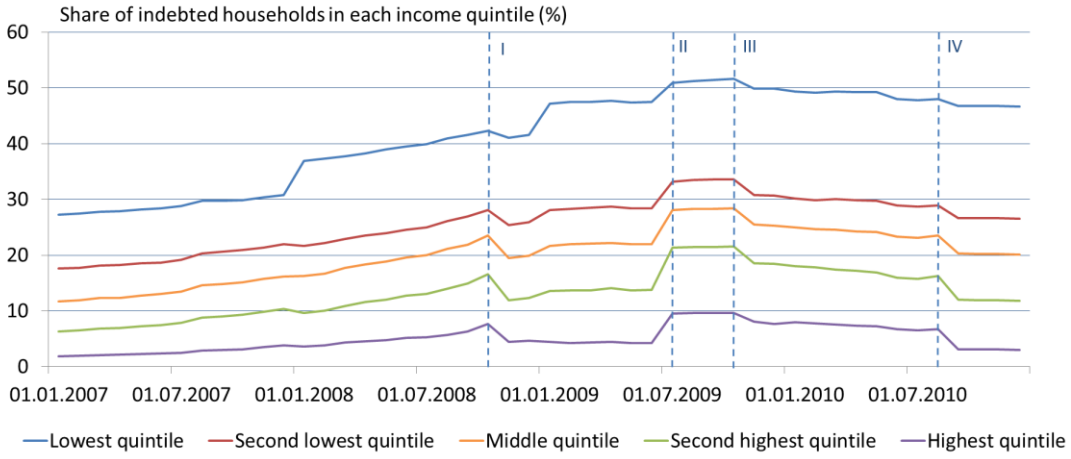
Household income is one of the determinants of the probability of financial difficulties. This is unsurprising, as a household's income level determines its capacity to take on debt and cover necessary living expenses. It is then up to the individual household (and possibly its creditor, if it is credit-constrained) to decide to what extent it makes use of this capacity. We analyse the share of households in financial distress across different income quintiles. The results clearly show that the degree of financial distress is inversely related to income.

The share of households in distress at the beginning of the period varies widely across income quintiles. For instance, it is assessed at roughly 27 per cent in the lowest income quintile, 11½ per cent in the middle group, and only 2 per cent in the highest income quintile. The scope of financial distress also varies at the end of the four-year period. It measures just shy of 47 per cent in the lowest income quintile group, roughly 20 per cent in the middle income quintile, and only 2 per cent in the highest income quintile group (Figure 2).[120]

[120] It is likely that we overestimate the share of low-income households in distress, as we probably underestimate the income of students, who earn a large share of their income during the summer, and we are counting some young persons as individual households, due to the fact that they receive their own family number at age 18. However, when we compare the relative size of this age group within the lowest income quintile to the size of this age group within the distress group they are the same. Approximately 28 per cent of households in the lowest income quintile are in the age interval 18-24 years old and roughly 28 per cent of the lowest income households assessed to be in distress are in this age interval.

Figure 2

Share of indebted households in distress by income quintiles in the baseline scenario[1]



1. I: Freezing of many foreign-denominated loans begins, II. freezing ends and payment smoothing of foreign-denominated mortgages begins, III. payment smoothing of indexed ISK mortgages begins, IV: recalculation of foreign-denominated loans takes place.

Source: Ólafsson, T. T. and K. Á. Vignisdóttir (2012). Households' position in the financial crisis in Iceland: Analysis based on a nationwide household-level database. Central Bank of Iceland Working Paper No. 59.

Using the second-lowest income quintile as an example, the share of households in this group that were already in financial distress in early 2007 is estimated at around 17½ per cent. Following the financial crisis, the share in distress peaked at roughly 33½ per cent in autumn 2009. After payment smoothing of ISK mortgages was introduced, it fell gradually, to an estimated 26½ per cent at the end of 2010. Roughly 65 per cent of the total number of distressed households belongs to the two lowest income quintiles. It is therefore evident that low-income households are much more likely to have experienced financial difficulties than high-income households.

It is noteworthy that the results indicate that households in the second-highest quintile seem to have benefitted most from the recalculation of foreign-denominated loans, as the share in distress declined by 4.3 percentage points afterwards. For comparison, the decline was 1.2 percentage points in the lowest quintile and 2.3 percentage points in the second-lowest quintile. This reflects that high-income households were more likely to have foreign-denominated debt. Over half of all FX borrowers belong to the two highest income quintiles.

It is not just in terms of income that a clear pattern emerges regarding the extent of financial distress. The currency denomination of debt is also an important factor. We analyse the extent to which financial distress differs across households with at least some foreign-denominated debt (FX borrowers) and those with ISK-denominated loans only (ISK borrowers). In short, it is clear that the share of households in financial distress is considerably higher in the former group, although the recalculation of foreign-denominated loans has narrowed the difference between the two groups to a certain extent.

Around 18½ per cent of FX borrowers were already in financial distress in January 2007, compared to 9½ per cent of ISK borrowers. Distress among FX borrowers had probably increased to some extent in 2006 when the currency depreciated abruptly in the so-called mini-banking crisis. The share of FX borrowers in distress rose over the course of 2007, with the

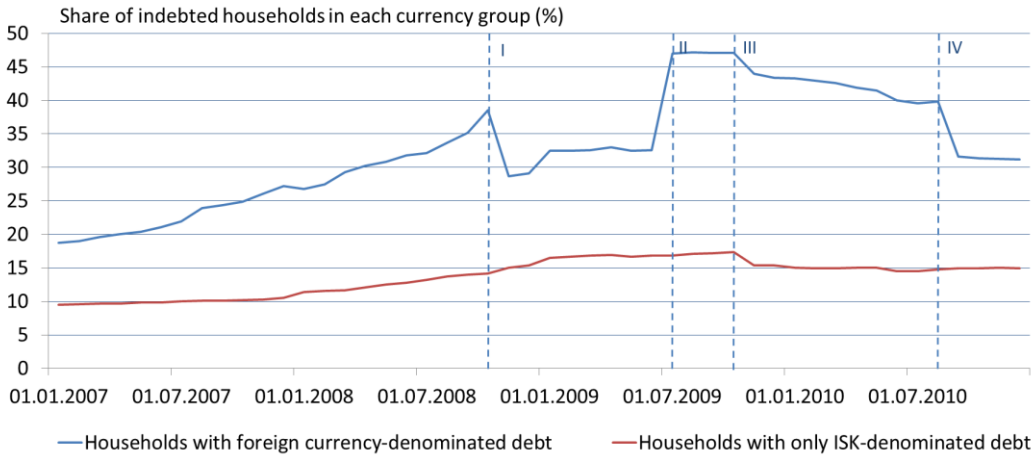
largest increase occurring in August, with the onset of the global financial crisis. The currency depreciation gained momentum in early 2008, paused for a while over the summer months, and then continued in the autumn. Hence roughly 38½ per cent of FX borrowers are estimated to have been in distress by the time the banks collapsed in October 2008, following the 50 per cent currency depreciation (using our constructed household debt exchange rate index). The share of FX borrowers in distress is estimated to have peaked at 47½ per cent after the temporary freezing of many foreign-denominated loans ended in mid-2009, although this result should be interpreted with care as payments on many loans remained frozen beyond this point in time. Hence the number of FX borrowers in distress had almost tripled from January 2007.

The share of FX borrowers in distress fell to 31 per cent at the end of 2010 following further debt restructuring measures and recalculation of foreign-denominated loans. The recalculation was especially influential, as roughly a quarter of FX borrowers escaped distress following it (Figure 3).

The share of ISK borrowers in distress rose gradually, from below 10 per cent in early 2007 to 17½ per cent in the autumn of 2009. This represents a 75½ per cent increase in the number of ISK borrowers in distress over this period, when the consumer price index, to which a large share of this group's debt is indexed, rose by 32½ per cent. The share in distress fell by 2 percentage points when payment smoothing of indexed ISK mortgages is assumed to have begun, and remained close to 15 per cent throughout 2010 (Figure 3). Therefore, there is still a significant difference across currency groups despite the recalculation of foreign-denominated loans, as the share in distress is twice as high for FX borrowers as for ISK borrowers. This is the same relative difference as at the start of the period.

Figure 3

Share of indebted households in distress by currency-denomination of debt in the baseline scenario[1]

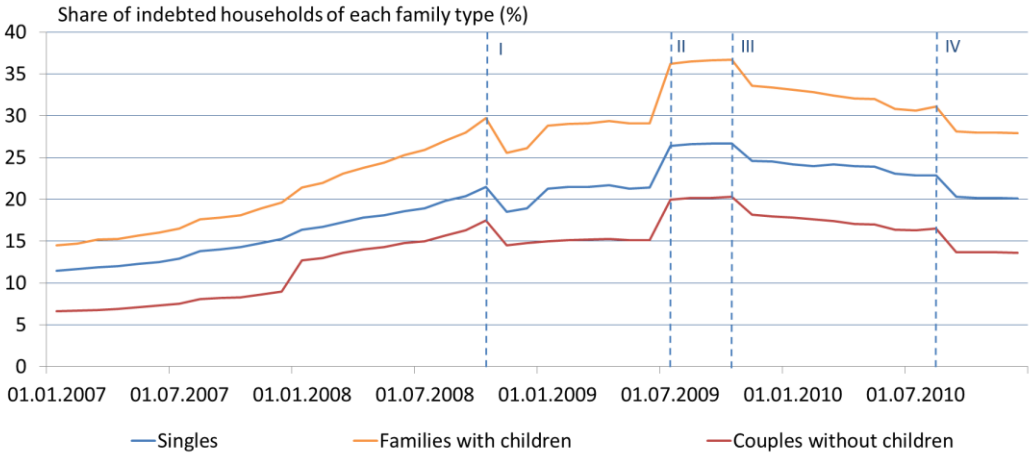


1. I: Freezing of many foreign-denominated loans begins, II. freezing ends and payment smoothing of foreign-denominated mortgages begins, III. payment smoothing of indexed ISK mortgages begins, IV: recalculation of foreign-denominated loans takes place.

Source: Ólafsson, T. T. and K. Á. Vignisdóttir (2012). Households' position in the financial crisis in Iceland: Analysis based on a nationwide household-level database. Central Bank of Iceland Working Paper No. 59.

Figure 4

Share of indebted households in distress by family type in the baseline scenario[1]



1. I: Freezing of many foreign-denominated loans begins, II. freezing ends and payment smoothing of foreign-denominated mortgages begins, III. payment smoothing of indexed ISK mortgages begins, IV: recalculation of foreign-denominated loans takes place.

Source: Ólafsson, T. T. and K. Á. Vignisdóttir (2012). Households' position in the financial crisis in Iceland: Analysis based on a nationwide household-level database. Central Bank of Iceland Working Paper No. 59.

There is also a clear pattern in financial distress across different family types, as families with children are much likelier to experience payment difficulties than childless households. As early as January 2007, 14½ per cent of families with children were in distress. The share in distress rose until autumn 2009, when it peaked at 36½ per cent. It declined by 3 percentage points after payment smoothing of indexed ISK mortgages was introduced, continued to decline gradually until the recalculation of foreign-denominated loans took place when the share in distress fell by 3 percentage points. At the end of 2010, roughly 28 per cent of indebted families with children were in distress (Figure 4). Hence roughly one out of every five children had parents in financial distress at year-end 2010.

Childless couples are the least likely to be in financial distress. Only 6½ per cent of these households were in distress in early 2007. The share is assessed to have reached 17½ per cent by the time the banks collapsed, peaking at 20½ per cent in autumn 2009, and then declining to 13½ per cent. The share of singles in distress falls between the childless couples and those with children. One out of nine is assessed to have been in distress in early 2007. The share peaked at just shy of 27 per cent and then decreased to 20 per cent (Figure 4).

As expected, financial distress is inversely related to age (Ólafsson and Vignisdóttir, 2012). A particularly hard-hit group consists of young households with children that took mortgages late in the housing boom. Roughly 21½ per cent of these households were already in distress in January 2007, and by mid-2009 the share was nearly 47 per cent. At year-end 2010, approximately 35½ per cent of these young households were still likely to be in distress.

The effects of the crisis are also evident in changes to households' financial margin distributions across time. Not only did the extent of distress almost double in the run-up to the banking collapse but the extent of *acute financial distress*, defined as having a negative margin

exceeding 100,000 kr. a month, close to quadrupled to 10½ per cent.[121] Most households in distress in January 2007 had only a small negative margin but the situation had deteriorated considerably when the banks collapsed. By December 2010, the share in acute distress was still just shy of 8 per cent and roughly half of all acutely distressed households at that time were families with children, over 70 per cent of which had foreign-denominated loans.

We find that some of the seeds of households' financial difficulties were sown by imprudent lending in 2007 and 2008, when 16 per cent of the total amount of new loans was granted to households already in distress in the three months running up to the loan issuance. Furthermore, up to 34 per cent of households in distress at year-end 2010 were granted loans in 2007-2008, when they were already financially distressed.

3.2 Results of housing equity analysis

We assess each indebted homeowner's housing equity by relating the value of his/her property according to the constructed housing wealth profiles to the outstanding balance on the mortgage according to the constructed payment profiles. We are particularly interested in assessing the share of indebted homeowners in negative housing equity; i.e., those whose mortgage debt exceeds housing wealth, and to what extent this goes hand-in-hand with financial distress.

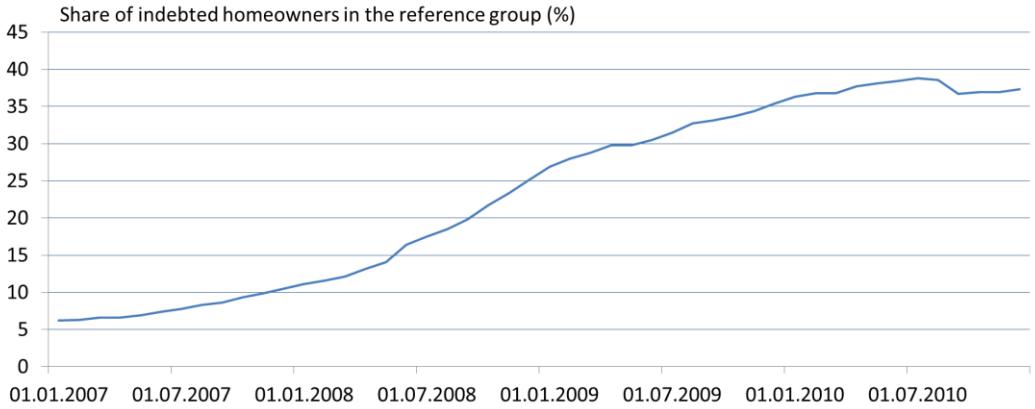
Negative housing equity can affect indebted homeowners in at least three ways. First, it greatly reduces their bargaining power and can prevent mortgagors with (temporary) payment problems from getting out of distress by liquidating housing assets or negotiating debt restructuring with their creditors. Second, some mortgagors with negative housing equity may opt to default if they assess the costs associated with default to be lower than the costs of continuing to service the mortgage. Third, homeowners with negative housing equity cannot trade up or down in the real estate market in response to changes in family size, or in employment and income status.

For most countries it applies that a household ends up with negative housing equity if the decline in the price of the home from the peak exceeds the combined buffer comprising (i) initial equity (which is, again, a function of the loan-to-value ratio), (ii) the equity built up by house price increases from the house purchase to the peak of the housing prices, and (iii) the reduction in principal due to instalments made since the loan was originally taken. Research has shown that the design of mortgage contracts influences the risk of negative housing equity by affecting the first and third of the aforementioned factors (Ellis, 2008). Icelandic households are relatively more likely to end up in negative housing equity than households in many other countries due to the characteristics of Icelandic mortgage contracts. This is mainly due to the extensive indexation to consumer price inflation and exchange rate developments, which exposes the debt position to exchange rate and inflation risks. Another contributing factor is the popularity of fully amortising payment loans with a long maturity (30-40 years), which means that debt payments consist mainly of interest payments for many years and reduction of principal through instalment payments progresses slowly. In addition, like in many other countries, loan-to-value ratios were raised dramatically at the beginning of the housing boom,

[121] This corresponds to having a negative margin exceeding roughly €650 a month.

Figure 5

Share of indebted households in negative housing equity in the baseline scenario[1]



1. Share of homeowners in the reference group in negative housing equity, i.e. with outstanding balance on their mortgages according to constructed payment profiles for the baseline scenario exceeding the value of their dwellings according to constructed housing wealth. The baseline scenario allows for recalculation of foreign-currency denominated mortgages in August 2010.
Source: Ólafsson, T. T. and K. Á. Vignisdóttir (2012). Households' position in the financial crisis in Iceland: Analysis based on a nationwide household-level database. Central Bank of Iceland Working Paper No. 59.

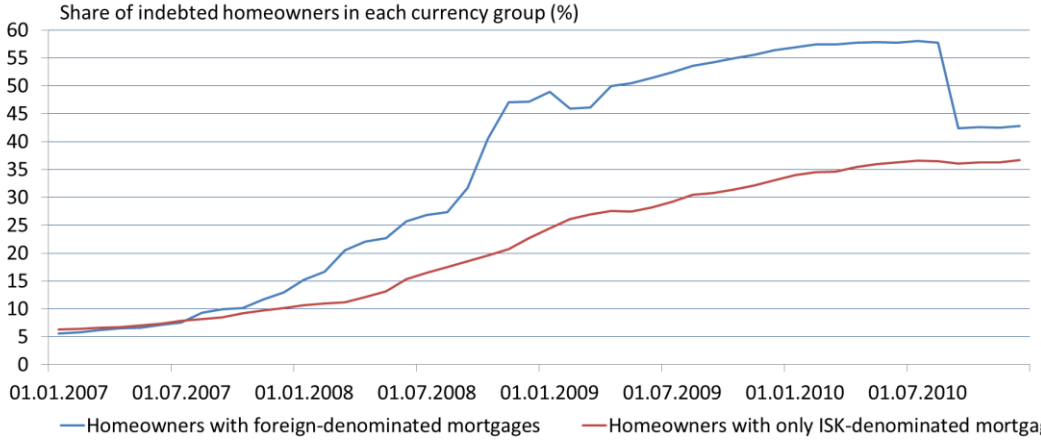
reducing households' ability to withstand adverse shocks to house prices and debt and the introduction of mortgage equity withdrawals made it possible for households to run down their equity without trading in the real estate market, which further increased the risk of negative housing equity under adverse conditions.

The incidence of negative housing equity increased considerably in the run-up to and aftermath of the crisis, as house prices declined and mortgage debt levels rose due to the currency depreciation and accompanying inflation on top of the rapid debt accumulation. The share of households with negative housing equity increased gradually from about 6 to 13 per cent from January 2007 to April 2008 and then rose at a more rapid pace thereafter. Almost 22 per cent of indebted homeowners were underwater at the time of the banking sector collapse, and by February 2009, when the currency had more or less stabilised, it had reached 28 per cent. The inflation spike and further house price declines made the share in negative housing equity continue to escalate even further (Figure 5). It peaked at almost 39 per cent before the court ruling and new legislation on foreign-denominated loans reduced it slightly, to 37 per cent. Hence roughly 27 per cent of all homeowners (indebted and debt-free) were in negative housing equity at the end of the four-year period.

Consistent with the comparison of households in financial distress, it is interesting to view the results on negative housing equity across various groups. The share in negative equity among ISK mortgagors increased steadily from 6½ per cent in early 2007 to 37 per cent in December 2010. This share increased more sharply for FX mortgagors, especially over the course of 2008, peaking at 58 per cent in August 2010 before the recalculation of FX loans reduced it to 43 per cent (Figure 6).

Figure 6

Share of indebted households in negative housing equity by currency-denomination of debt[1]



1. Share of homeowners in each currency group in negative housing equity, i.e. with outstanding balance on their mortgages according to constructed payment profiles exceeding the value of their dwellings according to constructed housing wealth. The baseline scenario allows for recalculation of foreign-currency denominated mortgages in August 2010.

Source: Ólafsson, T. T. and K. Á. Vignisdóttir (2012). Households' position in the financial crisis in Iceland: Analysis based on a nationwide household-level database. Central Bank of Iceland Working Paper No. 59.

FX mortgagors were seriously underwater before the recalculation of foreign-denominated loans; in addition, many had seen their equity deteriorate substantially, although they had not reached the stage of being in negative housing equity. However, the debt position of many FX mortgagors improved after the recalculation. The share of FX mortgagors in negative housing equity fell by 17 percentage points, mainly reflecting a decrease in the group of FX mortgagors who were in negative housing equity by more than 10 m.kr. The share of FX mortgagors in this group was cut in half, decreasing from 34 per cent to 17 per cent as a result of recalculation. Furthermore, the share of FX mortgagors with more than 10 m.kr. in positive equity increased by 9½ percentage points.

Hence it is clear from the above that the currency-denomination of mortgages plays an important role in determining the incidence of negative housing equity. The share of indebted homeowners in negative housing equity is higher among FX mortgagors, although the recalculation has narrowed the difference considerably, but the fact is that a large majority of homeowners underwater are ISK mortgagors. Now we turn to income groups. Is there a clear difference in the incidence of negative housing equity across different income quintiles?[122]

Our analysis of the share of indebted homeowners in negative housing equity across income quintiles reveals that all income groups except the lowest one (which we discuss later) follow a very similar path over the four-year period. They all start off with a relatively low share in negative housing equity – between roughly 5½ and 7 per cent – and the share increases to between 19 and 24 per cent at the time of the banks' collapse. In August 2010, before recalculation of foreign-denominated loans takes place, all these income groups have between 37 and 42 per cent of indebted homeowners in negative housing equity. The effects of the recalculation of foreign-denominated loans on the incidence of negative housing equity increase

[122] Homeownership increases in line with income, in our database it increases from roughly one-third in the lowest income quintile to 5⁄6 in the highest income group.

in line with income, as is discussed in Section 3.3. By year-end 2010, almost 35 per cent of homeowners in the highest income group were in negative housing equity, as opposed to 38 per cent of homeowners in the second-lowest income quintile.

Homeowners in the lowest income quintile seem to deviate from other income groups, as a smaller proportion is in negative housing equity throughout the four-year period. The share is almost 29 per cent at year-end 2010. It is interesting that roughly a fifth of indebted homeowners in the lowest income quintile had more than 20 m.kr. in positive housing equity at the start of the period. Furthermore, more than a third had between 10 and 20 m.kr. in positive housing equity at that time. Hence many low-income households had considerable ability to withstand adverse shocks to house prices and debt levels before falling into negative housing equity. This stands in stark contrast to their capacity to withstand the rise in debt service and living expenses that resulted from the crisis.

The largest number of households in negative equity comes from the two highest income quintiles. This holds throughout the four-year period. In December 2010, roughly 52 per cent of households in negative housing equity come from the two highest income quintiles, or more than double than from the two lowest income quintiles. These results confirm that higher-income households were more heavily indebted than lower-income households, especially in foreign-denominated mortgages, and were therefore more likely to end up in negative housing equity.

An analysis of the results on housing equity by family type reveals a pattern similar to that found in the results on financial distress. Families with children are more likely to end up in negative housing equity than other groups are. The largest increase occurs among single parents, 48 per cent of which were estimated to be in negative housing equity in December 2010, as opposed to 4½ per cent in January 2007. Almost 42 per cent of couples with children were in negative equity at the end of the reference period, compared to roughly 8 per cent at the beginning. Relatively speaking, childless couples are least vulnerable, even though almost 30 per cent of them were underwater at the end of 2010. Similarly, childless couples were least likely to be in financial distress according to the financial margin analysis.

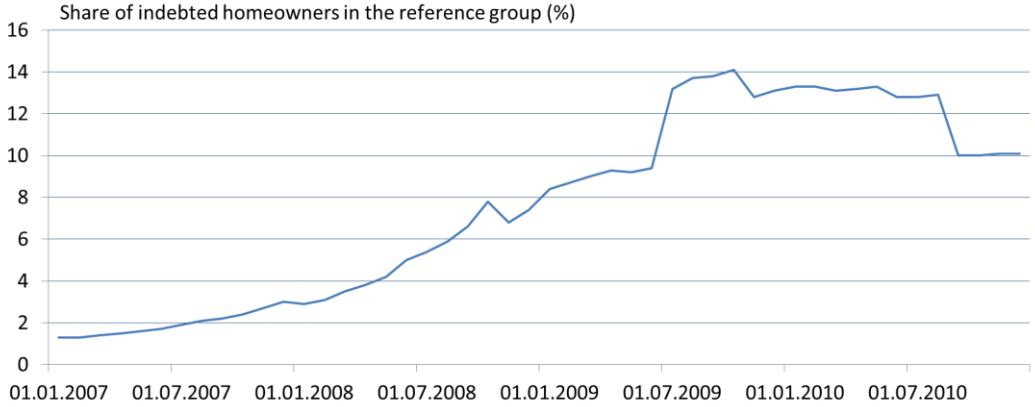
3.3 Homeowners in both financial distress and negative housing equity: the findings

As discussed in Section 3.1, households in financial distress have various methods of easing their financial burden and are not always in serious risk of default. However, households' possibilities to escape from distress by selling their properties or negotiating debt restructuring are diminished if they are simultaneously in distress and negative housing equity. Hence in order to estimate the size of the group in greatest danger of default, we assess the share of households that are in both financial distress and negative equity.

As with other measures of financial vulnerability, the share of homeowners in both financial distress and negative housing equity rose sharply over the reference period. At the beginning of 2007, only 1.3 per cent of indebted homeowners were estimated to be in this vulnerable group. This share began to escalate shortly thereafter, rising to almost 8 per cent by

Figure 7

Share of indebted homeowners in both financial distress and negative housing equity[1]



1. Share of homeowners with both a negative financial margin (when the 60 per cent buffer is taken into account) and in negative housing equity, i.e. with outstanding balance on their mortgages according to constructed payment profiles for the baseline scenario exceeding the value of their dwellings according to constructed housing wealth. The baseline scenario allows for explicit debt restructuring measures and recalculation of foreign-currency denominated mortgages.

Source: Ólafsson, T. T. and K. Á. Vignisdóttir (2012). Households' position in the financial crisis in Iceland: Analysis based on a nationwide household-level database. Central Bank of Iceland Working Paper No. 59.

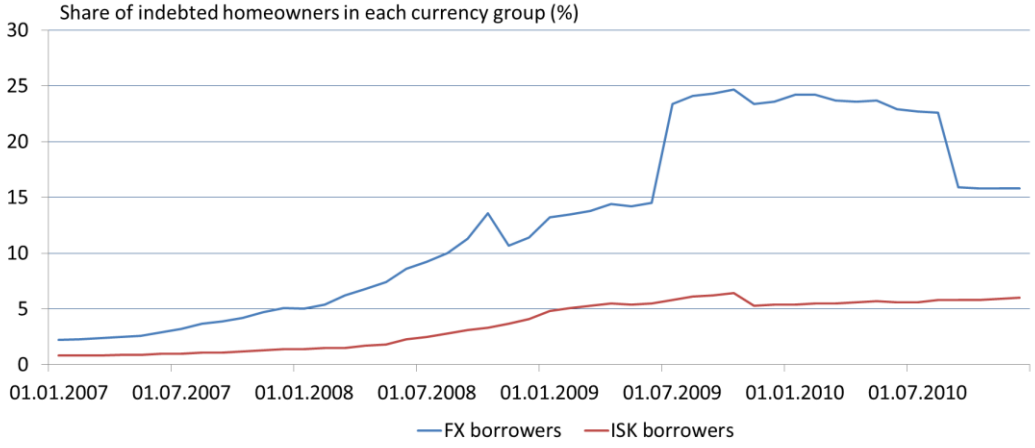
the time of the banking collapse. It then peaked at 14 per cent in October 2009 and had fallen to approximately 10 per cent by the end of 2010. This corresponds to 7 per cent of all homeowners (indebted and debt-free) being in this vulnerable position. The recalculation of foreign-denominated loans managed to reduce this group by roughly 3 percentage points (Figure 7).

As expected, lower-income homeowners were relatively more likely to be in both financial distress and negative housing equity throughout the four-year period. In fact, the two lowest income quintiles follow a similar path, where the share of homeowners with both payment and debt difficulties is estimated to have risen from around 2½ per cent in January 2007 to 17-19 per cent in December 2010. The second highest income quintile, however, developed broadly in line with the entire reference group, except that the share in both distress and negative equity at the end of the period is estimated at almost 8 per cent, which is lower than the share for the entire group. In December 2010, 55 per cent of homeowners both in financial distress and negative housing equity came from the middle and second-lowest income groups, whereas 20 per cent belonged to the lowest income quintile and 5½ per cent came from the highest income quintile.

By these measures, homeowners in the second-highest income quintile benefitted the most by the recalculation of foreign-denominated loans, with the share of homeowners in both financial distress and negative equity falling by 4 percentage points. The corresponding reduction was estimated at 2.8 percentage points in the highest income quintile and 3 percentage points in the middle-income quintile. It is noteworthy that the share of homeowners in the lowest-income quintile declined by only 0.9 percentage points due to the recalculation, a further indication that lower-income homeowners were less likely to have foreign-denominated debt than those with higher income.

Figure 8

Share of indebted homeowners in both financial distress and negative housing equity by debt currency-denomination[1]



1. Share of indebted homeowners in each currency group with both a negative financial margin and in negative housing equity in the baseline . The baseline scenario allows for explicit debt restructuring measures and recalculation of foreign-currency denominated mortgages.
Source: Ólafsson, T. T. and K. Á. Vignisdóttir (2012). Households' position in the financial crisis in Iceland: Analysis based on a nationwide household-level database. Central Bank of Iceland Working Paper No. 59.

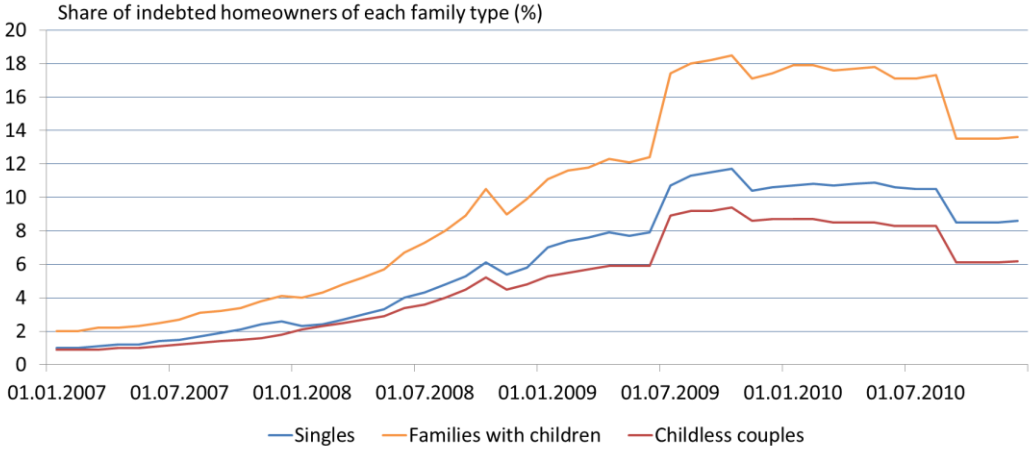
The currency-denomination of debt plays a crucial role in whether homeowners are simultaneously in payment difficulties and negative housing equity. The share of those homeowners that had foreign-denominated debt of some kind and were in both financial distress and negative equity rose from just over 2 per cent in January 2007 to almost 23 per cent in August 2010, before the recalculation reduced it to approximately 16 per cent. Therefore, a large majority of homeowners in severe payment and debt troubles had some kind of foreign-denominated debt. Homeowners that had ISK-denominated debt only were in a much less vulnerable position, as only 6 per cent of them were likely to be in both financial distress and negative equity at the end of 2010, up from just shy of 1 per cent four years earlier (Figure 8).

When the results are viewed by family type, they confirm previous findings that families with children are most likely to experience payment and debt problems, as they are often buying their first apartment, are highly indebted, and have relatively high necessary living expenses. Only 2 per cent of families with children were in both financial distress and negative equity in January 2007. The share began to rise at that time and peaked at 18½ per cent in October 2009, before payment smoothing of indexed ISK mortgages began. In December 2010, around 13½ per cent of families with children were assessed to be in distress and negative housing equity, almost 4 percentage points lower than before foreign-denominated loans were recalculated. In comparison, 8½ per cent of singles and over 6 per cent of childless couples fell into this category at the time (Figure 9). Therefore, at the end of 2010, roughly 57 per cent of households in both payment and debt troubles are families with children, while childless couples represented 17 per cent and singles 26 per cent.[123]

[123] The possibility that the share of singles in financial distress is overestimated is less important in this case, as only homeowners are included.

Figure 9

Share of indebted homeowners in both financial distress and negative housing equity by family type[1]



1. Share of homeowners of each family type with both a negative financial margin and in negative housing equity in the baseline . The baseline scenario allows for explicit debt restructuring measures and recalculation of foreign-currency denominated mortgages.

Source: Ólafsson, T. T. and K. Á. Vignisdóttir (2012). Households' position in the financial crisis in Iceland: Analysis based on a nationwide household-level database. Central Bank of Iceland Working Paper No. 59.

3.4 Characteristics of households in financial difficulties

One of the main purposes of our analysis is to shed light on the characteristics of vulnerable households. Our results indicate that distress is inversely related to income and age, that a larger share of families with children are in distress compared to childless households, and that the share of FX borrowers in distress is roughly twice as high as that among ISK borrowers. On the other hand, negative housing equity was more common among high-income households than low-income ones, but as in the case of distress, the share in negative housing equity was higher among families with children than among childless households.

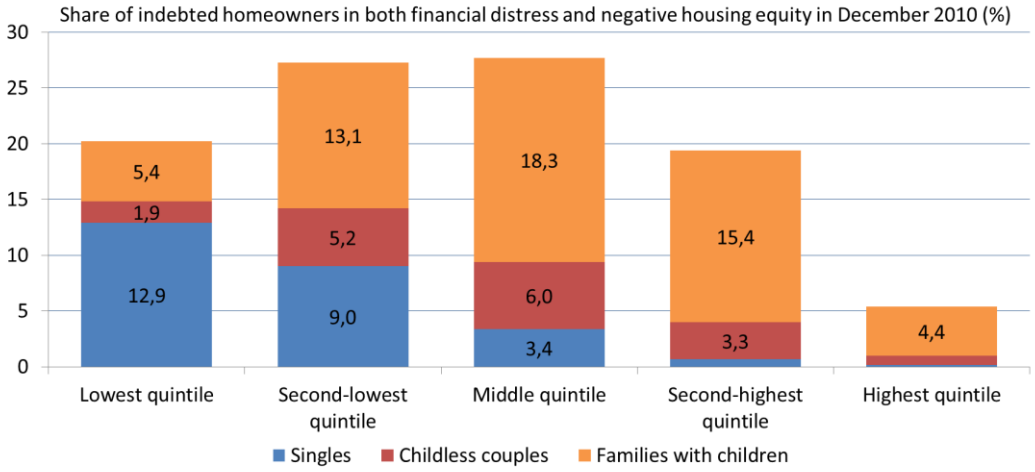
If we examine the composition of households in distress at the end of the period, simultaneously across both income quintiles and different family types, we find that 37 per cent of distressed households at year-end 2010 were low-income singles[124], while roughly a third were middle-income families with children. However, almost half of homeowners in negative housing equity are high-income nuclear families, while one in six are low-income singles.[125] More interestingly, when we turn to the composition of the most vulnerable households being simultaneously in distress and in negative housing equity at year-end 2010, two groups stand out. On the one hand, just shy of 47 per cent of them were middle-income families with children, of which two-thirds were FX borrowers. On the other hand, roughly 22 per cent were low-income singles, that were split evenly between being FX and ISK borrowers (Figure 10).

[124] It should be noted that 11 per cent of households in distress were singles in the 18-24 age group who, in many cases, could actually still be living at home with their parents.

[125] We use the term nuclear family for all households consisting of single parents, couples without children, and couples with children.

Figure 10

Composition of homeowners in financial distress and negative housing equity by income and family type



Source: Ólafsson, T. T. and K. Á. Vignisdóttir (2012). Households' position in the financial crisis in Iceland: Analysis based on a nationwide household-level database. Central Bank of Iceland Working Paper No. 59.

An analysis of *debt-at-risk* - i.e., the share of total debt held by households in distress across different types of debt - reveals that distressed households hold an unusually large share of motor vehicle debt. Motor vehicle debt-at-risk peaked at almost 54 per cent in October 2009 and is assessed to have measured 37½ per cent at year-end 2010, or almost twice the relative size of the group of debtors concerned. Mortgage debt-at-risk aligns more closely with the size of the distressed group, as these 20 per cent of households held 25½ per cent of total mortgage debt at year-end 2010. Overall, debt-at-risk measured 26 per cent at that time, after having peaked at 37½ per cent.[126] This implies that debt-financed motor vehicle purchases played an important role in bringing households into distress. In December 2010, almost one out of every six distressed household had more than one such loan.

3.5 International comparison

How does the financial position of Icelandic households compare to that of households in other countries hit by the global crisis or to earlier crisis episodes? International data on the extent of households' financial difficulties is scarce, and a comparison with data from individual countries can often be problematic due to differing definitions and metrics regarding households' vulnerabilities. Our preferred method of measuring financial distress is based on the financial margin analysis, but in Ólafsson and Vignisdóttir (2012) we also provide evidence based on debt service ratios. In this section, we provide some international comparison on the extent of households' financial difficulties, with a focus on evidence from micro data. First, we compare households' position in 2007, before the global financial crisis entered panic stage.

[126] The implications of these results for financial stability are not straightforward as the three large commercial banks received deep discounts on their assets, among those were household loans. Roughly 20 per cent of the book value of household loans from the three large banks and Housing Financing Fund were non-performing at year-end 2010, down from a peak of roughly 30 per cent.

Second, we provide some evidence on the situation at the end of our reference period in 2010. Third, we compare the evolution of financial distress in Iceland in the current crisis to developments in the Norwegian banking crisis in the late 1980s and early 1990s.

Our results indicate that, on average, roughly 14 per cent of indebted Icelandic households were in financial distress in 2007; the share rose from 12½ to 16½ per cent over the course of the year. According to survey data from Norges Bank, a similar share, or approximately 11½ per cent, of indebted Norwegian households had negative financial margins in 2007. Our results also indicate that, on average, roughly 16 per cent of indebted households in Iceland had to allocate more than 40 per cent of their disposable income to total debt payments in 2007. The share was only a little lower in the US, or 14.7 per cent, according to survey data (Bucks et al., 2009). We can also compare households' debt service burden in Iceland and Canada. The only caveat is that research within the Bank of Canada tends to focus on the share of households that must use more than 40 per cent of their gross income on debt payments, while we use disposable income. However, based on the assumption that disposable income averages around 75 per cent of gross income, the Bank of Canada threshold corresponds to roughly 53 per cent on our scale. Roughly 4 per cent of indebted Canadian households had such a high debt service ratio in 2007 (Faruqui, 2008), while, on average, just shy of 12 per cent of indebted Icelandic households had a total debt service ratio that exceeded 53 per cent at that time.

These results regarding households' position in 2007 indicate that the share of Icelandic households with either a debt service burden exceeding common threshold limits or negative financial margins was only a bit higher than in Norway and the US, while the position of Canadian households seems to have been considerably stronger. Of course, these figures do not capture possible underlying vulnerabilities such as those reflected in the composition of liabilities, which can lead to dramatic changes in households' debt service burden in the event of adverse shocks.

The effects of the global crisis have been evident in an overall decline in asset prices, a contraction in consumption, a rise in unemployment, and a surge in non-performing loans and incidence of negative housing equity, as is discussed in Section 1. A comparison of non-performing loans across countries can therefore provide some evidence of the effects of the crisis. Non-performing mortgages as a share of total mortgages outstanding at year-end 2010 measured roughly 15 per cent in Iceland, 7½ per cent in the US, 6 per cent in Ireland, 2½ per cent in Spain, 2 per cent in the UK, and ½ per cent in both Austria and Canada (IMF, 2012b). This implies that payment difficulties are more widespread in Iceland than in most, if not all, other advanced economies. However, while households' financial position is improving in Iceland, it is still deteriorating in some other countries – Ireland, for instance. Hence it is interesting that, at year-end 2010, a similar share of indebted households seems to be likely to have experienced both payment and debt problems in Iceland and Ireland (Kennedy and Calder, 2011).

The incidence of negative housing equity in Iceland is also high in an international context. Our results indicate that 37½ per cent of indebted homeowners in Iceland were underwater at year-end 2010, compared to 31 per cent in Ireland, 23-28 per cent in the US in

2011, and 7-11 per cent in the UK in 2009 (Kennedy and Calder, 2011; CoreLogic, 2011; Gittelsohn, 2011; Hellebrandt and Kawar, 2009). This is unsurprising in light of the combined effect of a drop in house prices and an increase in debt levels due to indexation to the consumer price index and foreign currencies in Iceland.

The Nordic banking crises in the late 1980s and early 1990s provide an interesting historical comparison to the crisis in Iceland, as well as for the global crisis in general. Norway, Sweden and Finland are small, open economies that underwent a boom-bust cycle where financial deregulation, rapid bank expansion, and low real after-tax interest rates contributed to strong credit and house price bubbles, as well as large increases in aggregate demand and accompanying current account deficits. The Norwegian crisis began in 1988, when a cyclical economic downturn went hand-in-hand with some small bank failures; the crisis became systemic in 1991 but was more or less over in late 1993. The share of Norwegian households in distress (i.e., with a negative financial margin) was higher in the run-up to the crisis than what we assess for Iceland, but the two crises' peak level of distress is almost identical at 27½ per cent. Higher after-tax real interest rates, a slowdown of income growth, rising unemployment, and declining asset prices all contributed to increased distress among Norwegian households following the boom years in the mid-1980s. For instance, higher nominal interest rates, a decline in inflation, and changes to the tax system caused the real after-tax interest rate for an average Norwegian household to increase from zero in 1987 to more than 7 per cent in 1992 (Norges Bank, 2004).

It is interesting to compare the pace of the decline in distress in the two crises episodes. It took roughly 7 years for the share of indebted households in distress to fall to 20 per cent in Norway, while the same decline was achieved in just 15 months in Iceland according to our analysis, although in practice it may have taken a bit longer due to the implementation of the recalculation of foreign-denominated loans. No household debt restructuring measures were introduced in the Norwegian banking crisis, but the welfare system provided important support to households' debt servicing capacity (IMF, 2012b). Hence it is interesting that our alternative scenario, where debt restructuring measures and the recalculation of foreign-denominated loans are excluded, indicates that the decline in distress over the aforementioned 15-month period would only have measured 2.8 percentage points, instead of 7½ percentage points in the baseline scenario. The debt restructuring measures have therefore played an important role in the relatively more rapid decline in distress among Icelandic households compared to that achieved in the Norwegian banking crisis.

4 Interpretation of the findings

We interpret our results such that households' rapidly deteriorating financial position in the crisis was caused by the build-up of vulnerabilities in the prelude to the crisis and the large shocks suffered by households, particularly the currency depreciation and the resulting surge in inflation. According to aggregate data from the IMF, the rise in household debt in the run-up to the crisis was not exceptional in Iceland (Figure 3.1 in IMF, 2012b), but Icelandic households were nevertheless among the most indebted household sectors at the outbreak of the global

crisis. Furthermore the composition of aggregate debt changed over time and vulnerabilities were exacerbated by the fact that the share held by low-income households is rather high in international comparison.

The accumulation of household debt in the run-up to the financial crisis in Iceland can be split into two phases. The former began in August 2004, when the newly privatised and lightly regulated commercial banks responded to looser lending standards at the state-owned Housing Financing Fund by entering the mortgage market with full force, empowered by enhanced access to foreign funding and increased balance sheet capacity. A massive credit boom, especially in indexed ISK-denominated mortgages, followed. During this phase, many Icelandic households opted to refinance existing debt at lower interest rates and with extended maturities while taking on new loans, so that their debt service did not rise in tandem with increased indebtedness, especially not when measured against rapidly rising disposable income. The credit expansion lost momentum in early 2006 during the so-called mini-banking crisis, when concerns escalated over mounting evidence of overheating in the Icelandic economy and the banks' business model, especially their high dependency on short-term market funding and their interconnectedness (cf., Fitch 2006, Danske Bank, 2006, and Moody's, 2006). As the banks' access to European debt markets grew tighter, they slowed the pace of new lending to households and the economy showed signs of adjustment as domestic demand eased. Unfortunately, at least in hindsight, concerns over the banking sector eased in the latter half of 2006, especially after an influential report on financial stability in Iceland by Mishkin and Herbertsson (2006) and the successful launch of foreign deposit accumulation. Furthermore, hopes of continuing strong output growth were boosted in early 2007 by indications of further large investment projects in aluminium production and easing of fiscal policy in the run-up to parliamentary elections. Hence any signs of adjustment in the economy soon disappeared, and a second phase of rapid household credit expansion began in early 2007.

We find that the debt accumulation taking place in the second phase of the credit boom in 2007 and 2008 was especially unfortunate, as foreign-denominated loans became more popular and these risky loans were increasingly granted to low- and middle-income households, many of which were already in financial distress at the time of loan issuance (Ólafsson and Vignisdóttir, 2012). Hence households became more exposed to adverse shocks and it is safe to state that such shocks did indeed materialise.

It is beneficial to get a sense of the size of the shocks suffered by households. From peak to trough, the currency depreciation measured 60 per cent (using our constructed household debt exchange rate index), the rise in the consumer price index 37½ per cent, the decline in real wages 13½ per cent, the increase in unemployment 8½ percentage points, and the fall in real house prices 34 per cent over this four-year period. These shocks caused large increases in households' debt service burden, debt levels, and living costs, as well as deep declines in housing wealth and real disposable income.

The currency depreciation and the accompanying rise in inflation on top of the large debt accumulation were the principal forces behind the increased frequency of payment difficulties. FX borrowers were the first to feel the impact of the currency depreciation through a rapid increase in their debt service burden and debt position, which caused a sharp rise in the

share of households with foreign currency-denominated debt in financial distress. The increase in payment difficulties among ISK borrowers was more subtle but nevertheless substantial. This is unsurprising, given that the shock these borrowers experienced was smaller and its effects on debt service burden were spread out over the remaining maturity of their loans. Both FX and ISK borrowers' capacity to withstand the rise in debt service was undermined as real wages declined, employment decreased, and unemployment rose. Real wages fell to a low in May 2010 but increased by 3½ per cent in the two following months, when the deferred wage increases resulting from the collective bargaining agreement signed in June 2009 took effect. Real wages rose by a total of 7 per cent from May to December 2010 and were at that time 7½ per cent below their January 2008 peak.

Short-term domestic interest rate developments seem to have limited direct effects on the extent of financial distress among Icelandic households. This stands out in stark contrast to households in many other advanced economies, which have benefited greatly from the monetary policy accommodation taking place over this four-year period. These differences reflect the different composition of households' debt and the nature of loan contracts. Nevertheless, monetary policy has important effects on households' position, through its impact on the exchange rate and inflation, both of which are among the main determinants of households' debt service burden and their overall debt position. Furthermore, the capital controls introduced during the crisis were crucial in preventing further currency depreciation, which would have increased households' financial difficulties considerably.

The government had limited fiscal space to counteract the effects of the crisis through increased fiscal expenditures, public investment, or tax cuts despite having a strong pre-crisis fiscal position. On the contrary, starting in mid-2009 the government introduced strict austerity measures to ensure public debt sustainability. Nevertheless, important changes were made to the tax system and benefit schemes over the period, where the tax burden of high-income individuals was increased and mortgage interest subsidies were temporarily raised. Hence, the austerity measures were designed to shield the groups most likely to be in financial distress from taking on a large share of the increased tax burden.

The increase in the number of households in negative housing equity is driven by two main factors. On the one hand, households' debt levels rose sharply as a result of the debt accumulation taking place in the run-up to the banking collapse and the effects of the currency depreciation and the associated rise in inflation, through the widespread indexation of debt to the consumer price index and exchange rates. Owing to the combined effects of these factors, the total mortgage debt of households in the reference group increased by 75 per cent from January 2007 to its peak, before the recalculation of foreign-denominated loans. On the other hand, the decline in house prices also played a part in the increased incidence of negative housing equity. Total nominal gross housing wealth of all homeowners in the reference group declined by 14 per cent from peak to trough over the four-year period. Hence it is clear that the increase in mortgage debt has been the main driving factor behind the rise in the number of underwater homeowners.

What are the policy implications of our findings? Clearly many households took on too much risk and overextended their debt service capacity in the run-up to the banking collapse. It

is likely that many households, especially younger ones, overestimated their future income in light of the rapid increase in income during the upswing. In some cases, borrowers took large risk intentionally, but it is likely that many households neither understood the costs associated with borrowing nor were in a position to assess the risk associated with different forms of loans, especially not the wide variety of new types of financial instruments. Research has confirmed that financial literacy is severely lacking in Iceland, especially among low-income households and those in the youngest and oldest age groups (Ministry of Business Affairs, 2009). Hence a clear policy implication from observed borrowers' behaviour in the escalation of households' financial vulnerability is the need to support education in financial literacy, particularly in schools, where this form of education has been more or less disregarded for years.

In our view, the main reason for the build-up of households' financial weaknesses nevertheless lies in the changed behaviour of lenders. After all, financial institutions' main role is to be efficient intermediaries of funds between savers and borrowers. This involves screening and monitoring borrowers in order to make enlightened decisions on who should be granted loans, as well as providing guidance on what type of loan is best suited for each borrower. This role was neglected by Icelandic financial institutions in their race for balance sheet growth and profits. Increased balance sheet capacity made the banks more willing and temporarily able to take on exposures and increase their provision of credit both at home and abroad, especially in foreign currency. However, the financial institutions' infrastructure was simply incapable of sustaining strong credit quality given the pace of credit expansion.

Despite the discussion above, our view is that the role of preventing the build-up of households' balance sheet weaknesses cannot rest solely on financial institutions, as their incentives and those of their borrowers and society as a whole will often diverge, at least in the short run. In the end, policy-makers must try to limit the escalation of financial imbalances. This was not done in Iceland during the upswing. On the contrary: various measures were taken to fuel credit expansion and domestic demand, and monetary policy was overburdened with fighting the overheating, all of which led to high interest rates, which again made foreign-denominated borrowing seem an attractive option to many households. Economic policy must aim for overall macroeconomic stability and should not overextend the economy with demand-supporting policies that make the economy highly-dependent on foreign funding and hence vulnerable to financial crises. Rapid household credit expansion should be seen as an indicator of mounting vulnerability in the household sector, even when income and asset prices are rising in tandem as those increases can turn out to be unsustainable under more adverse circumstances as in the case of Iceland. Furthermore, policy makers must look at the composition of household debt and assets, not just their aggregate level. This involves analysing how sensitive households' debt service burden is to adverse shocks, what possibilities are available to restructure the debt in the case of shocks, and to what extent households could deleverage through liquidating assets if needed. This type of analysis calls for access to micro data on households' financial position. What looks sustainable on an aggregate level can prove to be highly unsustainable once a more detailed overview emerges.

Iceland has been praised for a bold policy response to households' financial difficulties in the aftermath of the crisis (cf., IMF 2012a,b). More progress has been made than many

expected, and indeed, household deleveraging has been more rapid here than in other crisis episodes. We find that debt relief measures - for instance, write-offs due to court decisions declaring exchange rate-linked loans illegal and debt rescheduling in the form of payment smoothing - have enabled thousands of households to escape from financial distress. In two years, Iceland has achieved a decline in financial distress similar to that achieved in seven years in Norway following the banking crisis there. Despite this impressive progress, we remain critical of measures such as the 110 per cent option, which prioritises reducing the debt overhang instead of financial distress that is more likely, in our view, to lead to payment difficulties and personal bankruptcy.[127] We are also highly critical of repeatedly proposed across-the-board write-offs in discussions on these matters. Distressed households have only received a small share of the write-offs due to the 110 per cent option and of the special interest rebates financed by a special bank tax. The distribution of across-the-board write-offs would be even more skewed and still leave a large majority of distressed households still in distress, while exhausting the capacity to assist those households further. The emergency bank restructuring measure applied in Iceland during the crisis provided domestic financial institutions with valuable capacity for debt restructuring, and it is important that it be used efficiently to reduce financial distress, thereby reducing costly defaults.

5 Conclusions

The goal of this paper is to portray how households' financial position evolved in the run-up to and aftermath of the financial crisis in Iceland, and how it was affected by policy and legal interventions. We do this by designing and collecting an extraordinary detailed micro database with information covering nearly all individual loans and households within the country and then utilising the information to build profiles for debt service, outstanding balance, disposable income, living expenses, and housing wealth enabling us to capture the key dynamics of the crisis. To the best of our knowledge, no similar study of households' financial position has been carried out to date. A major benefit of our analysis is that it allows us to uncover a more complete account of both the build-up of households' balance sheet weaknesses, the devastating consequences of adverse shocks, and the mitigating effects of debt relief measures.

The picture that emerges from our analysis is of a household sector that became increasingly vulnerable to adverse shocks in tandem with strong credit expansion and unfortunate changes to the composition of both the type of household debt and income distribution of borrowers. We reveal evidence of quite extensive financial distress already in early 2007 reflecting the effects of the currency depreciation and associated rise in inflation taking place during the so-called mini crisis in 2006. At the time of the banks' collapse in

[127] In 2011 Icelandic homeowners could apply for a reduction of their mortgage debt if it exceeded 110 per cent of the underlying property value. Limits were set on maximum nominal write-offs and other assets could be taken into account and lead to reduced write-offs. Furthermore, a special interest rebate was paid out amounting to roughly 0.6 per cent of mortgage debt and was independent of households' income. We assess the distribution of the special interest rebates and the write-offs due to the 110 per cent option, as well as possible write-offs in relation to a hypothetical 20 per cent across-the-board principal reduction of indexed mortgages, and their effects on the degree of financial distress in Ólafsson and Vignisdóttir (2012).

October 2008, when most of the adverse shocks to households' debt service had already occurred, the share of households in distress had nearly doubled and the number of acutely distressed households almost quadrupled, since early 2007. Debt relief measures in the form of forbearance efforts, debt rescheduling, and court decisions, as well as rising income, managed to reduce the extent of financial distress to roughly 20 per cent by year-end 2010. Financial distress is found to be inversely related to income and age, as well as being higher among families with children and those with foreign-denominated debt than among childless households and those with ISK-denominated loans only. Roughly a third of distressed households are found to be in the highly vulnerable position of being simultaneously in negative housing equity and financial distress. Middle-income families with children, most of which have foreign-denominated loans, and low-income singles are found to be especially vulnerable.

Looking forward, we find that it is important to adjust the current framework for debt restructuring and manage expectations more efficiently with regard to what government-initiated measures can hope to achieve. We emphasise the need for tailor-made solutions for acutely distressed households, as no realistic across-the-board measure is going to enable them to escape from distress.[128] This involves individually appropriate combinations of principal and interest rate reductions, maturity extensions, and temporary forbearance efforts. Both creditors and borrowers must have a strong incentive to find such a solution where possible. Families with children are the majority of the acutely distressed group, and both lenders and the households themselves should prioritise efforts to seek a solution where possible. Financial institutions should not be reluctant to make use of reasonable principal reductions for individual distressed households where needed. They should continue to speed up decentralised debt restructuring. It is also important to avoid providing acutely distressed households with disincentives to participate in debt restructuring by continuously discussing unrealistic across-the-board measures.

We also suggest that the government should make adjustments to various benefit schemes in order to target households that can escape financial distress through such measures. This could include combined changes to child benefits and general mortgage interest subsidies, so as to channel them more effectively towards middle-income families with children. Such measures could allow thousands of not-too-acutely distressed households to escape from distress. In the end, future developments will also be highly dependent on the pace of economic recovery. Fortunately, economic growth has gained momentum, employment has increased, and disposable income has risen.

[128] It should be noted, however, that further write-offs due to a likely second round of foreign-denominated loan recalculation in light of recent and upcoming Supreme Court judgements is expected to provide some FX borrowers with further debt relief. The extent of these write-offs is, however, uncertain at the time of writing.

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CHAPTER 5

CROSS-BORDER CREDIT INTERMEDIATION AND DOMESTIC LIQUIDITY PROVISION IN A SMALL OPEN ECONOMY

Cross-border credit intermediation and domestic liquidity provision in a small open economy*

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Abstract

This paper develops a small open economy model with a sophisticated credit market set-up where global and domestic liquidity is intermediated to the corporate sector through two financial intermediation processes. On the one hand, investment banks intermediate cross-border credit through interlinked debt contracts to entrepreneurs and, on the other hand, commercial banks intermediate domestic savings to liquidity constrained final good producers. Both processes are needed to facilitate the use and development of key inputs in aggregate production. The richness of the credit market framework allows the model to qualitatively produce procyclical investment bank leverage dynamics, global liquidity spillovers, domestic money market pressures, and multifaceted macrofinancial linkages through which shocks propagate across the two financial intermediation processes, affecting interest rate spreads and balance sheets, as well as the real economy through investment and working capital channels. Furthermore, empirical motivation for modelling interactions between cross-border and domestic credit developments is provided by utilising banking statistics from the Bank of International Settlements for a sample of fifty countries.

Keywords: financial frictions, cross-border banking flows, macrofinancial linkages, financial intermediation, working capital, credit contracts.

JEL classification: E3, E22, E44, F34, F41, G1.

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1 Introduction

This paper develops a small open economy dynamic stochastic general equilibrium (DSGE) model with a rich credit market set-up where investment banks and commercial banks intermediate global and domestic liquidity to the corporate sector through two financial intermediation processes. In particular, global liquidity is intermediated by investment banks to entrepreneurs through interlinked credit contracts, that allow for asymmetric information and bankruptcies, which give rise to domestic and global interest rate and balance sheet relations, through which the cross-border financial intermediation and the real economy interact. On the other hand, commercial banks intermediate domestic liquidity to cash-in-advance constrained final good producers. Hence, production within the small open economy depends on both financial intermediation processes enabling funding and development of key production inputs.

The objective of this paper is to shed light on the interactions between cross-border banking flows, domestic credit and liquidity extension to corporates, and aggregate production in small open economies. In particular, with regard to the multifaceted macrofinancial linkages through which various financial shocks work their way across balance sheets and borders, the real economy, and the financial sector within an advanced small open economy.

In the aftermath of the recent financial crisis, there has understandably been renewed attention to global liquidity and cross-country spillovers. This holds both with regard to gross capital flows in general (cf. Forbes and Warnock, 2012, Broner et al., 2013, and Obstfeld, 2015), and cross-border banking flows, in particular. This paper is more closely related to the latter category. A common theme of interest in the rapidly growing literature on cross-border banking is to uncover the main driving factors of cross-border flows. Bruno and Shin (2015a) and Hofmann et al. (2016) emphasise the role of US investment banks' leverage in determining the ease of funding in global markets and the capacity of currency movements to shift the supply between countries through the so-called risk-taking channel of currency appreciation. Others have pointed towards other important driving factors of the supply of cross-border funding (cf. Rey, 2013, Cerutti et al., 2014), echoing earlier debates on the importance of push and pull factors in determining capital flows to emerging markets (cf. Calvo et al., 1993, 1996).

The model developed here neither attempts to account for the determinants of global liquidity nor does it allow exchange rate fluctuations to play a role. Instead, the emphasis is on providing a general equilibrium framework that is able to capture important interlinkages, for instance due to investment banks' procyclical leverage dynamics (Adrian and Shin, 2009, 2010, 2011) between cross-border credit intermediation, domestic liquidity provision, and the real economy. This represents an uncommon endeavour as the modelling approach with regard to cross-border banks has mainly consisted of deriving partial equilibrium models (cf. Bruno and Shin, 2015a and Hofmann et al, 2016). In addition, I provide empirical motivation for modelling interactions between cross-border and domestic credit and liquidity developments by utilising banking statistics from the Bank of International Settlements for a sample of fifty countries.

A second strand of literature that this paper is related to is the financial accelerator literature, especially its segment that makes use of Townsend's (1979) costly state verification framework that was first introduced into a general equilibrium model by Bernanke et al. (1999).

This literature traditionally emphasises the role of financial frictions related to credit demand due to balance sheet constraints faced by non-financial borrowers (cf. Bernanke and Gertler, 1989, Kiyotaki and Moore, 1997, Carlström and Fuerst, 1997, and Bernanke et al., 1999). The key ingredient in these models is the so-called external finance premium which lenders charge non-financial borrowers due to asymmetric information and bankruptcy cost. This premium depends inversely on the strength of the borrowers' balance sheet as lenders' potential losses are greater when the borrowers' net worth and collateral values are lower.[129]

A shortcoming of traditional financial accelerator models is that they assume that firms effectively borrow directly from households and treat financial intermediaries simply as a veil and thereby deem them to play a passive role in business cycle dynamics. The recent global financial crisis, however, has provoked renewed interest into the importance of financial intermediaries in macroeconomic dynamics, echoing early advocates of important role for banks in macroeconomic models (cf. Gurley and Shaw, 1955, Brunner and Meltzer, 1963, and Tobin and Brainard, 1963). In some ways, the financial accelerator extends naturally to financial intermediaries, which can face constraints on their ability to obtain funds, but there are important differences in their balance sheet composition that need to be taken into account, for instance, with regard to their reliance on leverage.

Hirakata et al. (2009, 2011, 2013), and Ueda (2012) expand the Bernanke et al. (1999) framework by introducing credit constrained financial intermediaries, in addition to credit constrained entrepreneurs. Hence, their credit contract framework uses the costly state verification structure at two stages in the credit intermediation and can therefore account for a wider variety of macrofinancial linkages than the traditional models.

Finally, this paper is related to the literature on working capital in macroeconomic models, for instance, Christiano et al. (1995), Christiano, Motto, and Rostagno (2010), Fernandez-Corugedo et al. (2011), and Kim and Shin (2013).

The model developed here is a small open economy DSGE model where there are two financial intermediation processes with the former applying the Hirakata et al. (2009) framework of interlinked credit contracts to cross-border credit intermediation by investment banks, while the latter involves commercial banks' domestic liquidity provision to fund working capital. The model will be shown to be qualitatively capable of producing important macrofinancial behaviour, such as procyclical leverage of investment banks, domestic money market pressures, and global liquidity spillovers. The model represents a more complicated financial intermediation structure than in both Hirakata et al. (2009), which has no role for working capital, domestic money market pressures, nor global liquidity shocks, or the abovementioned models with working capital, although they include nominal rigidities.

The rest of the paper is structured as follows: Section 2 provides some empirical motivation for modelling the interactions between cross-border and domestic credit developments. The model is developed in Section 3 with special emphasis on the two financial intermediation processes in the credit market. Section 4 describes the parameterisation used and presents the results of economic analysis of various shocks. Section 5 concludes.

[129] Gertler, Gilchrist and Natalucci (2007), Devereux et al. (2006), Elekdag et al. (2004, 2006), Céspedes et al. (2004), and Aghion et al. (2004) extended the traditional financial accelerator framework to the open economy.

2 Empirical motivation

This paper emphases the interactions within the financial system and across to the real economy between cross-border banking flows, domestic credit and liquidity extension, and aggregate production. For motivational purposes, I provide some empirical evidence in this section on cross-border banking flows and domestic credit extension by utilising statistics on international and domestic banking activity.

2.1 The data

My country sample includes forty-three small open economies, in addition to seven large economies. To expose important differences in cross-border and domestic credit developments across different country groups, I divide the sample into groups with regard to income levels, geography, and financial system characteristics (i.e. with regard to whether their financial system is more bank- or market-based, as explained below). Table 1 gives an overview of the country sample and its division into different groups.

My source of data on cross-border credit and banking flows is the Bank for International Settlements (BIS) locational banking statistics, which provide a comprehensive picture of cross-border exposures (i.e. loans, securities, and other claims) for a wide range of countries over a rather long time span. It is compiled following principles consistent with balance of payments and is reported in US dollars. I use the exchange rate adjusted data to capture changes in the actual underlying positions of bank claims rather than effects of exchange rate movements. In particular, I use quarterly data covering the period from 1985Q1-2013Q4.

I compile three different measures of cross-border credit. The first measure is domestic banks' gross cross-border liabilities, which captures the banks' overall reliance on funding from abroad. I follow Borio et al. (2011) and use claims held by rest-of-world against banks in each country as a proxy for countries that do not report to the BIS (with claims on banks being given by the difference between claims on all sectors and claims on non-banks in each county).

The second measure of cross-border credit is domestic banks' net cross-border liabilities, which is given by the difference between cross-border liabilities of banks and their cross-border claims. I only focus on cases where this variable is positive to capture the banks' use of cross-border credit to fund domestic credit extension. Hence, this measure can be referred to as indirect (or domestic bank-intermediated) cross-border credit.

The third measure is direct cross-border credit to domestic non-banks, which represents cross-border claims held by rest of the world on non-banks in each country (including on the government and domestic non-banking financial institutions). The aim is to compare the characteristics of such credit flows that by-pass domestic banks with the aforementioned bank-intermediated cross-border flows.

To capture domestic credit developments, I use the BIS statistics for domestic banks' credit to the non-financial private sector. I follow Borio et al. (2011) and convert the published data to constant 2013Q4 US dollar exchange rate to ease the comparison with cross-border

credit developments. As the BIS domestic credit statistics do not cover as many countries over such a long time span as the cross-border credit data, I focus for the most part on domestic credit developments in advanced small open economies and compare it with the evolution of cross-border bank funding.

I use crisis indicator variables from the Laven and Valencia (2013) database and GDP data from the IMF World Economic Outlook database to highlight developments in the run-up to and the aftermath of some financial distress and GDP contractionary episodes.

Table 1 Country sample

Argentina	Finland	Latvia	Singapore
Australia	France	Lithuania	South Africa
Austria	Germany	Luxembourg	Slovakia
Belgium	Greece	Malta	Slovenia
Brazil	Hong Kong	Malaysia	Spain
Bulgaria	Hungary	Mexico	Sweden
Canada	Iceland	Netherlands	Switzerland
Chile	Indonesia	New Zealand	Thailand
Croatia	Ireland	Norway	Turkey
Cyprus	Israel	Poland	United Kingdom
Czech Republic	Italy	Portugal	United States
Denmark	Japan	Romania	
Estonia	Korea	Russia	

Different country groups

Advanced economies

Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States

Emerging market economies

Argentina, Brazil, Bulgaria, Chile, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Indonesia, Latvia, Lithuania, Malaysia, Malta, Mexico, Poland, Romania, Russia, Singapore, South Africa, Slovakia, Slovenia, Thailand, Turkey

Small open economies

Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Greece, Hong Kong, Hungary, Iceland, Indonesia, Ireland, Israel, Korea, Latvia, Lithuania, Luxembourg, Malaysia, Malta, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, Singapore, Slovakia, Slovenia, South Africa, Sweden, Switzerland, Thailand, Turkey.

Advanced small open economies with bank-based financial systems

Austria, Belgium, Finland, Greece, Iceland, Ireland, Israel, Luxembourg, New Zealand, Norway, Portugal.

Advanced small open economies with market-based financial systems

Australia, Canada, Denmark, Hong Kong, Korea, Netherlands, Sweden, Switzerland.

A few geographical country groups

(i) Central and Eastern European (CAEE) countries: Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Russia, Slovakia, Slovenia; (ii) South-East Asian countries: Hong Kong, Indonesia, Korea, Malaysia, Singapore, Thailand; (iii) Scandinavian countries: Denmark, Finland, Norway, Sweden; (iv) Latin American countries: Argentina, Brazil, Chile, Mexico

Finally, I follow Demirguc-Kant et al. (2013) and use the World Bank Development indicators to construct a financial structure ratio for each country in my sample to split them into countries with market- and bank-based financial systems. The financial structure ratio is given by the mean ratio of private credit (i.e. deposit money bank credit to the private sector) to stock value traded over the sample period (as data availability allows). This categorisation allows me to provide further insight into the interactions between cross-border banking flows and domestic credit extension with regard to the relative importance of the banking system in domestic financial intermediation.

2.2 Cross-border and domestic credit developments in small open economies

Table 2 summaries key properties of the three cross-border credit measures for the whole sample period and for two subsamples, which roughly divide the data into two equally long periods. The former subsample covers the period of global liberalisation of financial markets, beginning in the mid-1980s, as well as the run-up to and aftermaths of financial crises in Scandinavia and East Asia in the 1990s. The latter subsample, however, covers the period leading up to the recent financial crisis and the subsequent years when the crisis unfolded and a weak recovery took place. Key statistics on domestic banks' gross and net cross-border funding, as well as direct cross-border credit to domestic non-banks, are provided for the whole country sample and different country groups, i.e. advanced (also split into bank- and market-based) and emerging market small open economies.

As Table 2 shows, banks in advanced small open economies have increased their cross-border funding more than their emerging market counterparts. This holds particularly for the degree to which banks make use of cross-border liabilities to fund their domestic assets (including credit) although there is evidence of increased tendencies to do the same among emerging market banks in the latter half of the period. Banks' cross-border funding seems to be more volatile (especially net liabilities) than cross-border credit extended directly to domestic non-banks. Finally, banks' overall reliance on cross-border funding seems to have grown more rapidly and be more volatile in bank-based advanced countries than among small open economies that rely to a larger extent on financial markets.

Figure 1 provides a graphical representation of cross-border credit developments in different groups of small open economies over the sample period. The upper-panel shows the expansion of domestic banks' gross and net cross-border liabilities. The prolonged expansion and subsequent deleveraging by emerging market banks in the run-up to and aftermath of the East Asian financial crisis during the 1990s is evident, as well as the even more extreme evolution in advanced economies with regard to the recent global financial crisis. During the recent post-crisis era, banks' cross-border funding recovered swiftly in emerging markets and market-based advanced economies, but continued to contract for years in bank-based advanced economies.

Table 2 Summary statistics for cross-border credit

	Total sample (1985Q1-2013Q4)		First half (1985Q1-1999Q4)		Second half (2000Q1-2013Q4)	
	Mean	St.dev.	Mean	St.dev.	Mean	St.dev.
			Gross cross-border bank funding			
Country sample	0.038	0.044	0.040	0.041	0.035	0.059
Advanced SOEs	0.042	0.046	0.042	0.047	0.040	0.051
Emerging market SOEs	0.025	0.059	0.019	0.029	0.037	0.074
Advanced bank-based SOEs	0.049	0.062	0.044	0.047	0.054	0.074
Advanced market-based SOEs	0.036	0.046	0.038	0.050	0.032	0.047
			Net cross-border bank funding			
Country sample	0.034	0.068	0.031	0.069	0.042	0.088
Advanced SOEs	0.044	0.092	0.050	0.093	0.042	0.093
Emerging market SOEs	0.003	0.123	0.001	0.062	0.035	0158
Advanced bank-based SOEs	0.050	0.118	0.047	0.146	0.056	0.115
Advanced market-based SOEs	0.050	0.136	0.045	0.141	0.057	0.128
			Direct cross-border credit to domestic non-banks			
Country sample	0.038	0.038	0.038	0.038	0.038	0.045
Advanced SOEs	0.039	0.039	0.034	0.033	0.051	0.048
Emerging market SOEs	0.032	0.047	0.033	0.050	0.021	0.059
Advanced bank-based SOEs	0.045	0.049	0.042	0.036	0.056	0.060
Advanced market-based SOEs	0.037	0.040	0.032	0.041	0.047	0.046

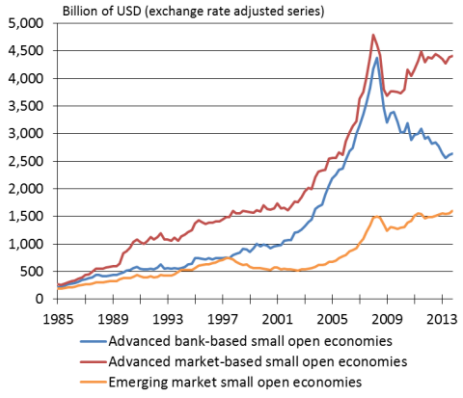
The lower-panel of Figure 1 shows cross-border banking for specific geographical groups (1c) and selected individual countries (1d). There is a notable difference in the intensity and volatility of banks' cross-border liabilities developments between different geographical country groups. For instance, South-East Asian countries had just reached their pre-East-Asian-crisis peak in gross cross-border funding when the recent global crisis caused a swift, but short-lived, decline. Central and Eastern European countries, however, experienced an even more rapid increase in the run-up to the recent crisis and gross cross-border banking flows did not stage a lasting recovery during the rest of the sample period.

Figure 1d provides evidence of increased domestic banks' reliance on cross-border funding for domestic credit purposes in the run-up to various financial crises in selected small open economies. Korea is a noticeable example as net cross-border funding increased and subsequently declined during the financial crisis in Japan, the East Asian financial crisis, and the recent global crisis. The increase in net cross-border funding was also dramatic in the case of Ireland and Iceland, with Icelandic banks reaching a net cross-border funding position similar (in US dollars) as banks in Sweden during the country's financial crisis in the early 1990s.[130]

[130] A historical account of Icelandic banks' reliance on foreign funding and its financial and macroeconomic implications is provided in Einarsson et al. (2015, 2016 – i.e. chapters 2 and 3 in this dissertation), as well as in a

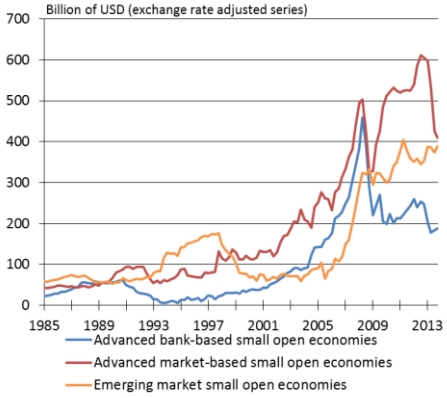
Figure 1 Cross-border banking flows in small open economies[1]

Figure 1a
Gross cross-border funding by domestic banks in 43 small open economies[1]



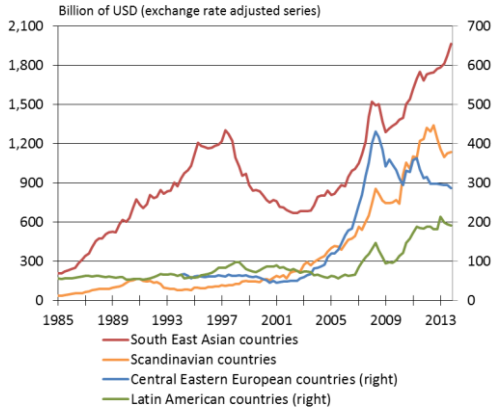
1. Cross-border liabilities of domestically-resided banks in each country. For non-BIS-reporting countries, claims held by rest-of-world against banks in each country is used as a proxy (where claimes on banks are given by the difference between claims on all sectors and claims on non-banks in each county). Countries are bank-based (market-based) if they have below (above) mean values for the World Bank's *Structure* indicator.
Sources: BIS Locational banking statistics, World Bank, own calculations.

Figure 1b
Net cross-border funding by domestic banks in a sample of 43 small open economies[1]



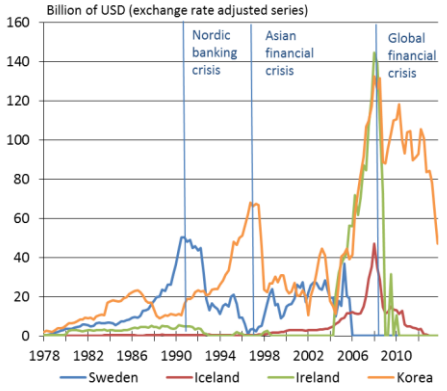
1. Difference between cross-border liabilities of banks and their cross-border claims for countries where the difference is positive. For non-BIS-reporting countries, claimes held by rest-of-world against banks in each country is used as a proxy (where claimes on banks are given by the difference between claims on all sectors and claims on non-banks in each county). Countries are bank-based (market-based) if they have below (above) mean values for the World Bank's *Structure* indicator.
Sources: BIS Locational banking statistics, own calculations.

Figure 1c
Gross cross-border funding by domestic banks in selected country groups[1]



1. Cross-border liabilities of domestically-resided banks in each country. For non-BIS-reporting countries, claims held by rest-of-world against banks in each country is used as a proxy (where claimes on banks are given by the difference between claims on all sectors and claims on non-banks in each county).
Sources: BIS Locational banking statistics, own calculations.

Figure 1d
Net cross-border funding by domestic banks and financial crises in selected countries[1]



1. Difference between cross-border liabilities of banks and their cross-border claims where the difference is positive. For non-BIS-reporting countries, banks' cross- border liabilities are proxied by claims held by BIS-reporting countries on those banks (where claims on banks are given by the difference between claims on all sectors and claims on non-banks) and in a similar fashion, the banks' cross-border claims are proxied by cross-border liabilities of BIS-reporting countries.
Sources: BIS Locational banking statistics, author's calculations.

forthcoming Central Bank of Iceland (2016) report on the capital account liberalisation in Iceland, of which I am the main author.

Figure 2 shows the developments in the three measures of cross-border credit, as well as domestic bank credit to the non-financial private sector in advanced small open economies. The upper-panel provides evidence of contrasting developments in both cross-border and domestic bank credit between the two groups of advanced economies with regard to whether their financial intermediation is chiefly bank- or marked-based. The difference between cross-border banking flows in the two groups was discussed above, but Figure 2 reveals that this distinction also applies to domestic bank credit, which has contracted in bank-based economies but expanded in market-based economies.[131] The figure also implies that there is something special about the part of cross-border credit, which is intermediated by domestic banks, as there is no clear difference between direct cross-border credit developments in the two country groups: in both cases foreign banks' credit extension to domestic non-banks stagnates during the post-crisis era.

The lower-panel of Figure 2 portrays cross-border and domestic credit developments in two prominent examples, Ireland and Korea, with the former belonging to the bank-based group while the latter has a market-based financial system. Domestic banks' cross-border liabilities expanded rapidly in Ireland in the pre-crisis era, to the extent that a considerable net liability position had built-up as result of the banks' use of foreign funds to fuel the ongoing domestic credit boom. What followed was a severe systemic banking crisis with dramatic declines in cross-border banking flows (which were replaced by official flows) and a prolonged and severe contraction in domestic credit and economic activity. Again, the decline in direct cross-border credit to non-banks is less severe compared to cross-border banking flows. Similar developments, although less severe in terms of magnitude and endurance of contraction in domestic credit took place in Korea in the East Asian crisis, but the country managed to escape from experiencing a banking crisis in the recent global crisis (although not a currency crisis), but nevertheless opted to introduce prudential limits on domestic banks' cross-border liabilities (cf. Bruno and Shin, 2014).

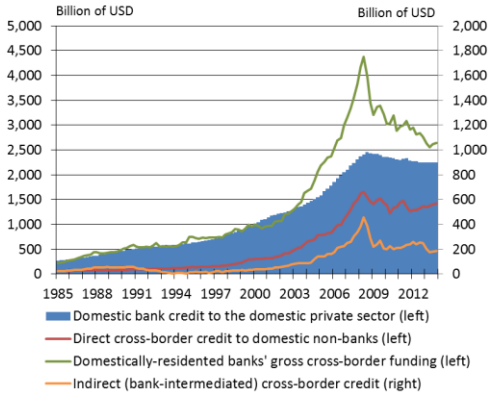
In short, the empirical evidence provided in this section suggest that there may be value in further analysis into the interactions between cross-border banking flows, on the one hand, and domestic credit and macroeconomic developments, on the other. In the next section, I will introduce a small open economy DSGE model that allows for some interactions of this kind, in particular by enabling shocks to be transmitted through interlinked credit intermediation across borders and between balance sheets in the real economy and the financial sector.

[131] This difference is still present if countries experiencing a systemic banking crisis is excluded from both groups.

Figure 2 Cross border credit and domestic bank credit to the domestic non-financial private sector in advanced small open economies

Figure 2a

Domestic bank credit and cross-border credit in advanced bank-based SOEs[1]



1. Domestic bank credit is in constant billion USD at 2013Q4. Cross- border credit is split into direct cross-border claims held by rest of the world on non-banks and indirect cross-border credit, i.e. domestic banks' net cross-border funding, which is given by the difference between their cross-border liabilities and cross-border claims (if the difference is positive). Also shows is the domestic banks' gross cross-border funding. Crisis dates are from Laven and Valencia (2013), except for currency crisis date which is discussed in Chapter 1 of this thesis. Black lines indicate start of contraction in annual GDP. *Sources*: BIS Locational banking statistics, BIS credit data, IMF WEO database, Laeven, L. and F. Valencia (2013). Systemic banking crisis database. *IMF Economic Review*, 61, 225-270, own calculations.

Figure 2b

Domestic bank credit and cross-border credit in advanced market-based SOEs[1]

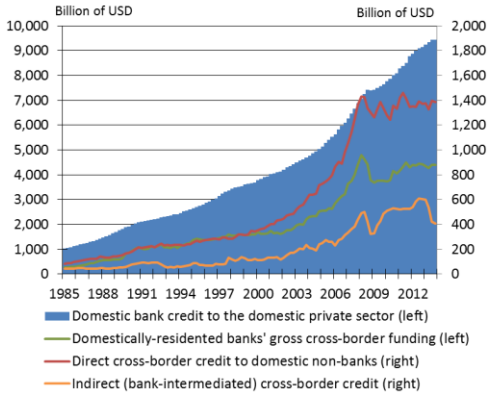


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Figure 2c

Domestic bank credit, cross-border credit and banking flows, and financial crisis in Ireland[1]

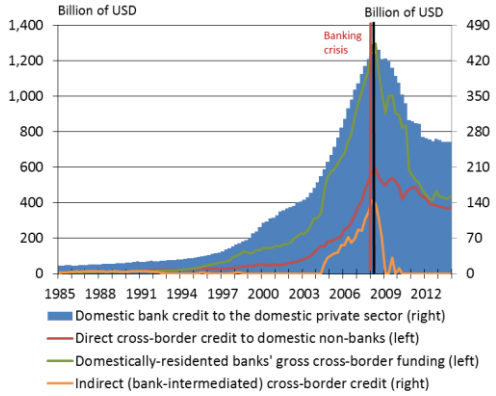

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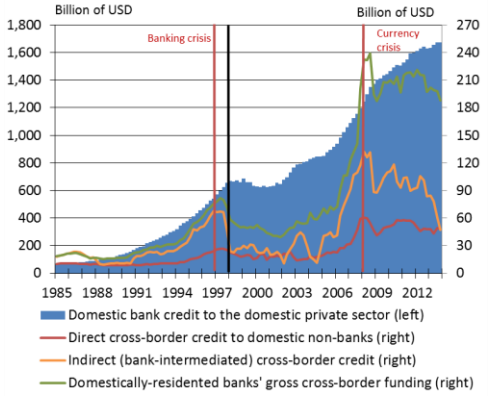
Figure 2d

Domestic bank credit, cross-border credit and banking flows, and financial crises in Korea[1]



1. Domestic bank credit is in constant billion USD at 2013Q4. Cross- border credit is split into direct cross-border claims held by rest of the world on non-banks and indirect cross-border credit, i.e. domestic banks' net cross-border funding, which is given by the difference between their cross-border liabilities and cross-border claims (if the difference is positive). Also shows is the domestic banks' gross cross-border funding. Crisis dates are from Laven and Valencia (2013), except for currency crisis date which is discussed in Chapter 1 of this thesis. Black lines indicate start of contraction in annual GDP. *Sources*: BIS Locational banking statistics, BIS credit data, IMF WEO database, Laeven, L. and F. Valencia (2013). Systemic banking crisis database. *IMF Economic Review*, 61, 225-270, own calculations.

3 The model

In this section, I develop a small open economy model with the key elements that the funding and development of production inputs relies on both cross-border credit being intermediated by investment banks and commercial bank's domestic liquidity provision.

3.1 Overview of the model

Cross-border credit frictions and domestic liquidity constraints, with the former operating through an investment channel and the latter trough a working capital channel, play a pivotal role in the model and other types of market imperfections are excluded from the analysis. Hence, a credit market set-up with two financial intermediation processes is introduced into an otherwise standard version of the small open economy real business cycle model.

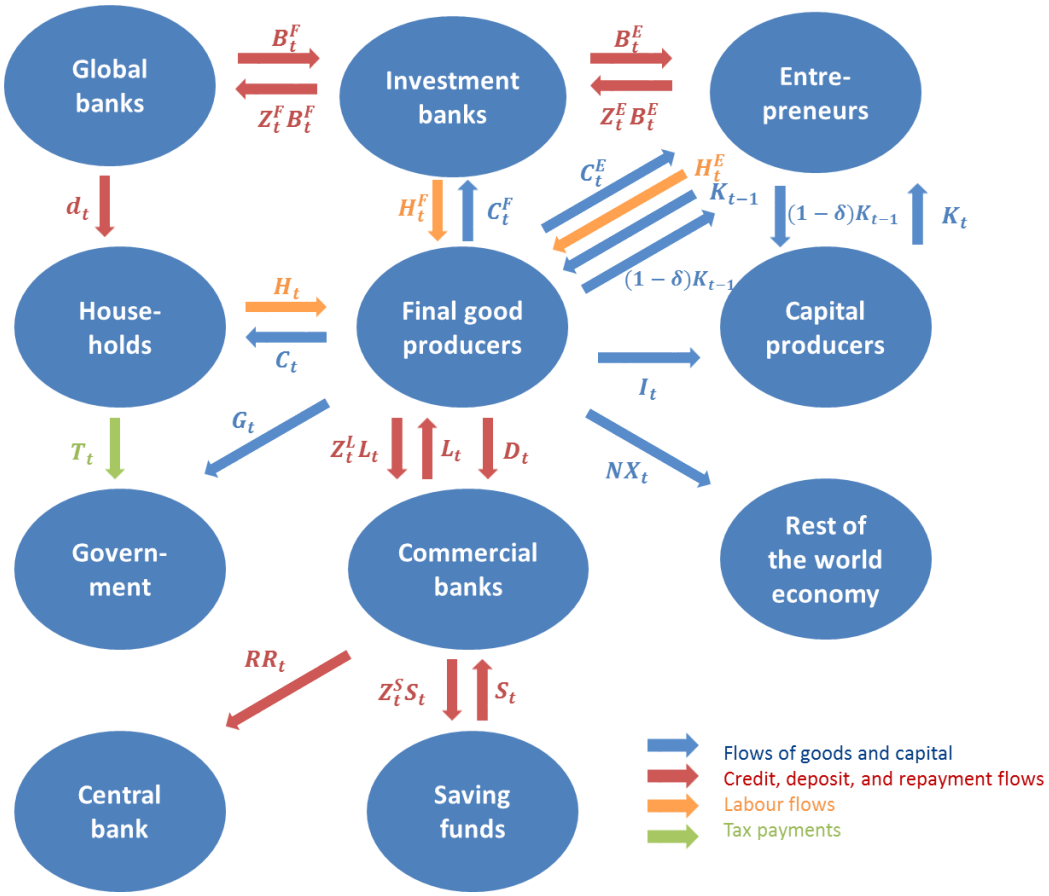
As in the standard version the model includes a single homogenous final good, single one-period internationally traded bond, and neither money nor other nominal variables (cf. Mendoza, 1991, and Schmitt-Grohé and Uribe, 2003). In the standard version, however, households accumulate capital and put capital to work in a completely straightforward manner. Furthermore, borrowers and lenders are implicitly assumed to be the same people and with no conflict of interest between them. In contrast, in my model, putting capital to work involves a special kind of creativity that only entrepreneurs possess and the transformation of new installed (raw) capital into effective capital services is risky. Importantly, entrepreneurs are assumed to have insufficient equity to finance their investments such that they borrow from domestic investment banks, who again need to borrow from global banks, as discussed below. This gives rise to interlinked debt contracts that are designed to mitigate the assumed asymmetry with regard to information on payoffs and the presence of bankruptcy. In addition, the model includes another financial intermediation process where commercial banks channel domestic savings to liquidity constrained final good producers. The combination of these two financial intermediation processes are at the heart of the nexus between the financial system and the real economy within the model.[132]

In the model there are ten type of agents: households, final good producers, entrepreneurs, capital producers, government, a central bank, saving funds, investment banks, commercial banks, and global banks. The good market is assumed frictionless, i.e. input and output markets are fully competitive and nominal rigidities are absent. Final good producers use rented effective capital from entrepreneurs and labour from households, the domestic financial institutions, and the entrepreneurs to produce final goods using Cobb-Douglas technology. Importantly, final good producers are assumed to be liquidity constrained as they have to pay for their wage bill in advance. Commercial banks provide them with working capital loans, by intermediating domestic savings in the form of non-interest bearing deposits and interest bearing certificates of deposits bought by saving funds in the money market. The central bank subjects commercial banks to reserve requirements. Final goods are consumed

[132] As is common in models with financial frictions, this model does neither allow for substitution between bank credit and bonds, nor maturity transformation in financial intermediation.

domestically by households and the government, or abroad, or used domestically for investment. Capital producers possess the technology to transform final goods into new installed capital but their activities are subject to investment adjustment costs. Entrepreneurs use their own net worth and borrowed funds from domestic investment banks to purchase new installed capital from capital good producers and provide effective capital services to the final good producers. Figure 3 provides a bird's eye view of the model.

Figure 3 Bird's eye view of the model



The transformation of new installed capital into effective capital is risky as the success of projects requires a combination of talent and good fortune. Hence, some entrepreneurs will go bankrupt, while others experience sufficient returns to repay their debt. This is taken into consideration in the design of the FE loan contract between domestic financial institutions and entrepreneurs. Households' deposits accumulated by global banks across the globe are the source of all cross-border credit to the domestic economy. Domestic investment banks are both lenders and borrowers as they intermediate funds from the global banks to entrepreneurs but this intermediation is assumed risky, not only due to entrepreneurial credit risk, but also due to risk to the domestic financial institutions' capacity to manage their balance sheet given various (un-modelled) liquidity, market and operational risk. This is taken into account in the design of the GF loan contract between global banks and the domestic financial institutions.

3.2 Credit market

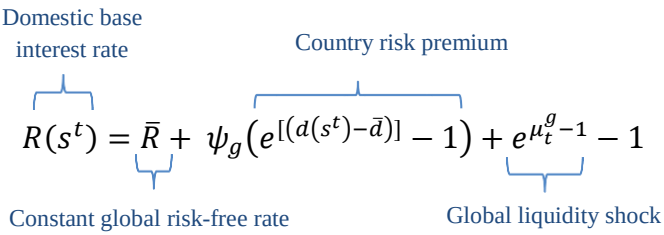
This section describes the credit market of the model, which gives rise to different interest rate spreads and balance sheet relations, that play an important role in allowing developments in the credit market and the real economy to interact. This holds true in general for financial friction models, but the particular framework developed here provides a greater number of credit market participants and spreads than is most often the case in the literature. It can therefore include a number of shocks originating both domestically and in global financial markets.

There are eight types of participants in the credit market: global banks (all others are domestic), investment banks, entrepreneurs, commercial banks, saving funds, final good producers, a central bank, and households. The focus is on credit intermediation to the corporate sector (entrepreneurs and final good producers). Households are assumed to borrow to smooth consumption in a relatively frictionless manner and the dynamics of their borrowing plays a minor role within the model. They are for simplicity reasons assumed to borrow solely from the global banks. The role of the central bank is also limited to liquidity regulation in the form of reserve requirements, which gives rise to a spread between commercial banks' lending and funding rates.

This section is split into four parts: first, the base interest rate determination within the economy is established; second, the cross-border credit intermediation underpinning entrepreneurial investment activity is developed; third, the domestic liquidity provision to fund production inputs that need to be paid in advance is described, and finally, a graphical representation of the key macrofinancial linkages in the model is provided.

Domestic base interest rate

The domestic base interest rate determination reflects the assumption that the small open economy faces a risk premium on top of the constant global risk free rate, $\bar{R}$. In particular, I follow Schmitt-Grohé and Uribe (2003) to introduce independence of the model's steady state from initial conditions by assuming that the small open economy faces a debt-elastic interest rate premium, that is subjected to an exogenous shock, μ_t^g (similar to the set-up in Garcia-Cicco et al., 2010):



(1)

where R represents the base interest rate within the domestic economy, s^t is the state in period t, ψ_g is a debt elastic interest rate parameter, d is foreign debt, $\bar{d}$ is its steady state level. The domestic base interest rate therefore already includes one spread, which is affected by a global

liquidity shock. As discussed in Garcia-Cicco et al. (2010), this shock can either be interpreted as a country specific risk premium shock, possibly reflecting domestic financial imperfections, or as a global liquidity shock, which is uncorrelated with the state of domestic fundamentals. Here the latter interpretation is applied as the model includes domestic financial frictions that give rise to country-specific interest rate spreads. Here, the role of the shock is therefore to allow changes in global liquidity conditions to affect the base interest rate within the small open economy, and then affect spillover effects on investment and overall production through the two financial intermediation processes (described below).

Intermediation process #1: Cross-border credit intermediation by investment banks

This part of the credit market describes the former financial intermediation process in the model. It relies on Hirakata et al. (2009), however, as this model includes an additional financial intermediation process there are important departures from their model, for instance, including the presence of domestic liquidity constraints, a working capital channel, and commercial banks that can face money market pressures, and are subjected to regulatory restrictions. The model developed here therefore gives rise to macrofinancial linkages between aggregate production and a number of balance sheets, spreads, and shocks - both domestically and across borders. This will be discussed in more detail below.

This first financial intermediation process relates global banks, investment banks, and entrepreneurs through interlinked credit contracts. It is assumed that a continuum of risk neutral entrepreneurs invest in domestic projects transforming new installed capital into effective capital services. The entrepreneurs' net worth is insufficient to cover the cost of their investments and hence they make one-period credit contracts with domestic investment banks to fund the difference between the cost of their projects and their net worth. The investment banks have their own net worth but it is insufficient to finance their portfolio of loans to the entrepreneurs and hence they make one-period credit contracts with global banks, which as discussed above accumulate deposits from households across the globe in a frictionless manner.

The costly state verification framework applies to both contracts in this credit intermediation. Hence, both the investment banks and the entrepreneurs are assumed to be subjected to exogenous idiosyncratic productivity shocks and their assets returns only being observable to their lenders at a cost, interpretable as bankruptcy or monitoring cost. The entrepreneur's idiosyncratic shock is a substitute for more complicated processes, such as the stochastic quality or success level of projects, and reflects the riskiness of entrepreneurial investments. The investment banks' idiosyncratic "productivity" shock is also a substitute for more complex processes, such as shocks to bankruptcy costs, technology of funding short-term assets and liabilities, and the overall quality and riskiness of their investments. The cost of funds for both the investment banks and the entrepreneurs are therefore set above the domestic base rate due to this information asymmetry and their associated bankruptcy costs, giving rise to interlinked interest rate spreads.

Uncertainty in entrepreneurial return is modelled such that each entrepreneur is assumed to independently draw a random variable, ω^E, assumed i.i.d across entrepreneurs and represents an idiosyncratic disturbance to each firm's return. The draw is assumed to be from a continuous

and once differentiable c.d.f., $F^E(\omega^E)$, over a non-negative support and with mean unity. More precisely, the c.d.f. is assumed to be log-normal and its properties is captured by its standard deviation, which is denoted by σ_t^E. Entrepreneurs that draw $\omega^E \geq \bar{\omega}^E$ experience sufficient returns to repay their debt while those drawing $\omega^E < \bar{\omega}^E$ go bankrupt. The realisation of ω^E is unknown at the time of loan issuance and is in the following only freely observable to the entrepreneur while the lender has to pay a monitoring cost to receive such information. The cross-sectional dispersion of ω^E is controlled by the risk parameter, σ_t^E, referred to as riskiness. As described in Section 3.3, innovations to this risk parameters are mean-preserving risk shocks and a negative shock makes the left tail of the distribution fatter, leading to more bankruptcies, and hence both higher spreads on loans and less borrowing. The uncertainty among investment banks is modelled in the same manner but with a different risk parameter, σ_t^F.

As in Hirakata et al. (2009), but different from Bernanke et al. (1999), investment banks are assumed to be monopolistic lenders of the entrepreneurs that maximize their profits and determine the borrowing rates of both contracts ensuring that the participation constraints of the entrepreneurs and the global banks are satisfied. More precisely, each investment bank, for instance, a type i, enters loans agreements with a specific segment of entrepreneurs, say group j_i, that are attached to the bank. Each investment bank can diversify the credit risk associated with each segment of entrepreneur, ensuring a return on their loan portfolio equal to $R^F(s^t)$.

As in Hirakata et al. (2009), the investment banks and the entrepreneurs are both at the heart of the nexus between credit frictions and investment activity in the model, while entrepreneurs are alone in that role in the more simple set-up in Bernanke et al. (1999). The borrowing rates in the interlinked credit contracts change with fluctuations in the riskiness and net worth (i.e. leverage) of both the investment banks and the entrepreneurs, as well as due to various other shocks and spread changes in the model. In contrast to Hirakata et al. (2009), however, another financial intermediation will be added to the model (as described in the next subsection).

FE contracts

The loan contracts between the investment banks and the entrepreneurs are standard loan contracts specifying both the amount of debt borrowed and the interest rate. Or, equally, the contracts provide a menu of leverage and cut-off values of the idiosyncratic disturbance to its real return on capital, $\bar{\omega}^E(s^t)$, where the cut-off values reflect when the entrepreneur can repay his debt. Hence, the cut-off value equalises the entrepreneurs' profits and his repayments on the loan reflecting that all entrepreneurs with a lower ω^E will default:

$$\underbrace{\bar{\omega}_{j_i}^E(s^{t+1}|s^t)}_{\text{Cut-off value}}\underbrace{(1+R^E(s^{t+1}|s^t))Q(s^t)K(s^t)}_{\text{Average return from the investment with borrowed funds and own equity}} = \underbrace{[1+Z_{j_i}^E(s^{t+1}|s^t)]}_{\text{Borrowing rate}}\underbrace{(Q(s^t)K(s^t)-N_{j_i}^E(s^t))}_{\text{Amount borrowed}} \quad (2)$$

where $Z_{j_i}^E(s^{t+1}|s^t)$ is the interest rate on the entrepreneur's loan. Hence, there is a direct relation between the cut-off value and the borrowing rate and it will prove to be easier to work with the cut-off value in solving the maximization problem of the investment banks. I focus on the case where entrepreneurs' participation constraint is fulfilled such that they participate in borrowing from investment banks. This implies that their share of returns from investing their net equity and borrowed funds are equal to what they would receive from only investing their equity:

Share of entrepreneurial earnings kept by the entrepreneur

Average return from the investment with borrowed funds and own equity

$$\{(1-\Gamma_t^E(\bar{\omega}_{j_i}^E(s^{t+1}|s^t))\}(1+R^E(s^{t+1}|s^t))Q(s^t)K(s^t)$$

$$\geq \underbrace{(1+R^E(s^{t+1}|s^t))N_{j_i}^E(s^t)}_{\text{Average return from only investing for own equity}} \forall j_i, s^{t+1}|s^t \quad (3)$$

In the expression above, $\{(1-\Gamma_t^E(\bar{\omega}_{j_i}^E(s^{t+1}|s^t))\}$, is the expected share of entrepreneurial earnings kept by the entrepreneurs, and, $\Gamma_t^E\left(\bar{\omega}_{j_i}^E(s^{t+1}|s^t)\right)$ the gross share of entrepreneurial earnings received by the investment banks, given by

$$\Gamma_t^E\left(\bar{\omega}_{j_i}^E(s^{t+1}|s^t)\right) = G_t^E\left(\bar{\omega}_{j_i}^E(s^{t+1}|s^t)\right) + \bar{\omega}_{j_i}^E(s^{t+1}|s^t)\int_{\bar{\omega}_{j_i}^E(s^{t+1}|s^t)}^{\infty} dF_t^E(\omega^E) \quad (4)$$

where $G_t^E\left(\bar{\omega}_{j_i}^E(s^{t+1}|s^t)\right) \equiv \int_0^{\bar{\omega}_{j_i}^E(s^{t+1}|s^t)} \omega^E dF_t^E(\omega^E)$ represents the part of the c.d.f. where entrepreneurs default if they draw from that segment. The net share of entrepreneurial earnings going to the monopolistic investment banks is given by

$$\Phi_{j_i,t}^E(\bar{\omega}_{j_i}^E(s^{t+1}|s^t)) \equiv \Gamma_t^E\left(\bar{\omega}_{j_i}^E(s^{t+1}|s^t)\right) - \mu^E G_t^E\left(\bar{\omega}_{j_i}^E(s^{t+1}|s^t)\right) \quad (5)$$

where μ^E represents the fixed share of entrepreneurial bankruptcy costs as a ratio of entrepreneurial total assets. Hence, entrepreneurial bankruptcy costs represent a deadweight loss to society due to the financial frictions and the costs are given by

$$\mu^E \bar{\omega}_{j_i}^E(s^{t+1})(1 + R^E(s^{t+1}|s^t))Q(s^t)K(s^t). \quad (6)$$

where $0 < \mu^E < 1$. This allows for expressing the investment banks' expected earnings (from each FE contract) as the net share of average aggregate return on capital:

$$\Phi_{j_i,t}^E(\bar{\omega}_{j_i}^E(s^{t+1}|s^t))(1 + R^E(s^{t+1}|s^t))Q(s^t)K(s^t) \quad (7)$$

which also allows for defining the expected return on the loans to entrepreneurs, $[1 + R^F(s^{t+1}|s^t)]$, as

$$\begin{aligned} &\Phi_{j_i,t}^E(\bar{\omega}_{j_i}^E(s^{t+1}|s^t))(1 + R^E(s^{t+1}|s^t))Q(s^t)K_i(s^t) \\ &= (1 + R^F(s^{t+1}|s^t))(Q(s^t)K(s^t) - N_i^E(s^t)), \forall s^{t+1} \big| \, s^t \end{aligned} \quad (8)$$

where

$$K_i(s^t) \equiv \int_{j_i} K_{j_i}(s^t) dj_i \quad (9)$$

$$N_i^E(s^t) \equiv \int_{j_i} N_{j_i}^E(s^t) dj_i \quad (10)$$

GF contracts

The investment banks act as intermediaries of funds from global banks to the entrepreneurs. Hence, they borrow from global banks according to the GF contract, which has the same standard debt contract form resulting from the costly state verification framework as the FE contract. In a sense, the monopolistic investment banks split their share of the earnings resulting from the FE contract with global banks to obtain funding to finance their investment. Just as in the FE contract, there is a cut-off value, $\bar{\omega}^F(s^t)$, where the investment banks can repay their loans to global banks:

$$\bar{\omega}_i^F(s^{t+1}|s^t)(1+R^F(s^{t+1}|s^t))(Q(s^t)K_i(s^t)-N_i^E(s^t)) = [1+Z_i^F(s^{t+1}|s^t)](Q(s^t)K_i(s^t)-N_i^F(s^t)-N_{j_i}^E(s^t)) \quad (11)$$

where $Z_i^F(s^{t+1}|s^t)$ is the interest rate on the investment banks' loan and $[Q(s^t)K_i(s^t) - N_i^F(s^t) - N_{j_i}^E(s^t)]$ the amount borrowed from global banks. As before, it is possible to interchange between the borrowing rates and the cut-off value. The participation constraint of global banks reflects that their earnings from the GF contract must equal their opportunity cost of lending:

$$\left\{\Gamma_t^F\left(\bar{\omega}_i^F(s^{t+1}|s^t)\right)-\mu^F G_t^F\left(\bar{\omega}_i^F(s^{t+1}|s^t)\right)\right\}(1+R^F(s^{t+1}|s^t))[Q(s^t)K_i(s^t) - N_i^E(s^t)] \geq (1+R(s^t))[Q(s^t)K_i(s^t)-N_i^E(s^t)-N_i^F(s^t)] \quad (12)$$

Optimal contracts

The monopolistic investment banks solve a maximization problem subjected to the two participation constraints given by equations (3) and (12):

$$\max_{\bar{\omega}^F,\bar{\omega}^E,\ K}\sum_{s^{t+1}}\pi(s^{t+1}|s^t)[1-\Gamma^F(\bar{\omega}^F(s^{t+1}|s^t))][1+R^F(s^{t+1}|s^t)][Q(s^t)K_i(s^t)-N_i^E(s^t)] \quad (13)$$

where $\pi(s^{t+1}|s^t)$ is the probability weight for state s^{t+1} given state s^t, $[1-\Gamma^F(\bar{\omega}^F(s^{t+1}|s^t))]$ represents the share of the investment banks' earnings kept by the institutions themselves, $[1+R^F(s^{t+1}|s^t)]$ is the average return on the FE contracts, and $[Q(s^t)K_i(s^t)-N_i^E(s^t)]$ the amount lent to entrepreneurs. To solve this maximization problem it is beneficial to use equation (8) to replace $[1+R^F(s^{t+1}|s^t)]\left[Q(s^t)K_i(s^t)-N_i^E(s^t)\right]$ with the equal expression $\Phi_{j_{i,t}}^E(\bar{\omega}_{j_i}^E(s^{t+1}|s^t))(1+R^E(s^{t+1}|s^t))Q(s^t)K_i(s^t)$. Appendix 1 provides details on the solution of the problem.[133] The combined first-order-conditions are given by

[133] Analytical expressions for the variables appearing in equation (14) are available in Dynare and are listed in Hirakata et al. (2009).

$$
\begin{aligned}
0 = \sum \pi(s^{t+1}|s^t) \\
\left\{\left[1-\Gamma_t^F\left(\bar{\omega}_i^F(s^{t+1}|s^t)\right)\right]\Phi_{i,t}^F(s^{t+1}|s^t)[1+R^E(s^{t+1}|s^t)]\right\} \\
+\frac{\Gamma_t'^F(\bar{\omega}_i^F(s^{t+1}|s^t))}{\Phi_{i,t}'^F(\bar{\omega}_i^F(s^{t+1}|s^t))}\Phi_{i,t}^F(s^{t+1}|s^t)\Phi_{i,t}^E(s^{t+1}|s^t)[1+R^E(s^{t+1}|s^t)] \\
-\frac{\Gamma_t'^F\left(\bar{\omega}_i^F(s^{t+1}|s^t)\right)}{\Phi_{i,t}'^F\left(\bar{\omega}_i^F(s^{t+1}|s^t)\right)}[1+R(s^t)] \\
+\frac{\left[1-\Gamma_t^F\left(\bar{\omega}_i^F(s^{t+1}|s^t)\right)\right]\Phi_{i,t}'^E(s^{t+1}|s^t)}{\Gamma_t'^E(\bar{\omega}_{j_i}^E(s^{t+1}|s^t))}[1-\Gamma_t^E\left(\bar{\omega}_{j_i}^E(s^{t+1}|s^t)\right)][1 \\
+R^E(s^{t+1}|s^t)] \\
+\frac{\Gamma_t'^F(\bar{\omega}_i^F(s^{t+1}|s^t))\Phi_{i,t}^F(s^{t+1}|s^t)\Phi_{i,t}'^E(s^{t+1}|s^t)}{\Phi_{i,t}'^F\left(\bar{\omega}_i^F(s^{t+1}|s^t)\right)\Gamma_t'^E(\bar{\omega}_{j_i}^E(s^{t+1}|s^t))}\left[1-\Gamma_t^E\left(\bar{\omega}_{j_i}^E(s^{t+1}|s^t)\right)\right][1 \\
+R^E(s^{t+1}|s^t)], \forall j_i.
\end{aligned}
\tag{14}
$$

Equation (14) represents the efficiency condition for the interlinked credit contracts underpinning the cross-border and domestic credit intermediation in the model.

The two participation constraints can be rewritten to provide a pivotal relation between the excess return on domestic investment over the base rate needed for those investment activities to be funded (i.e. the external finance premium) given the set-up of the credit market, on the one hand, and the net worth in the investment banking and entrepreneurial sectors, respectively, on the other. Equation (3) can be rewritten as $\Phi_{i,t}^F(s^{t+1}|s^t)\Phi_{i,t}^E(s^{t+1}|s^t)[1+R^E(s^{t+1}|s^t)] = [1+R(s^t)][1-\frac{N^F(s^t)}{Q(s^t)K(s^t)}-\frac{N^E(s^t)}{Q(s^t)K(s^t)}]$ and equation (12) as $\left[(1-\Gamma_t^E(\bar{\omega}^E(s^{t+1}|s^t))\right]Q(s^t)K(s^t) = \frac{N^F(s^t)}{Q(s^t)K(s^t)}$ such that

$$
\frac{[1+R^E(s^{t+1}|s^t)]}{[1+R(s^t)]} = [\Phi_t^F(\bar{\omega}^F)]^{-1}\ [\Phi_t^E(\bar{\omega}^E)]^{-1}[1-\frac{N^F(s^t)}{Q(s^t)K(s^t)}-\frac{N^E(s^t)}{Q(s^t)K(s^t)}] \tag{15}
$$

Hence, the external finance premium is inversely related to the share of investment banks' earnings going to global banks (the first term on the right-hand-side), inversely related

to the share of entrepreneurs' earnings that is received by the investment banks (the second-term), and positively dependant on the ratio of entrepreneurs' and investment banks' combined debt to aggregate capital (the third term). It seems straightforward that the cost of funds is lower when the lenders' share of the profits increases as reflected in the two first terms. Furthermore, that bankruptcy costs increase in line with rising total debt, which should, given all else being equal, lead to higher exposed debt and hence higher credit spreads. However, it is interesting that equation (15) indicates that the distribution of net worth between the two borrowing sectors is an important determinant of the cost of funds. This reflects the important differences in the degree of leverage between firms (entrepreneurs) and financial institutions. Hirakata et al. (2009) analyse the quantitative importance of this distribution in greater detail.

This expression can be rewritten to relate cross-border banking flows to the domestic spread confronted by entrepreneurs and the share of their entrepreneurial profits going to lenders through the interlinked credit contracts:

Cross-border banking flows

Excess return of domestic investment over base rate needed to be funded

Share of profit going to investment banks in the FE contract

$$[Q(s^t)K_i(s^t) - N_i^E(s^t) - N_i^F(s^t)] = \frac{\left[1+R^E\left(s^{t+1}|s^t\right)\right]}{[1+R(s^t)]}[\Phi_t^F(\bar{\omega}^F)]\ [\Phi_t^E(\bar{\omega}^E)] \quad (16)$$

Share of profit going to global banks in the GE contract

Entrepreneurs and investment banks build-up net worth through earnings from entrepreneurial projects split between them by the credit contract. Furthermore, both receive labour income from providing labour input to final good producers. In order to prevent entrepreneurs and investment banks from accumulating sufficient equity to fund their investments without borrowing I follow standard procedure and assume that a fraction of them dies each period and consumes their net worth. Hence, the law of motion for net worth is given by:

$$N^F(s^t) = \gamma^F V^F(s^t) + W^F(s^t) + \Delta n^F(s^t) \quad (17)$$

$$N^E(s^t) = \gamma^E V^F(s^t) + W^E(s^t) + \Delta n^E(s^t) \quad (18)$$

where γ^F and γ^E are the survival rates, $\Delta n^F(s^t)$ and $\Delta n^E(s^t)$ are exogenous shocks defined below, and

$$V^F(s^t) = \left[1 - \Gamma_t^F\left(\bar{\omega}^F(s^{t+1}|s^t)\right)\right]\Phi^E(\bar{\omega}^E(s^{t+1}|s^t))[1 + R^E(s^{t+1}|s^t)]\, Q(s^t)K(s^t) \quad (19)$$

$$V^E(s^t) = \left[1 - \Gamma_t^E\left(\bar{\omega}^E(s^{t+1}|s^t)\right)\right][1 + R^E(s^{t+1}|s^t)]\, Q(s^t)K(s^t) \quad (20)$$

Intermediation process #2: Domestic liquidity provision by commercial banks

This section describes the latter financial intermediation process in the model where commercial banks channel domestic savings to liquidity constrained final good producers. The set-up here does not rely on the costly state verification framework, hence there are neither any agency problems, a role for net worth, nor bankruptcies, as in the previously described cross-border intermediation process involving investment banks. However, the commercial banks involved in the process are assumed to operate within the scope of a central bank's liquidity regulation such that they, in contrast to the unregulated investment banks, are required to hold unremunerated reserves at the central bank. This latter intermediation process adds four participants, two interest rate spreads, and one shock, to the credit market in the model.

Liquidity constrained final good producers

Final good producers combine rented effective capital and labour inputs to produce the final good within the economy, as will be described in more detail in Section 3.3. Here the focus is on their need for liquidity from commercial banks. The producers are assumed to be cash-in-advance liquidity constrained as they need to pay for their labour inputs prior to receiving revenue from sales. Producers therefore attain working capital loans from commercial banks in the beginning of each period, pay for their wage bill, and need to save part of their sale revenue in the form of non-interest bearing deposits between periods to repay their loans. The constraint therefore implies the following for end-of-period deposits:

$$D(s^t) = [1 + R^W(s^t)]\, L(s^t) \quad (21)$$

where $D(s^t)$ are end-of-period deposits, $R^W(s^t)$ the lending rate on the working capital loans, and $L(s^t)$ the amount borrowed. There are no profits (as discussed in Section 3.3) and the liquidity constraint therefore implies that producers borrow just exactly to fund their wage bill:

$$L(s^t) = W(s^t)H(s^t) + W^F(s^t)H^F(s^t) + W^E(s^t)H^E(s^t) \quad (22)$$

The composition of labour inputs is described in Section 3.3 where the final good producers' maximisation problem is set up.

Saving funds

The source of funds in this intermediation process is, on the one hand, the non-interest bearing producers' deposits, but, on the other hand, it is assumed that there exist domestic saving funds who invest in interest-bearing certificates of deposits issued by commercial banks in domestic money markets. The use of funds in this process are, on the one hand, working capital loans to producers, and, on the other hand, bank reserves at the central bank (discussed below):

$$S(s^t) = L(s^t) - D(s^t) + RR(s^t) \tag{23}$$

where is $S(s^t)$ the amount invested by saving funds in commercial banks' certificates of deposits and $RR(s^t)$ represent unremunerated required reserves. The saving funds are for simplicity reasons assumed to be domestic money market participants that have the resources to invest in these certificates of deposits and the willingness to do so, given that they receive an interest rate above the domestic base interest rate level (TED spread). However, it is also assumed that domestic money market conditions can change. Hence, there is a money market spread over the domestic base interest rate, which is affected by a so-called domestic money market shock, which impacts the part of commercial banks' liabilities that are funded on that market:

$$R^S(s^t) = R(s^t) + \psi_D\left(e^{[((L(s^t)-\bar{L})]} - 1\right) + e^{\mu_t{}^S - 1} - 1 \tag{24}$$

where $R^S(s^t)$ is the money market rate on certificates of deposits, ψ_D is a balance sheet elastic interest rate parameter, $L(s^t)$ debt, $\bar{L}$ is its steady state level.

Central bank

The role of the central bank in the model is to serve as a liquidity regulator to commercial banks (which traditionally have access to central bank liquidity services and even lender-of-last-resort loans). The investment banks as well as the saving funds, however, are assumed to be unregulated. The liquidity regulation takes the form of requiring commercial banks to hold unremunerated reserves at the central bank. The reserve requirement is set as a (fixed) ratio of commercial banks' total liabilities:

$$RR(s^t) = \varphi^{RR}[S(s^t) + D(s^t)] \tag{25}$$

where φ^{RR} is the reserve requirement ratio. This has the importance implication that a spread arises between the lending and funding rate of the commercial banks, as explained below.

Commercial banks

The role of commercial banks in the model is to intermediate domestic savings to liquidity constrained final good producers, as well as to fulfil the reserve requirements set by the central bank. The model assumes complete competition in commercial banking and there is no role for net worth (i.e. bank capital). Hence, the representative commercial bank's total assets are given

by the sum of working capital loans, $L(s^t)$, and unremunerated reserves, $RR(s^t)$, while their total liabilities are given by the sum of non-interest bearing producers' deposits, $D(s^t)$, and money market funding, $S(s^t)$. Hence, their balance sheet constraint implies that the interest rate on working capital loans is given by:

$$[1 + R^W(s^t)] = [[1 + R^S(s^t)]\, S(s^t) + D(s^t) - RR(s^t)]/L(s^t) \qquad (26)$$

such that there is a spread between the lending and funding rate (i.e. money market rate) of the commercial banks.

This concludes the development of the credit market in the model. Given the focus on financial intermediation, the rest of the model is kept as simple as possible, as described in the next section.

3.3 The rest of the model

Final good producers

The representative final good producer faces perfectly competitive input and output markets and produces a tradable homogenous final good, $Y(s^t)$. Technology is assumed to exist that can be used to convert the homogeneous final good one-for-one into a private or public consumption good, $C(s^t)$ or $G(s^t)$, while the transformation into new installed capital, $K(s^t)$, is subjected to adjustment costs, as explained below. The key element of the model is that production within this small open economy relies on corporate credit being extended to fund production inputs. Credit constrained entrepreneurs supply effective capital services to the representative final producer for a rental price, $R^E(s^t)$. The final producer also hires labour from households, $H(s^t)$, the domestic financial institutions $H^F(s^t)$, and entrepreneurs $H^E(s^t)$, but importantly he/her is assumed to be liquidity constrained as the wage bill has to be paid in advance resulting in working capital loans from commercial banks, as described above.

Other details with regard to the final goods producer is that his technology is represented by a relatively standard Cobb-Douglas production function, adapted to the composition of labour inputs (which for simplicity reason exclude participants in the financial intermediation of domestic savings). It is assumed that at the end of each period, the un-depreciated capital is sold back to entrepreneurs at price $Q(s^t)$. Note that capital is assumed to depreciate during the production process within each period. This assumption regarding the reselling of the un-depreciated capital is used to make the net worth of entrepreneurs well-defined at the end of each period, as they sell the un-depreciated capital further on to capital producers for the same price. The representative final producer's maximization problem is then given by:

$$\max_{Y(s^t),K(s^{t-1}),H(s^t),H^F(s^t),H^E(s^t),L(s^t),D(s^t)}$$

$$= Y(s^t) + \underbrace{Q(s^{t-1})K(s^{t-1})(1-\delta)}_{\text{Revenue from selling undepreciated capital back}}$$

$$\underbrace{-[1+R^E(s^t)]Q(s^{t-1})K(s^{t-1})}_{\text{Rental cost of capital}}$$

$$\underbrace{-W(s^t)H(s^t) - W^F(s^t)H^F(s^t) - W^E(s^t)H^E(s^t)}_{\text{Wage costs}}$$

$$\underbrace{-[1+R^W(s^{t-1})]L(s^{t-1})}_{\text{Cost of liquidity provision from commercial banks}} + \underbrace{[L(s^t) - L(s^{t-1})]}_{\text{Funds from net new liquidity provisions from commercial banks}} + \underbrace{D(s^{t-1}) - D(s^t)}_{\text{End-of-last-period's deposits to repay liquidity provision in the beginning of current period; needed end-of-current-period's deposits to repay in beginning of next period}} \tag{27}$$

s.t.

$$\underbrace{Y(s^t) = e^{a(s^t)}K^{\alpha}(s^t)\left(H(s^t)\right)^{(1-\Omega^F-\Omega^E)(1-\alpha)}(H^E(s^t))^{\Omega^E(1-\alpha)}(H^F(s^t))^{\Omega^F(1-\alpha)}}_{\text{Aggregate production function}}$$

$$\underbrace{D(s^{t-1}) = [1+R^W(s^{t-1})]L(s^{t-1})}_{\text{Liquidity constraint ensuring end-of-period deposits to repay liquidity provision provided to fund the wage bill in advance in the beginning of the next period}}$$

$$\underbrace{\begin{aligned} D(s^{t-1}) - [1+R^W(s^{t-1})]L(s^{t-1}) + L(s^t) \\ = W(s^t)H(s^t) + W^F(s^t)H^F(s^t) + W^E(s^t)H^E(s^t) \end{aligned}}_{\text{Combination of no-profits and the liquidity constraint ensures exact liquidity provision to fund the wage bill}}$$

where $a(s^t)$, δ, α, Ω^F, and Ω^E are the economy-wide level of total factor productivity, the capital depreciation rate, the capital share, the share of domestic financial institutions' labour input, and the share of entrepreneurial labour input, respectively. The assumed stationary stochastic process for $a(s^t)$ is defined below. $L(s^t)$, $D(s^t)$, and $R^W(s^t)$ are the working capital

loans from commercial banks, the final good producer's non-interest-bearing deposits, and the lending rate, respectively.

The first-order conditions for the representative final good producer are straightforward, equalising the marginal benefit of adding one extra unit of factor input to its marginal cost, taking the need for liquidity provision, and its associated deposits, to fund the wage bill into account:

$$\alpha \frac{Y(s^t)}{K(s^{t-1})} - [1 + R^E(s^t)]Q(s^{t-1}) + Q(s^{t-1})(1-\delta) = 0 \tag{28}$$

$$(1-\alpha)(1-\Omega^F-\Omega^E)\frac{Y(s^t)}{H(s^t)} = W(s^t)[1+R^W(s^t)] \tag{29}$$

$$(1-\alpha)\Omega^F \frac{Y(s^t)}{H^F(s^t)} = W^F(s^t)[1+R^W(s^t)] \tag{30}$$

$$(1-\alpha)\Omega^E \frac{Y(s^t)}{H^E(s^t)} = W^E(s^t)[1+R^W(s^{t-1})] \tag{31}$$

$$L(s^t) = W(s^t)H(s^t) + W^F(s^t)H^F(s^t) + W^E(s^t)H^E(s^t) \tag{32}$$

$$D(s^t) = [1+R^W(s^t)][W(s^t)H(s^t) + W^F(s^t)H^F(s^t) + W^E(s^t)H^E(s^t)] \tag{33}$$

Capital producers

The technology applicable to transform the final good of the small open economy into new installed capital is assumed to be in the hands of a single, perfectly competitive, representative capital producer. The capital producer buys $I(s^t)$ amount of final goods from the final good producer and combines it with the un-depreciated capital $(1-\delta)K(s^{t-1})$ it bought from the entrepreneurs at price $Q(s^{t-1})$. It then produces new installed capital, $K(s^t)$, from these inputs using technology subjected to adjustment costs, that are increasing in the rate of investment growth as defined below, and sells the new installed capital to entrepreneurs in a competitive market at price $Q(s^t)$. I follow Bernanke et al. (1999) in assuming that the price of new and used capital is the same (to the first order) and hence I can disregard the un-depreciated capital when setting up the maximization problem of the capital producer:

$$\max_{I_{t+l}} \sum_{l=0}^{\infty} \pi(s^{t+l}|s^t) \Delta(s^{t+l})$$

$$* \left[Q(s^t) \left(1 - F_I\left(I(s^{t+l}), I(s^{t+l-1}) \right) \right) I(s^{t+l}) - I(s^{t+l}) \right] \tag{34}$$

where the production technology is given by $F_I\left(I_{t+l}(s^{t+l}), I_{t+l-1}(s^{t+l-1}) \right) \equiv \frac{\kappa}{2}\left(\frac{I_{t+l}(s^{t+l})}{I_{t+l-1}(s^{t+l-1})} - 1 \right)^2$ and $\Delta(s^t)$ is the capital producer's subjective discount factor. Note that the parameter, κ, determines the investment adjustment cost, and that those costs do not affects the steady state of the model where the relative price of capital goods in terms of the final good, or Tobin's $Q(s^t)$, is unity. Investment adjustment costs are typically included in small open economy models to avoid excessive investment fluctuations in response to changes in domestic productivity or foreign interest rates. Furthermore, they are useful when introducing financial frictions into real business cycle models to attain a decline in the price of capital and hence net worth in the case of a negative risk shock. The first-order-condition of the capital producer's maximization problem is given by:

$$\begin{aligned} & Q(s^t) \left[1 - \frac{\kappa}{2}\left(\frac{I(s^t)}{I(s^{t-1})} - 1 \right)^2 \right] - Q(s^t) \left[\kappa \left(\frac{I(s^t)}{I(s^{t-1})} \right) \left(\frac{I(s^t)}{I(s^{t-1})} - 1 \right) \right] - 1 \\ & = E_t \left\{ \beta \frac{C(s^t)}{C(s^{t+1})} Q(s^{t+1}) \kappa \left(\frac{I(s^{t+1})}{I(s^t)} \right)^2 \left(\frac{I(s^{t+1})}{I(s^t)} - 1 \right) \right\} \end{aligned} \tag{35}$$

where I have made use of the assumption that the capital producers are assumed to be owned by the households and hence have the same subjective discounting factor. The law of motion for capital is traditional and reflects the presence of investment adjustment costs:

$$K(s^t) = \left(1 - F_I\left(I(s^t), I(s^{t-1}) \right) \right) I(s^t) + (1 - \delta) K(s^{t-1}). \tag{36}$$

Households

The small open economy is assumed to be populated by a continuum of infinitely lived households and the representative households maximises its expected utility subject to its budget constraint:

$$\max_{C(s^t),H(s^t),d(s^t)} \sum_{l=0}^{\infty} \beta^{t+l} E_t \left\{ \log C(s^{t+l}) - \chi \frac{H(s^{t+l})^{1+\frac{1}{\eta}}}{1+\frac{1}{\eta}} \right\} \quad (37)$$

s.t.

$$C(s^{t+l}) + \left(1 + R(s^{t+l})\right) d(s^{t+l}) + T(s^{t+l}) = d(s^{t+l+1}) + W(s^{t+l}) H(s^{t+l})$$

The budget constraint reflects that period t expenditures (use of funds) - reflecting consumption, debt repayments, and lump-sum taxes - need to be funded by new loans, $d(s^{t+1})$, and (after-tax) labour income earned from working for the final good producer. Note that profits of the capital producers are zero by assumption and do therefore not affect the households' budget constraint. Households borrow funds to smooth consumption at the domestic base interest rate, $R(s^t)$, that includes a country risk premium as defined above. The household's optimality conditions are standard:

$$\frac{1}{C(s^t)} = \beta E_t \left\{ \frac{1}{C(s^{t+1})} R(s^t) \right\} \quad (38)$$

$$W(s^t) = \chi H(s^t)^{\frac{1}{\eta}} C(s^t) \quad (39)$$

Government

The government plays a passive role in the model and simply collects a lump-sum tax from households, $T(s^t)$, and maintains a balanced budget in each period:

$$G(s^t) = T(s^t) \ , \forall t \quad (40)$$

Net exports and the economy's aggregate resource constraint

The key distinction between closed and open economies is that they have different constraints as there is international trade and capital flows in an open economy. The credit market set-up also implies that the aggregate resource constraint has to reflect the deadweight loss due to bankruptcy costs in the entrepreneurial and domestic financial sector, in addition to accounting for the domestic financial institutions' and entrepreneurs' consumption. Hence, the final goods produced in the small open economy that are neither spent on domestic consumption by households, entrepreneurs, the domestic financial institutions, and the government, investment by the capital producers, nor monitoring costs, are the country's net exports:

$$NX\,(s^t) = Y(s^t) - C(s^t) - C^E(s^t) - C^F(s^t) - I(s^t) - G\,(s^t) - dE(s^t) - dF(s^t) \tag{41}$$

where entrepreneurial and the domestic financial institutions' consumption reflect that entrepreneurs and domestic financial institutions that fail to survive in period t consume their net worth:

$$C^E(s^t) = (1-\gamma^E)\left(1-\Gamma^E\left(\bar{\omega}^E(s^{t+1})\right)\right)[1+R^E(s^{t+1})]Q(s^t)K(s^t) \tag{42}$$

$$C^F(s^t) = (1-\gamma^F)(1 - \Gamma^F(\bar{\omega}^F(s^{t+1})))\Phi^E\left(\bar{\omega}^E(s^{t+1}|s^t)\right)[1+R^E(s^{t+1})]Q(s^t)K(s^t) \tag{43}$$

Monitoring costs were defined above.

Exogenous shocks

The small open economy model includes seven exogenous shocks: a global liquidity shock, commercial banks' funding shock, two risk shocks, two net worth (leverage) shocks, and a total factor productivity shock. I follow Garcia-Cicco et al. (2010) in assuming that the global liquidity shock follows a first-order autoregressive process:

$$\log\mu_{t+1}^g = \rho_{\mu^g}\log\mu_t^g + \varepsilon_{t+1}^{\mu^g}\ ;\quad \varepsilon_t^{\mu^g} \sim N(0,\sigma_{\mu^g}^2) \tag{44}$$

The domestic funding shock affecting commercial banks is also assumed to follow a stationary first-order autoregressive process:

$$\log\mu_{t+1}^d = \rho_{\mu^d}\log\mu_t^d + \varepsilon_{t+1}^{\mu^d}\ ;\quad \varepsilon_t^{\mu^d} \sim N(0,\sigma_{\mu^d}^2) \tag{45}$$

The risk shocks are associated with idiosyncratic disturbances to the investment banks' and entrepreneurs' productivities, $\omega^F(s^t)$ and $\omega^E(s^t)$. As discussed above, $\omega^F(s^t)$ and $\omega^E(s^t)$, are assumed to be log-normally distributed with unit mean and time-varying standard deviation - $\sigma^F(s^t)$ and $\sigma^E(s^t)$ - referred to as riskiness. The innovations to these standard deviations are the risk shocks, $\sigma_{\sigma_F}^2$ and $\sigma_{\sigma_E}^2$:

$$\log\left(\frac{\sigma^F(s^t)}{\bar{\sigma}^F}\right) = \rho_{\sigma_F}\log\left(\frac{\sigma^F(s^{t-1})}{\bar{\sigma}^F}\right) + \varepsilon^{\sigma_F}(s^t)\ ;\ \ \varepsilon^{\sigma_F}(s^t) \sim \text{i. i. d. } N(0,\sigma_{\sigma_F}^2) \tag{46}$$

$$\log\left(\frac{\sigma^E(s^t)}{\bar{\sigma}^E}\right) = \rho_{\sigma_E}\log\left(\frac{\sigma^E(s^{t-1})}{\bar{\sigma}^E}\right) + \varepsilon^{\sigma_E}(s^t)\ ;\ \ \varepsilon^{\sigma_E}(s^t) \sim \text{i. i. d.}\ \ N(0, \sigma^2_{\sigma_E}) \qquad (47)$$

where $\bar{\sigma}^F$ and $\bar{\sigma}^E$ are the steady state values of the standard deviations. The economy-wide level of total factor productivity is assumed to follow a stationary first-order autoregressive process:

$$a(s^t) = \rho_A a(s^{t-1}) + \varepsilon^a(s^t)\ ;\quad \varepsilon^a(s^t) \sim \text{i. i. d.}\ \ N(0, \sigma_a^2) \qquad (48)$$

The net worth shocks in the entrepreneurial sector and in investment banking are also assumed to follow a first-order autoregressive process:

$$\Delta n^E(s^t) = \rho_{n_E} n^E(s^{t-1}) + \varepsilon^{n^E}(s^t)\ ;\quad \varepsilon^{n^E}(s^t)\ \sim \text{i. i. d.}\ \ N(0, \sigma^2_{nE}) \qquad (49)$$

$$\Delta n^F(s^t) = \rho_{n_F} n^F(s^{t-1}) + \varepsilon^{n^F}(s^t)\ ;\quad \varepsilon^{n^F}(s^t)\ \sim \text{i. i. d.}\ \ N(0, \sigma^2_{nE}) \qquad (50)$$

Equilibrium

An equilibrium consists of a set of prices: $\{R(s^t),\ R^E(s^t), R^F(s^t), R^S(s^t), R^W(s^t), W(s^t), W^E(s^t), W^F(s^t), Q(s^t), R^E(s^{t+1}|s^t), R^F(s^{t+1}|s^t), Z^E(s^{t+1}|s^t), Z^F(s^{t+1}|s^t)\}_{t=0}^{\infty}$ and the allocations $\{\{\omega^E_{j_i}(s^{t+1}|s^t)\}_{j_i=1}^{\infty}\}_{t=0}^{\infty}, \{\{\omega^F_i(s^{t+1}|s^t)\}_{i=1}^{\infty}\}_{t=0}^{\infty}, \{\{N^E_{j_i}(s^t)\}_{j_i=1}^{\infty}\}_{t=0}^{\infty},$, $\{\{N^F_i(s^t)\}_{i=1}^{\infty}\}_{t=0}^{\infty}, \{L(s^t), D(s^t), S(s^t), RR(s^t), Y(s^t), C(s^t), C^E(s^t), C^F(s^t), I(s^t), NX(s^t), d(s^t), K(s^t), H(s^t), H^E(s^t), H^F(s^t)\}_{t=0}^{\infty}$ for a given fiscal policy $\{G(s^t), T(s^t)\}_{t=0}^{\infty}$, realisation of exogenous variables $\{\varepsilon_t^{\mu^g}(s^t), \varepsilon_t^{\mu^d}(s^t), \varepsilon^a(s^t), \varepsilon^{\sigma_E}(s^t), \varepsilon^{\sigma_F}(s^t), \varepsilon^{N_E}(s^t), \varepsilon^{N_F}(s^t)\}_{t=0}^{\infty}$, and initial conditions $N^E_{-1}, N^F_{-1}, K_{-1}$, such that for all t, i, j_i:

(1) the household maximizes its utility given the prices;
(2) the investment banks maximize their profits given the prices;
(3) the entrepreneurs maximize their profits given the prices;
(4) the commercial banks maximize their profits given the prices;
(5) the final goods produces maximize their profits given the prices;
(6) capital goods producers maximize their profits given the prices;
(7) the saving funds buy issued certificates of deposits given the prices,
(8) the central bank enforces its reserve requirements,
(9) the government budget constraint holds; and
(10) markets clear.

4 Economic analysis

Solving for the steady state represents a substantial challenge in this model. Christiano et al. (2003, 2010, 2012) provide a method to solve a model with the traditional financial accelerator credit market set-up, but this is far more complicated in a framework combing interlinked credit contracts and domestic liquidity provision. I use the Dynare software to compute the steady state and linearise the model around the steady state. The computations are based on calibrating the model using traditional parameter values from the literature, as well to attain sensible interest rate spreads and shocks to those spreads.

I follow Hirakata et al. (2009) and Bernanke et al. (1999) for many of the calibrated parameter values (Table 3). These include parameter values related to the real economy, such as the discount factor, capital depreciation rate, capital share, risk free interest rate, elasticity of labour, utility weight on leisure, investment adjustment costs, and most of the autoregressive parameters associated with the shocks. I also follow Hirakata et al. (2009) to calibrate six parameters associated with the two credit contracts in the former financial intermediation process, i.e. the standard deviation of the idiosyncratic disturbances to investment banks' and entrepreneurs' productivity in steady state, the monitoring costs, and the two survival rates. I calibrate $\bar{d}$ to ensure that the household debt as a ratio to GDP is in line with the average for small open economies included in Cecchetti et al. (2011). The debt elastic interest rate parameter is taken from Schmitt-Grohé and Uribe (2003). The standard deviation of shocks to the global liquidity shock is based on Garcia-Cicco et al. (2010).

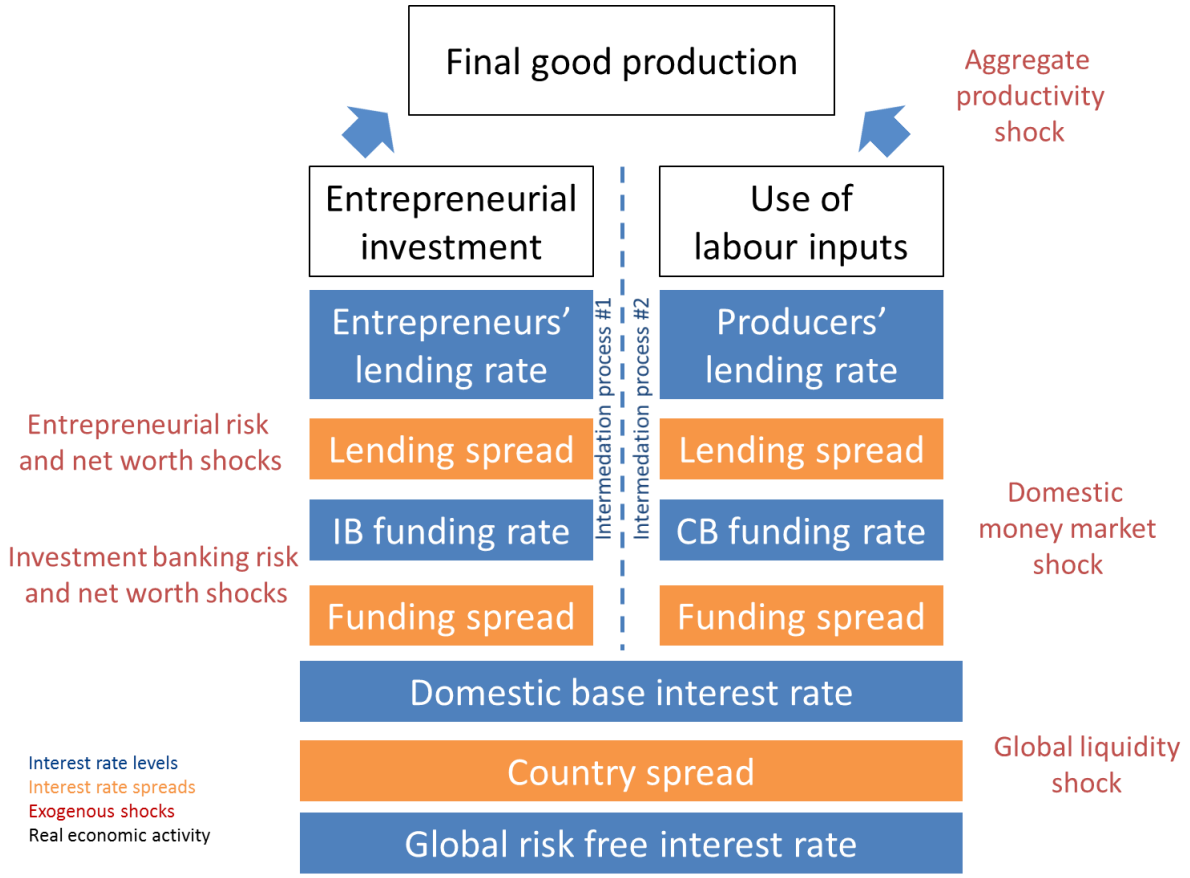
Parameters for the domestic money market are chosen to attain roughly the average historical quarterly interest rate spread between 3-month interbank rates and 3-month treasury bills (Ted spread), which is roughly 60 basis points (bps.) over the period 1986-2016. The money market shock is calibrated to produce a roughly 200-250 bps. increase in the TED spread, as has been the case in a few episodes over this period. The Central Bank's reserve requirement ratio is set to produce a roughly 300 bps. spread between commercial banks' lending and funding rate. This implies a high value for the ratio, but its main role within the model is to produce a lending to funding spread of reasonable value.

Before analysing the equilibrium responses of the model economy to some of the exogenous shocks, Figure 4 provides a graphical representation of the model's key macrofinancial linkages, which will serve as a useful roadmap for the interpretation of the impulse responses in Section 4.

Table 3 Parameterisation of the model

Parameter	Value	Description	Source
β	0.99	Discount factor	Hirakata et al. (2009)
δ	0.025	Capital depreciation rate	Hirakata et al. (2009)
α	0.35	Capital share in final goods production	Hirakata et al. (2009)
R	0.99^{-1}	Risk-free rate	Hirakata et al. (2009)
η	3	Elasticity of leisure	Hirakata et al. (2009)
χ	0.3	Utility weight on leisure	Hirakata et al. (2009)
κ	2.5	Investment adjustment cost	Hirakata et al. (2009)
$\rho_a, \rho_{\sigma^F}, \rho_{\sigma^E}$	0.85	Persistence of productivity and risk shocks	Hirakata et al. (2009)
$\bar{\sigma}^F$	0.107366	Standard deviations of risk shocks in investment banking at steady state	Hirakata et al. (2009)
$\bar{\sigma}^E$	0.312687	Standard deviations of entrepreneurial sector risk shocks at steady state	Hirakata et al. (2009)
$\bar{\sigma}^a$	0.0098	Standard deviations of total factor productivity shocks	Hirakata et al. (2011)
μ^F	0.033046	Bankruptcy costs in investment banking	Hirakata et al. (2009)
μ^E	0.013123	Bankruptcy costs in the entrepreneurial sector	Hirakata et al. (2009)
γ^F	0.963286	Survival rate in investment banking	Hirakata et al. (2009)
γ^F	0.983840	Survival rate in the entrepreneurial sector	Hirakata et al. (2009)
Ω^F	0.01	Investment banks' share of labour input	Ueda (2012)
Ω^E	0.01	Entrepreneurs' share of labour input	Ueda (2012)
ψ_g	0.0001	Debt elastic interest rate parameter for the domestic base interest rate level	Schmitt-Grohé and Uribe (2003)
$\bar{d}$	0.007	Household debt to GDP ratio at steady state	Cecchetti et al. (2011)
ρ_{μ^g}	0.85	Persistence of the global liquidity shock	
σ_{μ^g}	0.056	Standard deviation of the global liquidity shock	Garcia-Cicco et al. (2010)
σ_{NF}	0.01	Standard deviation of net worth shock in investment banking	
σ_{NE}	0.01	Standard deviation of net worth shock in the entrepreneurial sector	
$\rho_{\sigma^{NF}}, \rho_{\sigma^{NE}}$	0.85	Persistence of net worth shock in investment banking and the entrepreneurial sector	Same persistence as for others.
ψ_d	0.2	Balance sheet elastic interest rate parameter for the commercial banks	Average quarterly historical TED spread of roughly 60 bps.
$\bar{L}$	3.00	Commercial bank assets at steady state	
ρ_{μ^d}	0.85	Persistence of the money market shock	Same persistence as for others.
σ_{μ^d}	0.1	Standard deviation of the money market shock	250 bps. TED spread increase.
φ^{RR}	0.75	Required reserve ratio	300 bps. lending to funding spread.

Figure 4 Overview of the model's key macrofinancial linkages



Risk shock in the entrepreneurial sector

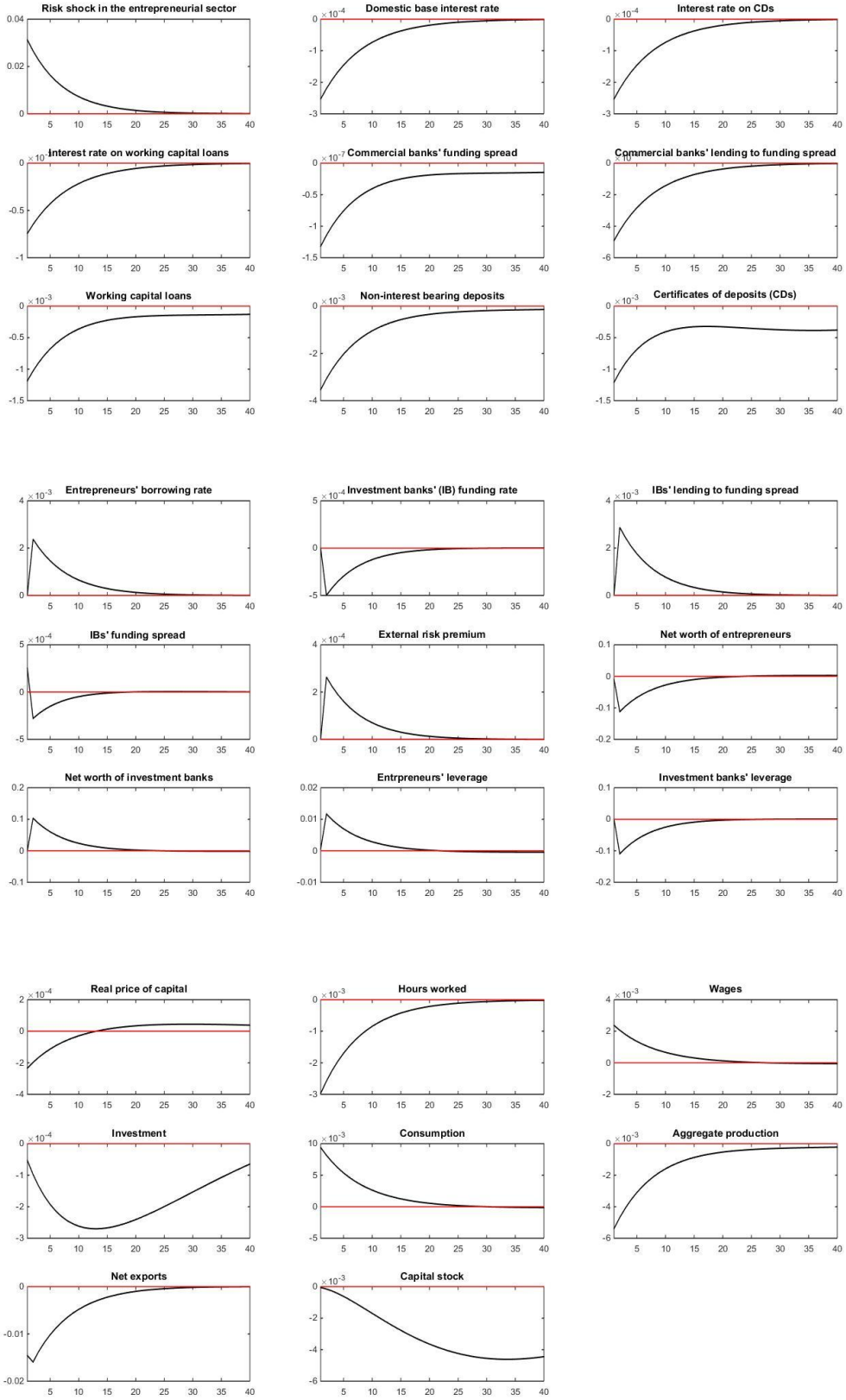
Figures 5 portrays the equilibrium responses to increased risk in the domestic entrepreneurial sector. The first thing to note is that the domestic base interest rate level declines, which plays an important role in causing consumption to increase and mitigate the otherwise contractionary effects of this shock. At first, this is surprising, but actually this reflects a common feature of real business cycle models with financial frictions. When financial shocks are transmitted in such models, they interfere with intertemporal substitution and due to the simple and frictionless set-up of the real economy, current consumption relative to future consumption (i.e. the real interest rate) declines, inducing increased consumption. This would not necessarily take place in a more realistic set-up with nominal rigidities and monetary policy based on a traditional Taylor rule, as these factors would dampen the real interest rate response. However, the focus in this paper is on the interaction between credit intermediation to the corporate sector through two processes including a number of interest rate spreads, on the one hand, and investment and production, on the other.

Figure 5 shows that as riskiness in the entrepreneurial sector increases, entrepreneurs' borrowing rate goes up, as investment banks' increase the spread on those loans relative to their own funding costs. This reaction is due to the fact that as riskiness increases, bankruptcies among entrepreneurs increase as a larger share of investment projects fail to attain sufficient returns to repay debt. As a result, the price of capital falls, entrepreneurs' net worth declines, and their leverage increases, resulting in a higher external finance premium. Hence, entrepreneurial investment activity falls, leading to further decreases in the price of capital, and tightening of credit constraints through the aforementioned dynamics. This amplification of shocks through credit frictions is why models with such features were generally referred to as financial accelerator models.

This shock originates in the entrepreneurial sector, and works its way through the former financial intermediation process to affect investment, and thereby production. Looking at the reaction in the latter financial intermediation process, movements in commercial banks' funding and lending rate seem to be reflect the fall in the domestic base interest rate level (discussed above), and the reaction in interest rate spreads is very muted. However, working capital loans decrease as demand for labour decreases alongside less investment and production. Hence, this is an example of the interaction between the two processes of financial intermediation, which in this case seem to first and foremost work their way through real economy linkages in aggregate production. Other types of macrofinancial linkages, through which the two intermediation process will interact, will become apparent when other shocks will be discussed below.

Finally, a positive shock would have had the opposite effects, making the model able to produce qualitative boom-bust behaviour around the steady state, although coming short from having the capacity to yield truly destabilising dynamics.

Figure 5 Impulse responses to a risk shock in the entrepreneurial sector



Risk shock in investment banking

The effects of a risk shock taking place in investment banking is shown in Figure 6. There are three important interrelated differences between the effects of a risk shock in investment banking compared to its previously discussed entrepreneurial counterpart.

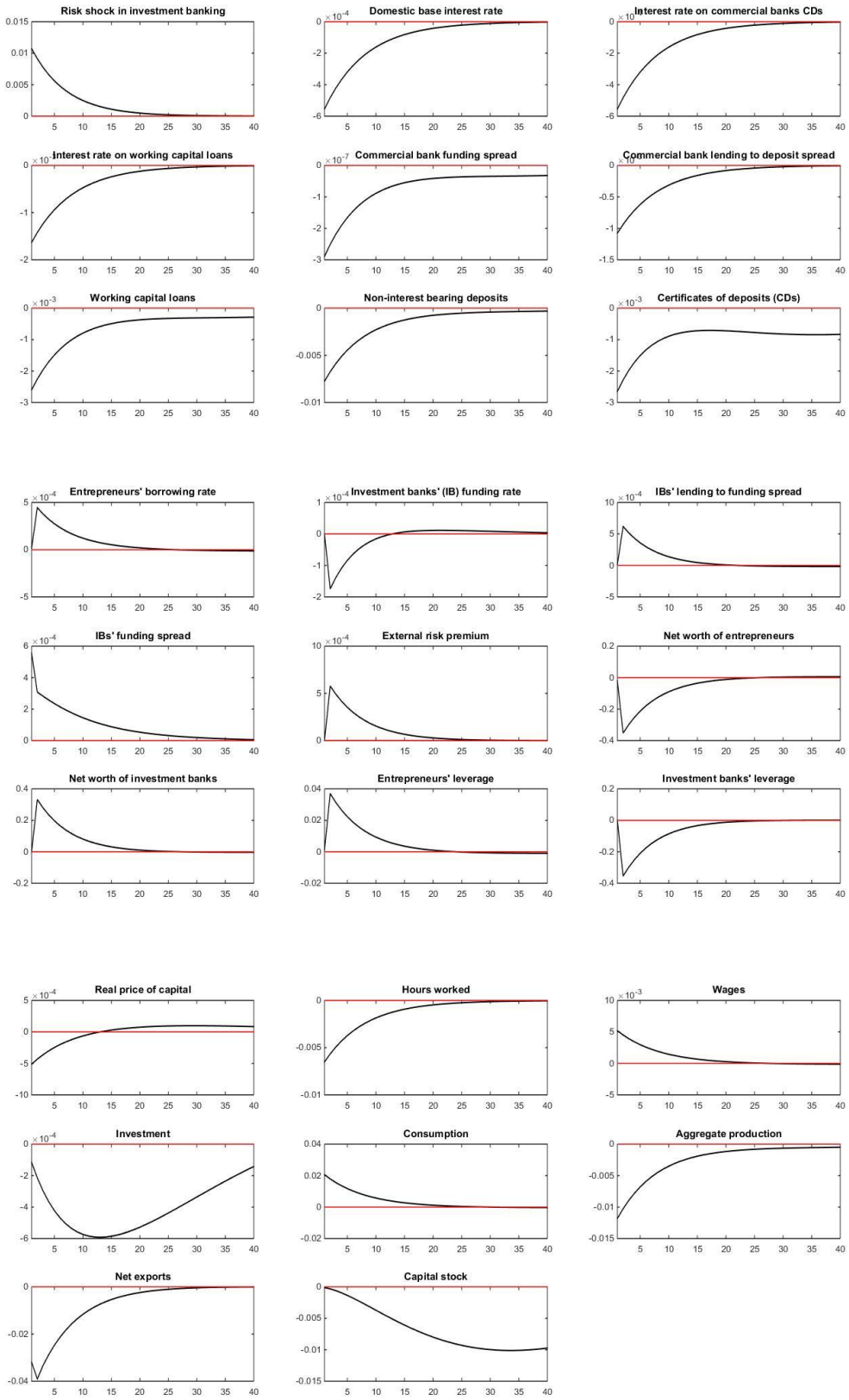
First, in contrast to the increase in entrepreneurs' borrowing rate as a result of a risk shock in their own sector, investment banks' funding rate decreases after they experience a negative sectoral risk shock. This reflects that the investment banks' funding rate reaction is dominated by the decline in the base interest rate level. This again reflects that the investment banks receive their funds from global banks at a spread over the base interest rate, while entrepreneurs' borrowing cost include an additional spread due to the extra step of intermediating the funds through the investment banks.

Second, as the effects of increased riskiness in investment banking work their way across the credit market and interact with the real economy (Figure 6), investment banks' leverage declines instead of increasing as in the case of entrepreneurs in Figure 5. This also reflects the difference positions of the two sectors in the intermediation process, as well as their specific balance sheet characteristics. Investment banks are the main actors in this former intermediation process in the model, such that they can affect key parameters in the interlinked credit contracts, resulting in a redistribution of losses across sectors. Entrepreneurs, however, are the ultimate borrowers in this credit process and are not in a position to mitigate the effects of a negative shock in the same manner. As a result of a negative risk shock, investment banks increase the spread between their lending and funding rate, which supports their own net worth (also helped by the direct decline in their funding rate which dominates their increased funding spread), but undermines the financial position of entrepreneurs. As a result, the investment banks deleverage, which is particularly important for them as they operate with more leverage than the entrepreneurs. The model's capacity to produce sectoral leverage dynamics of this kind, is discussed further below.

A final important distinction between the two risk shocks is that the macroeconomic effects of a shock originating in investment banking are considerably larger compared to when they originate in the corporate sector. Hence, the effects that work their way across the real economy and towards commercial banks' domestic liquidity provision is also stronger, as reflected in a larger drop in working capital loans. This sizeable difference in macroeconomic effects also reflects the aforementioned interrelated characteristics that investment banks are highly leverage institutions that due to their importance in the credit intermediation process can strongly affect the propagation and acceleration of negative shocks, both across sectors, aggregate production, and the other financial intermediation process.

These two risk shocks therefore provide important insight into the workings of model. Clearly there are important differences and interactions between the two sectors, providing preliminary evidence supportive of the modelling approach takin with regard to the credit market. In particular, it seems promising that the models gives raise to procyclical leverage dynamics resulting from investment bank behaviour within the model. This feature has been emphasised in a number of papers, in particular, by Adrian and Shin (2009, 2010, 2011).

Figure 6 Impulse responses to a risk shock in investment banking



Domestic money market shock

Figure 7 shows the effects of an adverse domestic liquidity shock in money markets, affecting the terms of commercial bank funding. Indeed, the banks' funding spread on the market increases and they respond by increasing their lending to funding spread (more than one-to-one for their balance sheet constraint to hold). This results in balance sheet deleveraging in the sense that the commercial banks' assets and liabilities shrink. Importantly, working capital loans decrease, as do labour usage and aggregate production through this working capital channel.

The dynamic response in the other financial intermediation process is interesting, especially in light of the discussion above in relation to risk shocks in the two credit market participants' sectors. The shock considered here originated in the domestic money market where neither investment banks nor entrepreneurs are assumed to participate. Hence, the effects of the shocks reach these sectors through the effect that the working capital channels has on investment via its effect on aggregate production. This is different from the risk shock scenarios where the effects were first transmitted across the interlinked credit contracts, and then affected the real economy. As shown in Figure 7, entrepreneurs respond to the contractionary effects on investment activity by deleveraging, which leads to a decrease in the investment banks' lending to funding spread, causing their net worth to decline. Hence, the fall in investment demand from entrepreneurs causes problems for the leveraged investment banks and, in contrast to the risk shocks, their capacity to propagate their problems onto the entrepreneurs is not the same.

Global liquidity shock

Figure 8 shows the impulse responses to a global liquidity shock, which is the only shock that directly affects the domestic base interest rate level. In contrast to the fall in the base interest rate level observed in previous domestic shocks, it increases following an adverse global liquidity shock, and now both financial intermediation processes are affected at once. Interestingly, both the commercial and investment banks' funding spread actually fall on impact, such that the raise in the base interest rate is not fully transmitted into their funding rate. These banks are therefore to some extent guarded against global shocks, but nevertheless, both intermediary types respond to this adverse shock by increasing their lending to funding spreads. The result is therefore that contractionary macroeconomic effects work their way across both intermediation processes, and onwards through the working capital and investment channels.

In case of a shock where the ease of financing in global financial system is enhanced, the opposite result would arise, with production being supported by enhanced financial intermediation on both parts of the credit market. Hence, the model captures some parts of possible risks associated with international capital flows and domestic financial conditions (cf. Jeanne and Korinek, 2010, Korinek, 2011, Rey, 2013, Cerutti et al., 2014, Brunnermeier and Sannikov, 2015, and Central Bank of Iceland, 2016).

Figure 7 Impulse responses to a domestic money market shock

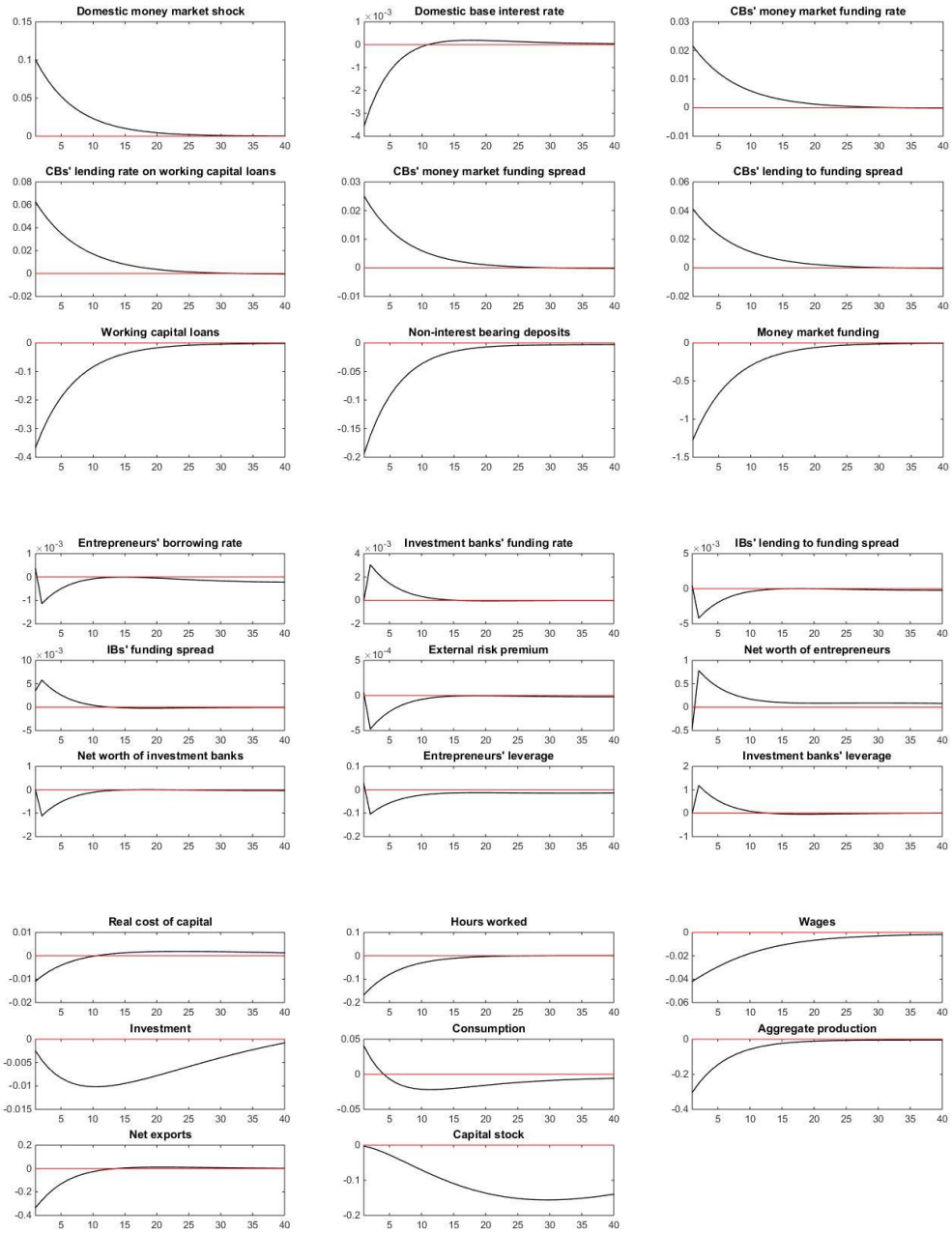
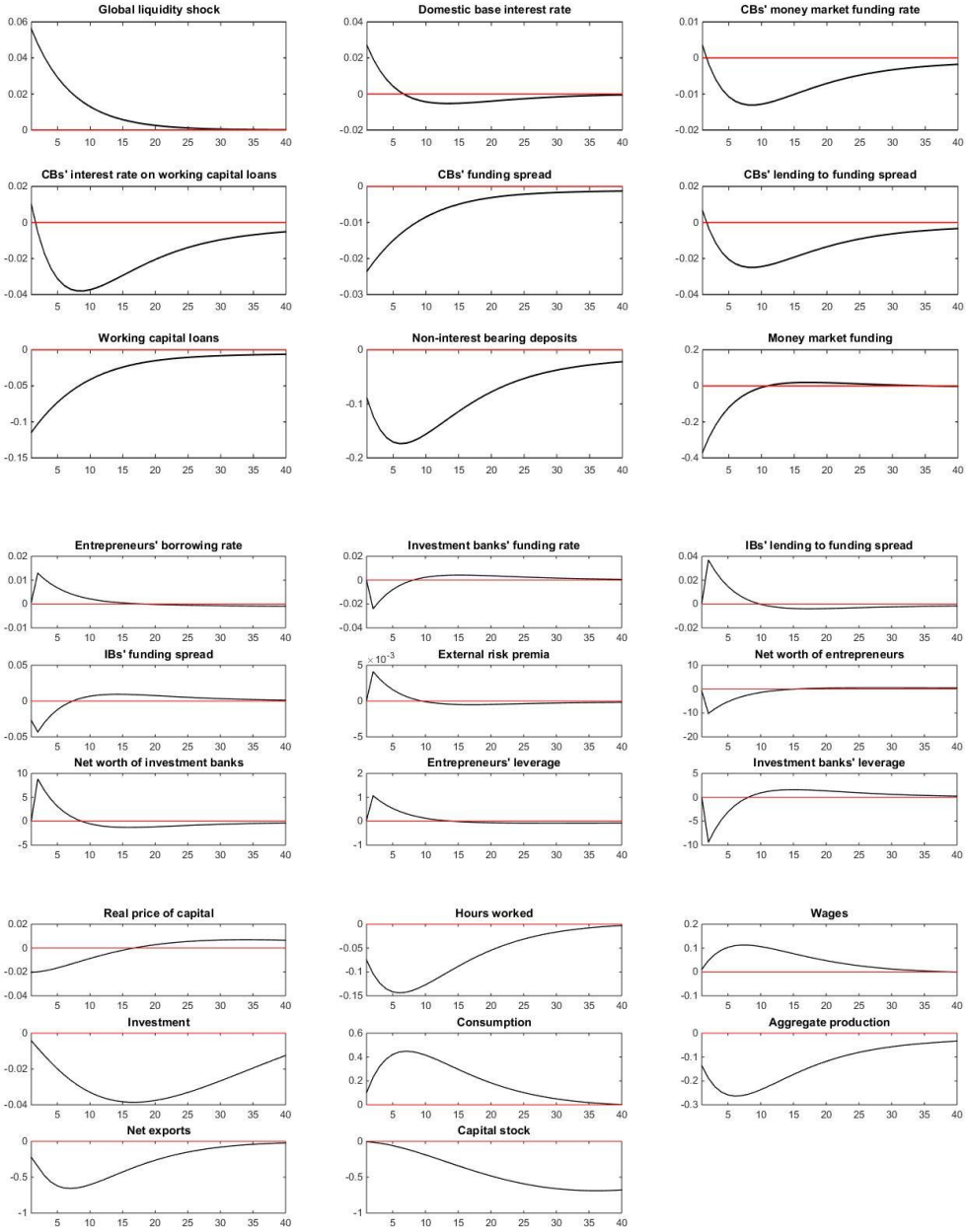


Figure 8 Impulse responses to a global liquidity shock



5 Conclusions

In this paper, a small open economy DSGE model is developed where investment banks and commercial banks intermediate global and domestic liquidity to the corporate sector through two financial intermediation processes. In particular, global liquidity is intermediated by investment banks to entrepreneurs through interlinked credit contracts, that allow for asymmetric information and bankruptcies which give rise to domestic and global interest rate and balance sheet relations through which the financial intermediation and the real economy interact. On the other hand, commercial banks intermediate domestic liquidity to cash-in-advance constrained final good producers. Hence, production within the economy depends on both financial intermediation processes as they enable funding and development of key production inputs. The richness of the credit market framework is reflected in the number of market participants, interest rate spreads, and shocks, as well as the diverse feedback and propagation mechanisms that it gives rise to between the financial system and the real economy.

The economic analysis of the model served to illuminate in a qualitative manner how the interconnectedness within the financial system and the macrofinancial linkages transmit shocks within the financial sector and across the real economy. The analysis showed that the model is qualitatively capable of producing a number of features in this regard, which have been emphasised in the literature.

First, the model has financial accelerator characteristics as risk shocks can give rise to boom-bust investment dynamics that are strengthened by the presence of investment banks and the interlinked credit contracts. This is unsurprising as the Hirakata et al. (2009) is used as the underlying framework for one of the financial intermediation processes.

Second, in contrast to Hirakata et al. (2009), the model also includes another intermediation process, where on the one hand, there is a role for specific domestic money market pressures that propagate through the working capital channel to the rest of the model. On the other hand, there is also an important role for shocks of various kinds to interact across the two financial intermediation processes, which is a relatively rare feature in financial friction models. This can reflect common shocks (i.e. the global liquidity shock) affecting both investment banks and commercial banks, but also shocks originating in either of the two intermediation processes (e.g. risk shocks or domestic money market shocks) that propagate across the two processes via the real economy. Hence, the model provides a richer framework than many other financial friction models, including Bernanke et al. (1999) and Hirakata et al. (2009), both with regard to the linkages within the financial system, global spillovers to the domestic financial system, and the macrofinancial linkages in place.

Third, there is a role for a central bank as a liquidity regulator in the model in the sense that commercial banks are assumed to be regulated, while investment banks and saving funds are unregulated. This is a realistic assumption for many small advanced economies. Another difference between commercial and investment banks in the model is that the costly state verification framework is applied to the more risky investment banking activity that operates across borders and involves funding risky entrepreneurial investments, while a simpler

approach is applied to model the more traditional and purely domestic liquidity services of commercial banks.

The qualitative capacity of the model to produce and analyse important macrofinancial features, such as procyclical leverage dynamics of investment banks, money market pressures, global liquidity spillovers, and a wide range of financial and macroeconomic interlinkages (including through investment and working capital channels), indicates that this approach deserves further examination and extensions.

Appendix 1 Solution to the investment banks' maximisation problem

The monopolistic domestic investment bank maximizes its expected profits:

$$\max_{\bar{\omega}^{F},\bar{\omega}^{E},\ K} \sum_{s^{t+1}} \pi(s^{t+1}|s^{t})[1 - \Gamma^{F}(\bar{\omega}^{F}(s^{t+1}|s^{t}))][1 + R^{F}(s^{t+1}|s^{t})][Q(s^{t})K_{i}(s^{t}) - N_{i}^{E}(s^{t})] \quad \text{(A1.1)}$$

where $\pi(s^{t+l}|s^{t})$ is the probability weight for state s^{t+l} given state s^{t+l-1}, $[1 - \Gamma^{F}(\bar{\omega}^{F}(s^{t+1}|s^{t}))]$ represents the share of investment banks' earnings kept by the institutions themselves, $[1 + R^{F}(s^{t+1}|s^{t})]$ is the average return on the FE contracts, and $[Q(s^{t})K_{i}(s^{t}) - N_{i}^{E}(s^{t})]$ the amount lent to entrepreneurs. This maximization is solved subject to the participation constraints of the entrepreneurs and the global banks, respectively:

$$\{(1 - \Gamma_{t}^{E}(\bar{\omega}_{j_i}^{E}(s^{t+1}|s^{t}))\}(1 + R^{E}(s^{t+1}|s^{t}))Q(s^{t})K_{j_i}(s^{t}) \geq (1 + R^{E}(s^{t+1}|s^{t}))N_{j_i}^{E}(s^{t})\ \forall j_i, s^{t+1}|s^{t} \quad \text{(A1.2)}$$

$$\left\{\Gamma_{t}^{F}\left(\bar{\omega}_{i}^{F}(s^{t+1}|s^{t})\right) - \mu^{F}G_{t}^{F}\left(\bar{\omega}_{i}^{F}(s^{t+1}|s^{t})\right)\right\}(1 + R^{F}(s^{t+1}|s^{t}))[Q(s^{t})K_{i}(s^{t}) - N_{i}^{E}(s^{t})] \geq (1 + R(s^{t}))[Q(s^{t})K_{i}(s^{t}) - N_{i}^{E}(s^{t}) - N_{i}^{F}(s^{t})] \quad \text{(A1.3)}$$

I focus on the case where these participation constraints hold with equality. For the entrepreneurs, this implies that their share of returns from investing their net equity and borrowed funds are equal to what they would receive from investing only their equity. In equation (A1.2) above, $\{(1 - \Gamma_{t}^{E}(\bar{\omega}_{j_i}^{E}(s^{t+1}|s^{t}))\}$, represents the expected share of entrepreneurial earnings kept by the entrepreneurs according to the FE contract, and $\Gamma_{t}^{E}(\bar{\omega}_{j_i}^{E}(s^{t+1}|s^{t}))$, represents the gross share of entrepreneurial earnings received by the investment banks according to the same contract. The participation constraint of the global banks (equation A1.3) reflects that their net earnings from the GF contract must equal their opportunity cost of lending, $(1 + R(s^{t}))$. The expression $\left\{\Gamma_{t}^{F}\left(\bar{\omega}_{i}^{F}(s^{t+1}|s^{t})\right) - \mu^{F}G_{t}^{F}\left(\bar{\omega}_{i}^{F}(s^{t+1}|s^{t})\right)\right\} \equiv \Phi^{F}(\bar{\omega}^{F}(s^{t+1}|s^{t})$ represents the net share of investment banks' earnings going to global banks according to the GF contract. I make us of the definition of the

expected return on the loans to entrepreneurs, $(1 + R^F(s^{t+1}|s^t))$ in equation (8) to rewrite the investment banks' expected profits as

$$\max_{\bar{\omega}^F, \bar{\omega}^E,\ K} \sum_{s^{t+1}} \pi(s^{t+1}|s^t)[1 - \Gamma^F(\bar{\omega}^F(s^{t+1}|s^t))]\Phi^F_{j_i,t}(\bar{\omega}^F_{j_i}(s^{t+1}|s^t))(1 + R^E(s^{t+1}|s^t))Q(s^t)K_i(s^t) \quad \text{(A1.4)}$$

where $\Phi^E_{j_i,t}(\bar{\omega}^E_{j_i}(s^{t+1}|s^t))$ represents the net share of entrepreneurial earnings going to the investment banks according to the FE contract. I also rewrite the global banks' participation constraint replacing $(1 + R^F(s^{t+1}|s^t))$ and using $\Phi^F(\bar{\omega}^F(s^{t+1}|s^t)$ instead of $\left\{\Gamma^F_t\left(\bar{\omega}^F_i(s^{t+1}|s^t)\right) - \mu^F G^F_t\left(\bar{\omega}^F_i(s^{t+1}|s^t)\right)\right\}$. Hence, the Lagrangian function becomes:

$$\begin{aligned} &L(\bar{\omega}^F, \bar{\omega}^E,\ K) \\ &= \sum_{s^{t+1}} \pi(s^{t+1}|s^t)[1 - \Gamma^F(\bar{\omega}^F(s^{t+1}|s^t))]\Phi^E_{j_i,t}(\bar{\omega}^E_{j_i}(s^{t+1}|s^t))(1 + R^E(s^{t+1}|s^t))Q(s^t)K_i(s^t) \\ &+\lambda^1\left\{\Phi^F(\bar{\omega}^F(s^{t+1}|s^t)\Phi^E_{j_i,t}(\bar{\omega}^E_{j_i}(s^{t+1}|s^t))(1 + R^E(s^{t+1}|s^t))Q(s^t)K_i(s^t) - (1\right. \\ &\left. + R(s^t))[Q(s^t)K_i(s^t) - N^E_i(s^t) - N^F_i(s^t)]\right\} \\ &+\lambda^2\left[\left\{(1 - \Gamma^E_t(\bar{\omega}^E_{j_i}(s^{t+1}|s^t))\right\}Q(s^t)K(s^t) - N^E(s^t)\right] \end{aligned} \quad \text{(A1.5)}$$

The first-order-conditions of the maximization problem with regard to $\bar{\omega}^F, \bar{\omega}^E$ and K, respectively, are given by:

$$\lambda^1 = \frac{\sum_{s^{t+1}} \pi(s^{t+1}|s^t)\Gamma'^F(\bar{\omega}^F(s^{t+1}|s^t))}{\Phi'^F(\bar{\omega}^F(s^{t+1}|s^t)} \quad \text{(A1.6)}$$

$$\sum_{s^{t+1}} \pi(s^{t+1}|s^t)[1-\Gamma^F(\bar{\omega}^F(s^{t+1}|s^t))]\Phi'^E_{j_{i,t}}(\bar{\omega}^E_{j_i}(s^{t+1}|s^t))(1+R^E(s^{t+1}|s^t)) \quad \text{(A1.7)}$$

$$+\lambda^1\Phi^F(\bar{\omega}^F(s^{t+1}|s^t)\Phi'^E_{j_{i,t}}(\bar{\omega}^E_{j_i}(s^{t+1}|s^t))(1+R^E(s^{t+1}|s^t)$$
$$-\lambda^2\Gamma'^F\left(\bar{\omega}^F(s^{t+1}|s^t)\right)=0$$

$$\sum_{s^{t+1}} \pi(s^{t+1}|s^t)[1-\Gamma^F(\bar{\omega}^F(s^{t+1}|s^t))]\Phi^E_{j_{i,t}}(\bar{\omega}^E_{j_i}(s^{t+1}|s^t))(1+R^E(s^{t+1}|s^t))$$

$$+\lambda^1\left[\Phi^F(\bar{\omega}^F(s^{t+1}|s^t)\Phi^E_{j_{i,t}}\left(\bar{\omega}^E_{j_i}(s^{t+1}|s^t)\right)(1+R^E(s^{t+1}|s^t)\right)-(1+R(s^t))] \quad \text{(A1.8)}$$

$$+\lambda^2\left[1-\Gamma^F\left(\bar{\omega}^F(s^{t+1}|s^t)\right)\right]=0$$

Inserting (A1.6) into (A1.7) and simplifying yields

$$\lambda^2 =$$

$$\frac{\sum_{s^{t+1}} \pi(s^{t+1}|s^t)[1-\Gamma^F(\bar{\omega}^F(s^{t+1}|s^t))]\Phi'^E_{j_{i,t}}(\bar{\omega}^E_{j_i}(s^{t+1}|s^t))(1+R^E(s^{t+1}|s^t))}{\Gamma'^F\left(\bar{\omega}^F(s^{t+1}|s^t)\right)} \quad \text{(A1.9)}$$

$$+\frac{\sum_{s^{t+1}} \pi(s^{t+1}|s^t))]\Gamma'^F\left(\bar{\omega}^F(s^{t+1}|s^t)\right)\Phi^F(\bar{\omega}^F(s^{t+1}|s^t)\Phi'^E_{j_{i,t}}(\bar{\omega}^E_{j_i}(s^{t+1}|s^t))(1+R^E(s^{t+1}|s^t))}{\Gamma'^F\left(\bar{\omega}^F(s^{t+1}|s^t)\right)\Phi'^F(\bar{\omega}^F(s^{t+1}|s^t)}$$

Inserting into (A1.8) yields equation (14) in the main text, i.e.:

$$0 = \sum \pi(s^{t+1}|s^t)$$

$$\left\{\left[1 - \Gamma_t^F\left(\bar{\omega}_i^F(s^{t+1}|s^t)\right)\right]\Phi_{i,t}^F(s^{t+1}|s^t)[1 + R^E(s^{t+1}|s^t)]\right\}$$

$$+\frac{\Gamma_t'^F(\bar{\omega}_i^F(s^{t+1}|s^t))}{\Phi_{i,t}'^F(\bar{\omega}_i^F(s^{t+1}|s^t))}\Phi_{i,t}^F(s^{t+1}|s^t)\Phi_{i,t}^E(s^{t+1}|s^t)[1 + R^E(s^{t+1}|s^t)]$$

$$-\frac{\Gamma_t'^F\left(\bar{\omega}_i^F(s^{t+1}|s^t)\right)}{\Phi_{i,t}'^F\left(\bar{\omega}_i^F(s^{t+1}|s^t)\right)}[1 + R(s^t)]$$

$$+\frac{\left[1 - \Gamma_t^F\left(\bar{\omega}_i^F(s^{t+1}|s^t)\right)\right]\Phi_{i,t}'^E(s^{t+1}|s^t)}{\Gamma_t'^E(\bar{\omega}_{j_i}^E(s^{t+1}|s^t))}[1 - \Gamma_t^E\left(\bar{\omega}_{j_i}^E(s^{t+1}|s^t)\right)][1 \quad (A1.10)$$

$$+ R^E(s^{t+1}|s^t)]$$

$$+\frac{\Gamma_t'^F(\bar{\omega}_i^F(s^{t+1}|s^t))\Phi_{i,t}^F(s^{t+1}|s^t)\Phi_{i,t}'^E(s^{t+1}|s^t)}{\Phi_{i,t}'^F\left(\bar{\omega}_i^F(s^{t+1}|s^t)\right)\Gamma_t'^E(\bar{\omega}_{j_i}^E(s^{t+1}|s^t))}\left[1 - \Gamma_t^E\left(\bar{\omega}_{j_i}^E(s^{t+1}|s^t)\right)\right][1$$

$$+ R^E(s^{t+1}|s^t)], \forall j_i.$$

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