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 indeed 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 and including data on credit, house prices, and bank balance sheet size and composition, we find that 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. 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. Furthermore, our results show 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. 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 (usually coinciding or with the Icelandic cyclical peak lagging by a year or two). There is also evidence that these spillover effects have been growing stronger over time. 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.

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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 indeed 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., 2014) 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, although other variables may provide useful complementary information. On this basis, we measure the financial cycle as the low-frequency cyclical co-movement of a set of financial variables, 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, 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 further to more than 80% in the post-1980 period. 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 Part I of our study. 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 financial 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 its strong and long-standing trade and financial links. 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. (2014). 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 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 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 issues these 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 relationship 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 one. 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.[1] 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., 2014, 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 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

[1] 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 its 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.[2] 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).[3]

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.

[2] Although cross-border banking liabilities can also serve as a proxy for (gross) capital flows, the first part of our study (Einarsson et al., 2015) suggests 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.

[3] 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. (2014) 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. (2014) 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. (2014) and use the Christiano and Fitzgerald (2003) asymmetric band-pass filter to isolate the pre-specified frequency range of the data.[4] 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.[5] 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.[6]

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 a financial cycle.

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

[4] 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 our previous study (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.

[5] Aikman et al. (2014) 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.

[6] 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.

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 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).[7]

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

[7] 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 also 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.

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	
	Expansion	Contraction	Full cycle	Expansion	Contraction	Expansion	Contraction
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
Bank 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 liabilities	6.00	5.50	11.00	0.04	-0.04	0.01	0.00
Total non-core liabilities	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 demand	5.00	5.50	10.00	0.16	-0.14	0.03	-0.03
Trade deficit-to-GDP ratio	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
Macroeconomic 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
Macroeconomic 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 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. 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 applies 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 3, which compare medium-term cycles in each variable with complete 2-30 year cycles. As the figures clearly show, the medium-term cycle captures a large part of the complete cycle 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. (2014) 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
Bank 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
Macroeconomic 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.[8] 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	Bank 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
Bank assets-to-GDP							1.00	-0.13	0.72	0.66
Bank leverage								1.00	0.08	-0.51
Foreign 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.[9] 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.

[8] 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.

[9] 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. they 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	Bank 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
Bank assets-to-GDP							1.00	-0.50	0.36	0.49
Bank leverage								1.00	-0.03	-0.90
Foreign 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
Bank assets-to-GDP							1.00	0.27	0.83	0.76
Bank leverage								1.00	0.19	0.00
Foreign 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
Bank assets-to-GDP							1.00	0.55	0.85	0.83
Bank leverage								1.00	0.51	0.53
Foreign non-core liab.									1.00	0.98
Total non-core liab.										1.00

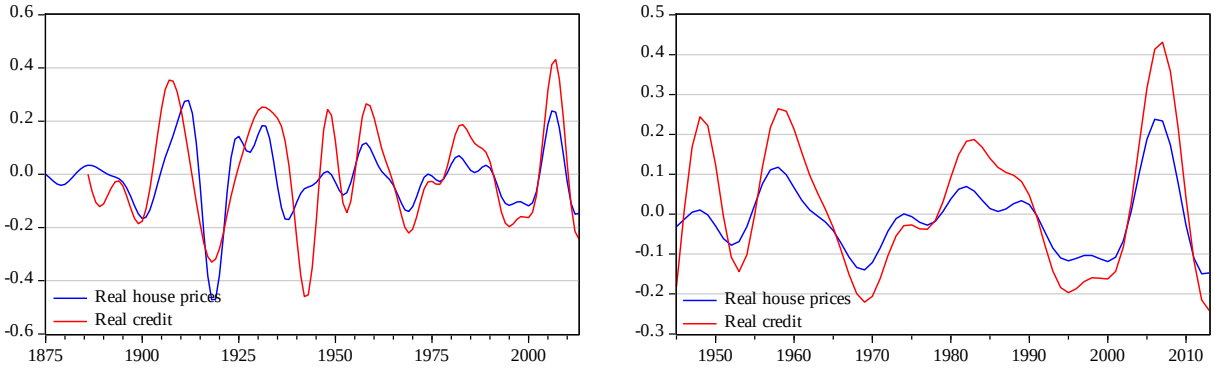
The table gives the contemporaneous correlations of the medium-term cyclical component of the financial variables for three different subsamples. Shaded sells highlight correlation coefficients larger than or equal to 0.7.

Source: Authors' calculations.

Figure 1 gives a visual impression of this tight co-movement among some of the key financial variables. It 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.[10] Such co-movement is what the financial cycle aims to capture.

[10] 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.

Figure 1 Medium-term cycles in house prices and credit
1875-2013 period (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 economic 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. The weights are obtained using a principal component analysis, which basically allows us to obtain different linear combinations of our variables that maximise the variability of each combination, while ensuring that they remain orthogonal to each other. We thus identify the aggregate financial cycle as the first principal component, i.e. the one that explains most of the combined variability in our set of financial variables. We therefore take a broader approach of measuring the financial cycle than, for example, Aikman et al. (2014) 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.[11] 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
Bank 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 linked 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. (2014), the limited role of bank leverage found here probably reflects the impact of financial depression 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

[11] 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 equity 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).

rather than the financial expansions reflected in the other financial variables. As discussed in 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.

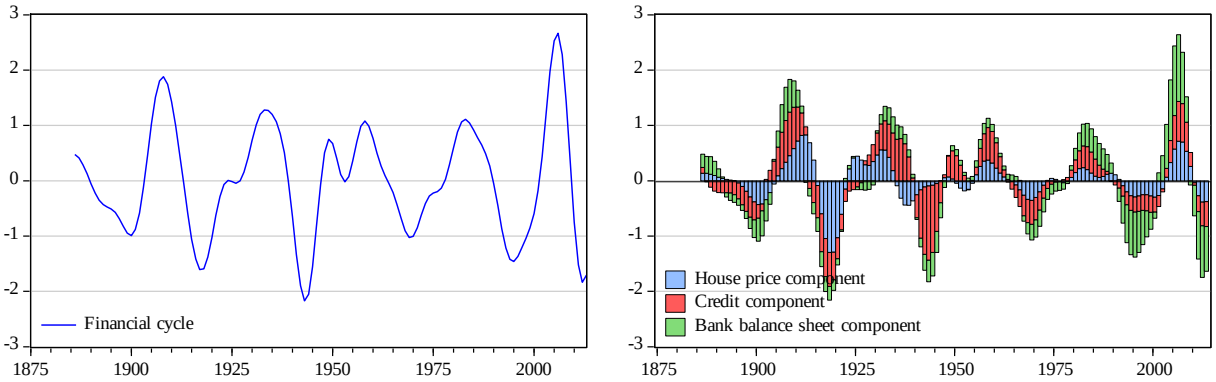
As it is not meaningful in the context of our exercise to include variables with a negative weight in our measure of a common financial cycle, we exclude the three variables with negative loadings in our subsequent analysis of the aggregate cycle (Schüler et al., 2015, use similar arguments). The resulting "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.[12] 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 estimated 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.

[12] Our results are therefore almost identical to using a simple average (as suggested by Drehmann et al., 2012). It may also be noted that when the three excluded variables are included in the subsample estimates, they obtain very small, albeit positive, weights and the aggregate cycle is basically identical to the one presented here (the correlation coefficients are in all cases equal to 0.97 or more). 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).

Figure 2 The financial cycle and contribution of individual cyclical components

Financial cycle (left) and contribution of 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.

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 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 sheet management 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.

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.[13]

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 3, which shows the

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

development of the financial cycle and the medium-term cycles in individual series).[14] 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.

Table 7 Correlations and concordance 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
Bank 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 liabilities	0.75	0.50	0.91	0.95	0.76	0.60	0.88	0.97
Total non-core liabilities	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 ratio	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
Macroeconomic 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.

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 (cf. Claessens et al., 2011). 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 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

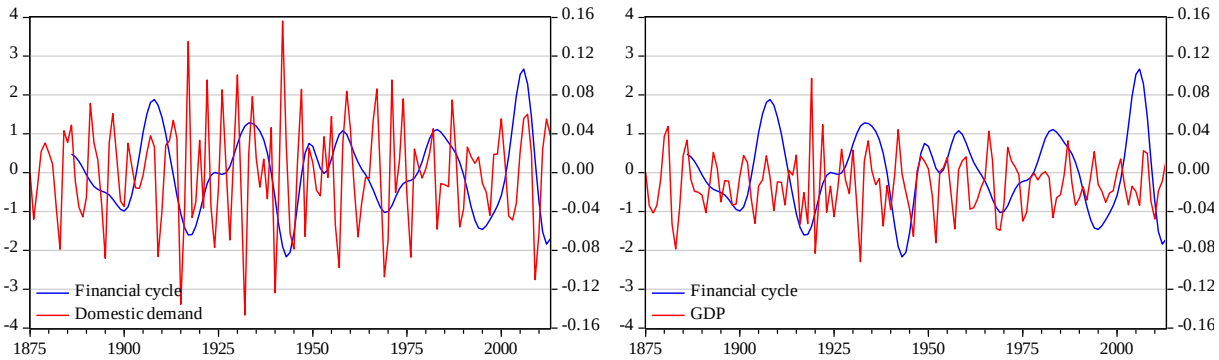
[14] Two series which are perfectly pro-cyclical (counter-cyclical) would therefore have a concordance index equal to unity (zero). For two series with fully independent cycles (hence, have a correlation coefficient equal to zero), however, the concordance index would equal 0.5.

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.[15]

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 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 only 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



Financial cycle (left axis) and short-term cycles in domestic demand and GDP (right axis).

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

[15] 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. they continue to hold if we end the sample in 2003).

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.[16] 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.[17]

Table 8 Domestic demand and GDP in different phases of the financial cycle

	Total sample	1875-1944	1945-2013	1980-2013
		Domestic demand		
Growth in expansionary phase of financial cycle	0.053	0.027	0.059	0.058
Growth in contractionary phase of financial cycle	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 of financial cycle	0.049	0.049	0.049	0.043
Growth in contractionary phase of financial cycle	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 the first part of our study (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

[16] The financial cycle is found to be roughly half of the time in an expansionary phase and the other half in a contractionary phase. This holds for both the whole sample period and the three subsamples.

[17] These results are consistent with the findings in the first part of our study (Einarsson et al., 2015) where we find 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.

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.

The transmission channels of these global spillovers are 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).

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 Iceland and the UK.

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 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 banking system size. 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 openness in Iceland, the domestic financial cycle has spent more than ninety years in the same phase as the US credit cycle.

Table 9 Correlations and concordance 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
Bank assets-to-GDP ratio	0.51	0.51	0.52	0.52	0.73	0.78	0.70	0.76
Real long-term interest 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 financial cycle	0.78	0.69	0.86	0.87	0.74	0.67	0.80	0.74

Dates of peaks in Icelandic and US financial cycles

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

Dates of troughs in Icelandic and US financial cycles

Iceland	–	1900	–	1917	1926	–	1943	1953	–	1969	–	1995	2012
US	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.

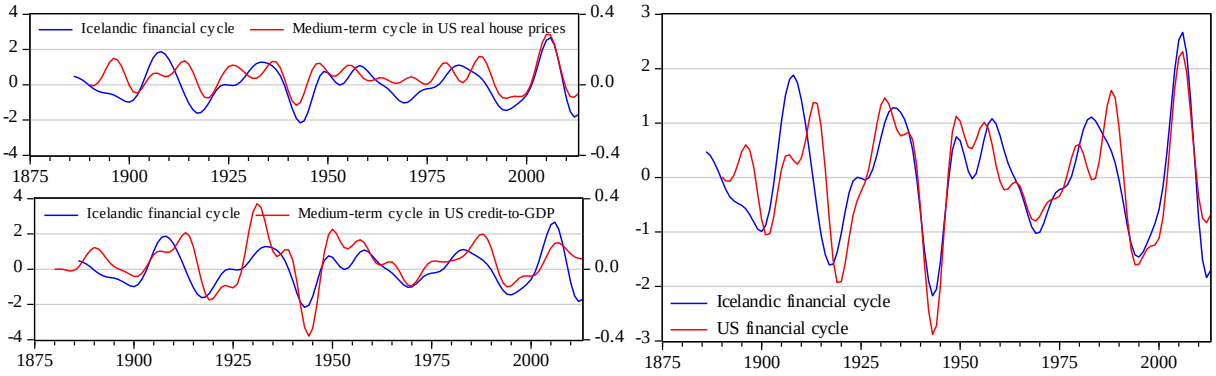
We construct a simple composite measure of the aggregate US financial cycle as the first principal component of the medium-term cyclical components of real house prices and the credit-to-GDP ratio, which are the two financial variables Borio (2014) argues most parsimoniously capture the aggregate financial cycle in advanced economies.[18] 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

[18] The first principal component 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).

reaches 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.

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 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.[19]

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 individual medium-term cycles of the Icelandic financial variables on a constant and the composite US financial cycle measure from above. 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).

[19] 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 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 the business cycles of other developed economies.[20] 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
Bank 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 liabilities	0.21	0.01	-0.02	0.89	0.53	0.00	0.58	0.00
Total non-core liabilities	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.[21] Thus, to focus on possible additional regional spillover effects, we simply measure

[20] 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.

[21] 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

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.

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
Norwegian 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.

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.

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.

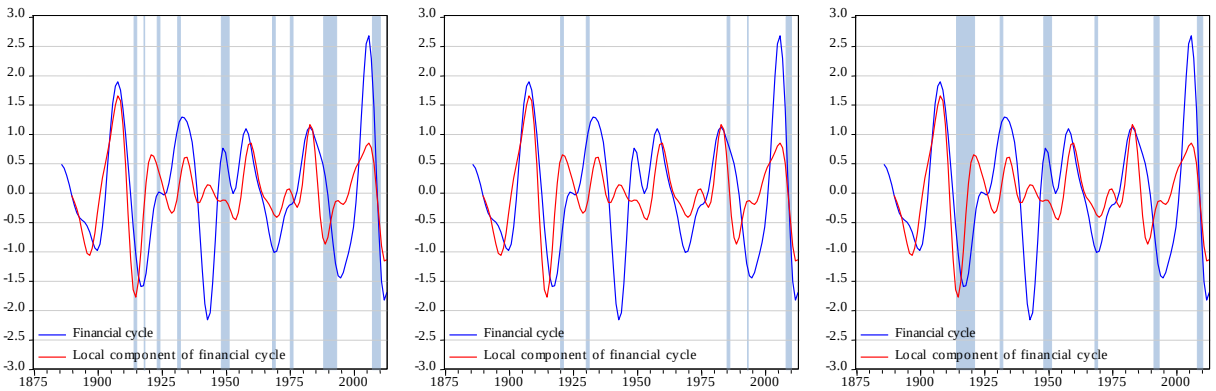
6 The financial cycle and financial crises

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 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).[22]

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 prices bubbles reach a climax. 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. (2014) 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, 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.

[22] 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.

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 the three year window (using the same window size as Drehmann et al., 2012).[23] Some of the crises 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 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.

[23] Here we disregard 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 financial expansion 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.

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 (see Appendix 3 for a summary of financial crises dates). 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.

Table 13 Cyclical expansions and financial crises

	Banking crises			Multiple financial crises		
	Expan-sions close to crises	Expan-sions not close to crises	Noise-signal ratio	Expan-sions close to crises	Expan-sions 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
Bank 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
Macroeconomic 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.

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.[24] 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).

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, 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, which is 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.

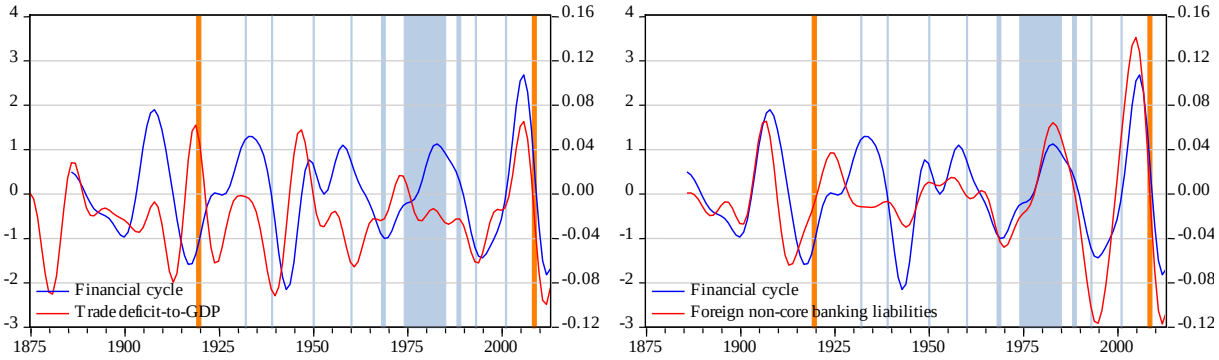
This is consistent with the analysis in the previous part of our study (Einarsson et al., 2015), which also shows that large trade reversals tend to coincide with currency crises, and is also evident from Figure 6, which shows that cyclical peaks in the trade deficit are frequently followed by a currency 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 liberal 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 sudden stop

[24] This is a slightly different approach to the early-warning exercise in our earlier study (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.

crises and the introduction of widespread capital controls.[25] 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, only to make reversals in the financial cycle go hand in hand with sharp reversals in capital flows and even currency crises.

Figure 6 The financial cycle, capital flows and sudden stops

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



Financial cycle (left axis) and medium-term cycles in the trade deficit-to-GDP ratio and the ratio of foreign non-core bank liabilities to total liabilities (right axis). 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.

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 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).

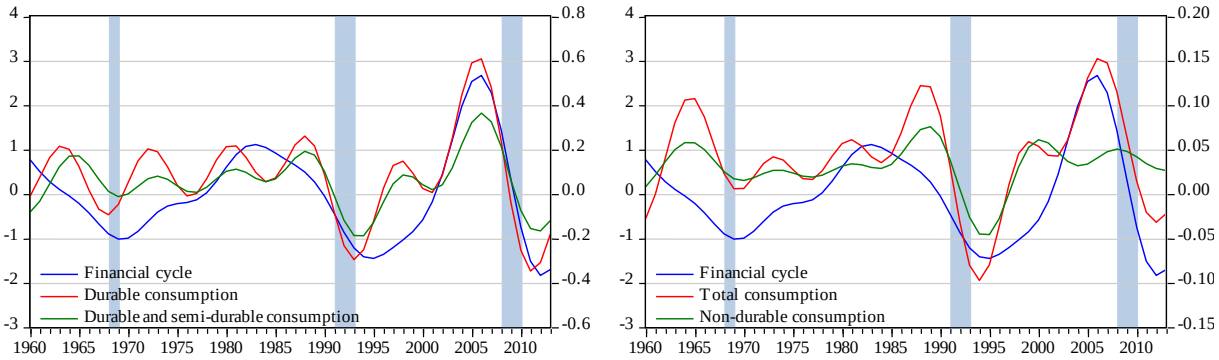
Einarsson et al. (2013) also document the cyclical volatility (at business cycle frequency) in several sub-components of private consumption, showing that a notable feature of the consumption cycle in Iceland is the high volatility of durable goods consumption, and that this volatility is strongly correlated 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

[25] Sudden stop crises are defined as 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.

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 in the most recent period 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 The financial cycle and consumption

Multiple financial crises shown as shaded areas



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

Sources: Authors' calculations.

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 components 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 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.

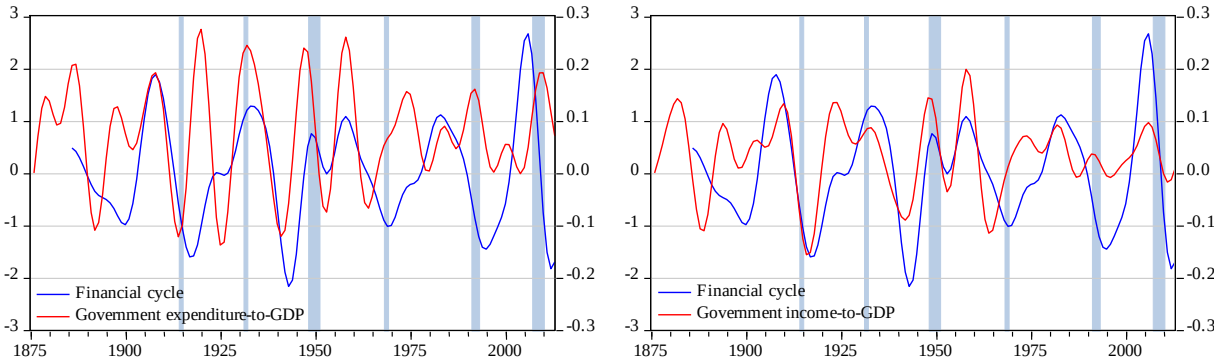
7.3 The financial cycle and fiscal policy

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, and Budina et al., 2015).

Figure 8 The financial cycle and fiscal policy

Multiple financial crises shown as shaded areas



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

Sources: Authors' calculations.

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 of this, with the expansion of the financial cycle followed by a strong cyclical expansion in current spending that peaks in 2010, some four years after the financial cycle peaks. 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.

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 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 for 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 reforms 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 a complement 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 scope 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 tame and understand the financial cycle are likely to offer serious policy challenges for years to come.

8 Conclusions

In the first part of our 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.

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 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

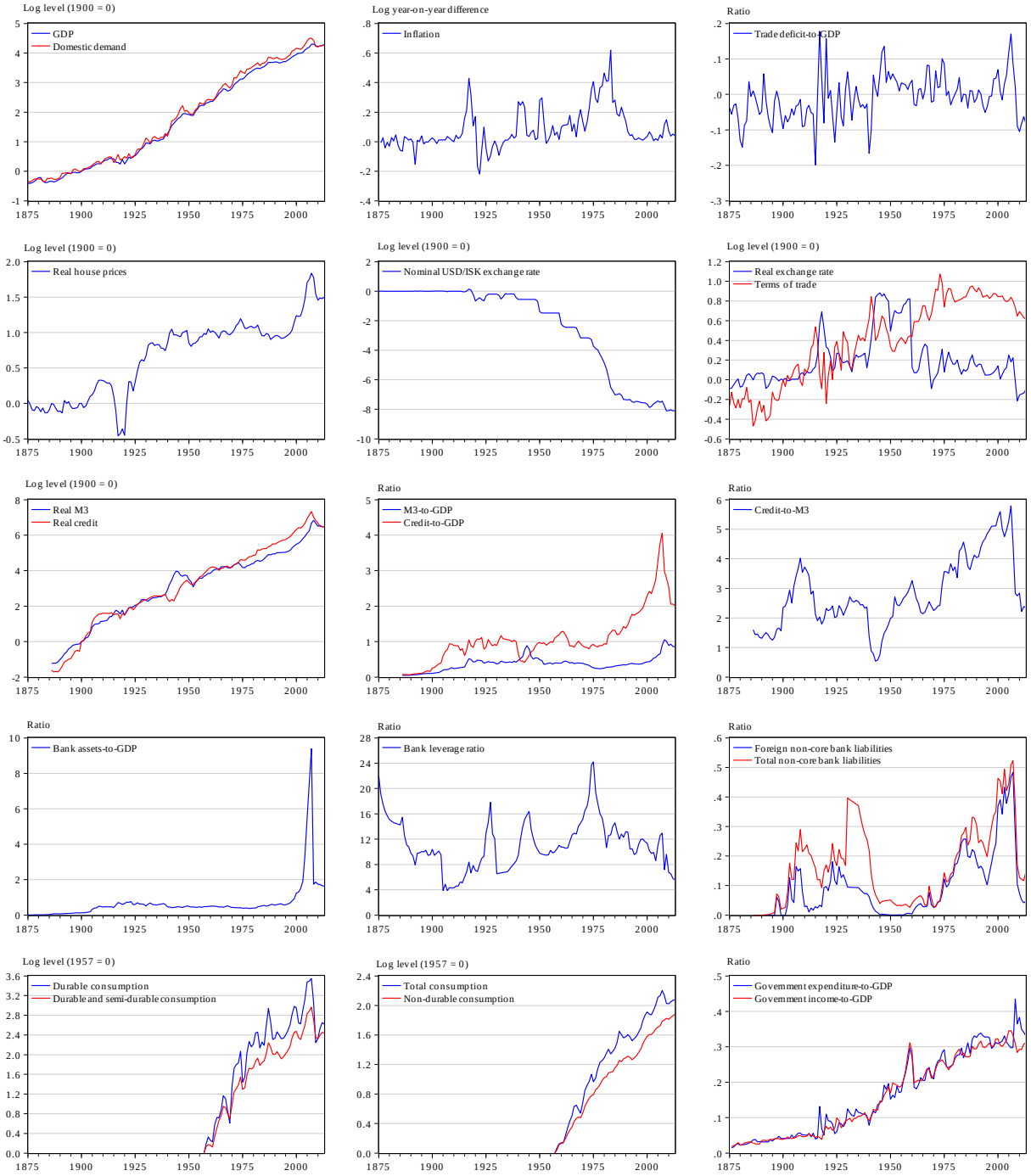
The data used in this paper is obtained from various sources. All of the data span the period 1875-2013, except for money, credit, and non-core banking liabilities which date back to 1886, and the data on private consumption which dates back to 1957 (for the consumption subcomponents, although data on 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 Authorities, 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

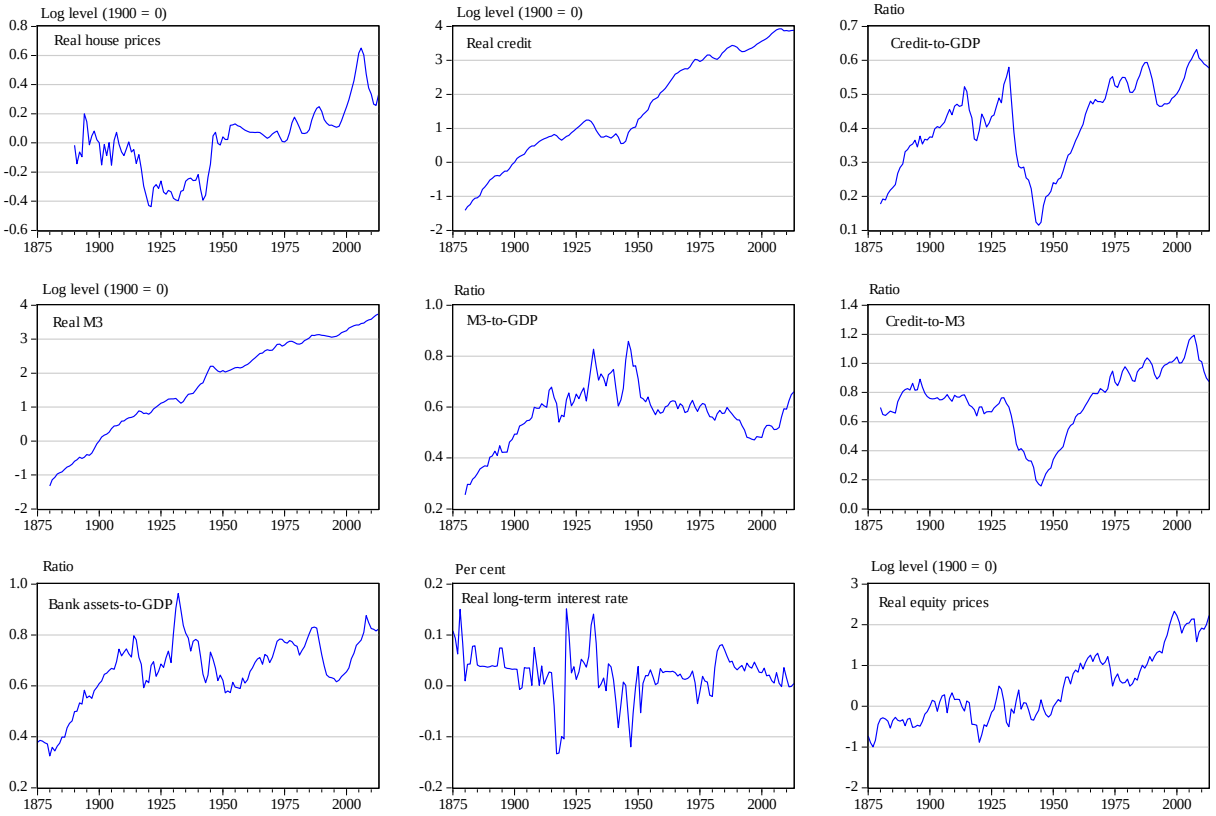
We use Eitrheim et al. (2004, 2007), with updates from the Norges Bank *Historical Database* as a source for credit (total credit private banks), nominal GDP, house prices (country-wide prices), and domestic consumer prices (consumer price index). There is a gap in the GDP series from 1940-45 and linear 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.

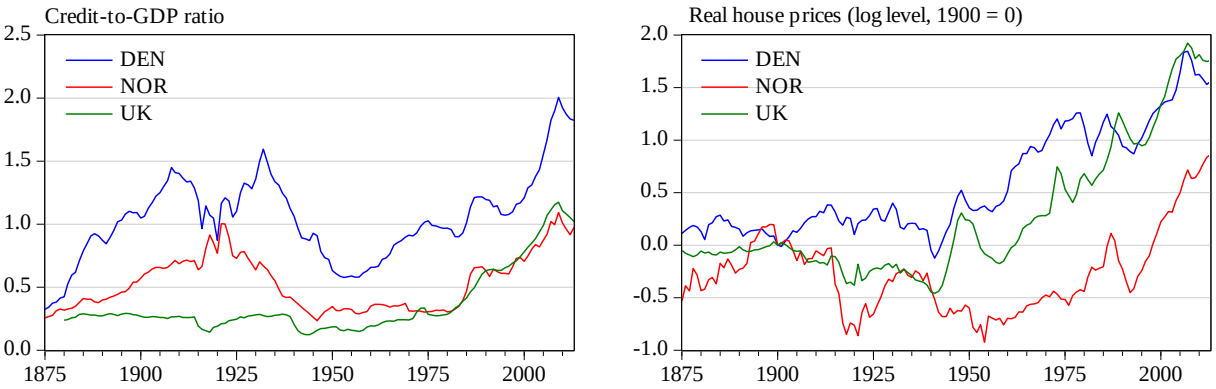
The following figures show the data: first Figure A.1.2 for the nine US variables used, followed by Figure A.1.3 for the credit-to-GDP ratio and real house prices for Denmark, Norway and the UK.

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

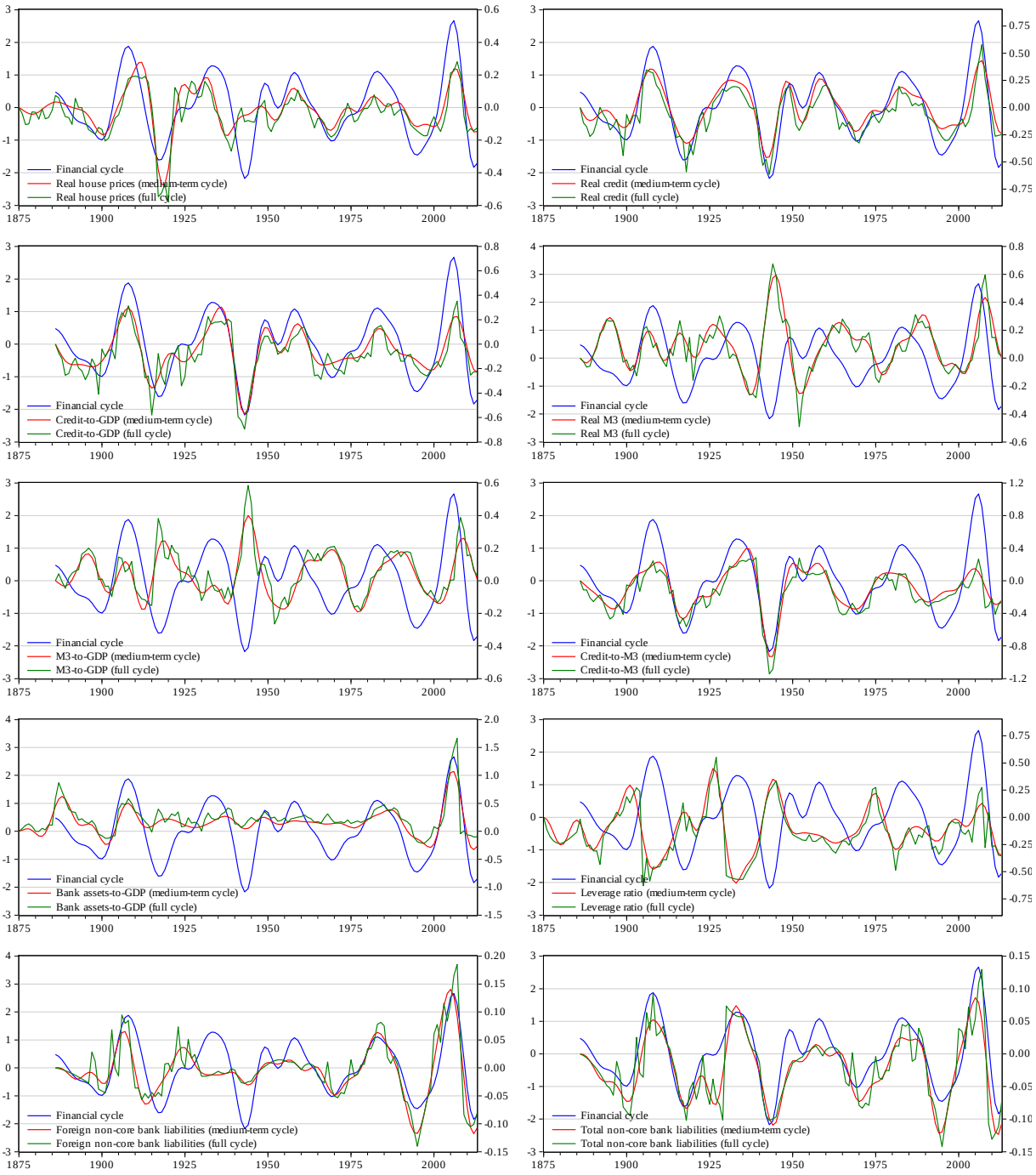


Sources: Abildgren (2006), Bank of England, Bank of International Settlements, Eitrheim et al. (2004, 2007), International Monetary Fund, and Norges Bank.

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 and macroeconomic variables together with the composite measure of the aggregate financial cycle.

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

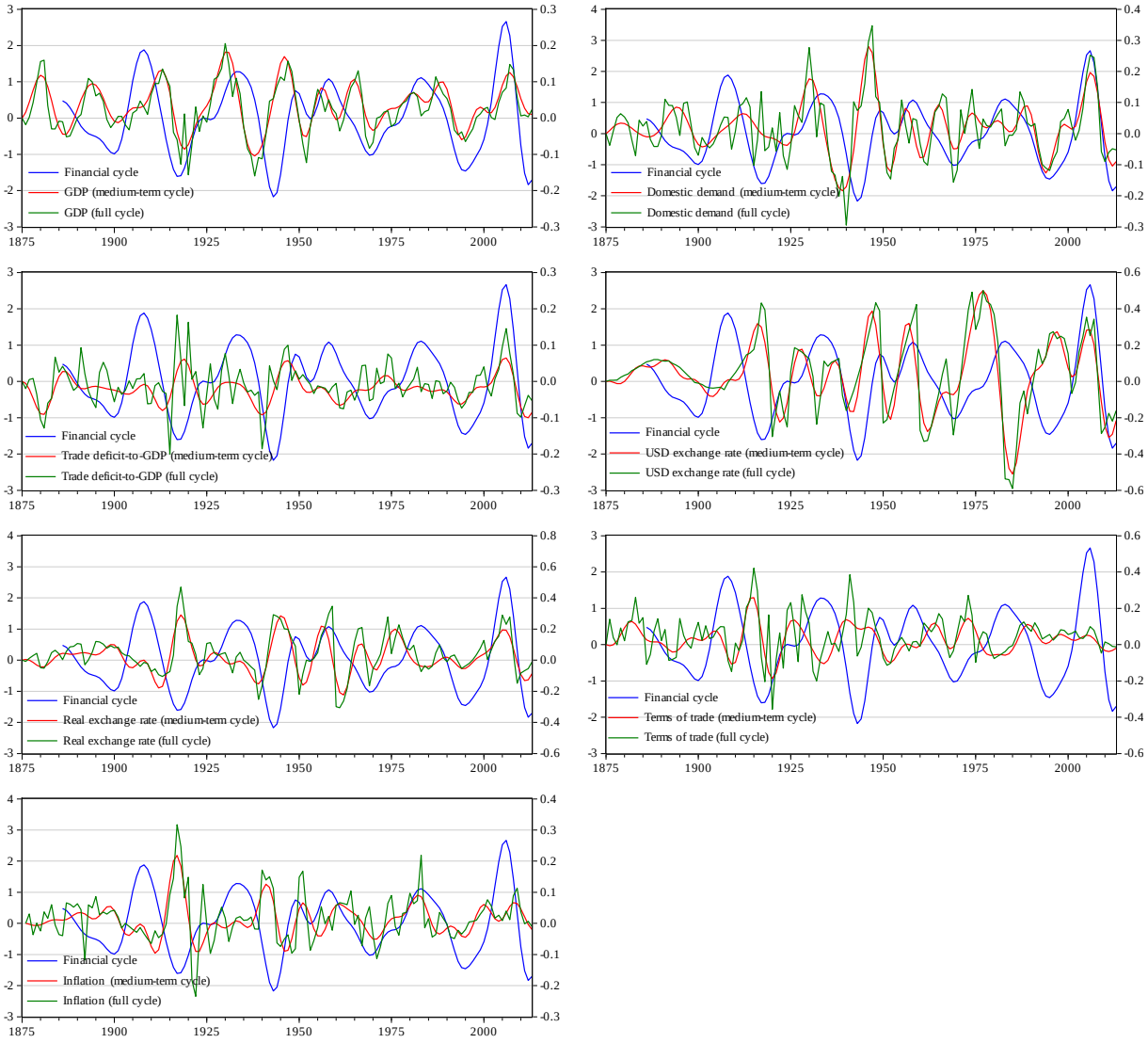


Financial cycle (left axis) and medium-term (8 to 30 year) and full (2-30 year) cycles in individual financial variables (right axis).

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 (left axis) and medium-term (8 to 30 year) and full (2-30 year) cycles in individual macroeconomic variables (right axis).

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 analyses, 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 (15% per annum for annual currency depreciations and 20% per annum for annual inflation) suggested by Reinhart and Rogoff (2009, 2011).[26] 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.[27]

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.

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

[27] 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).[28] 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 (general 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 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%.

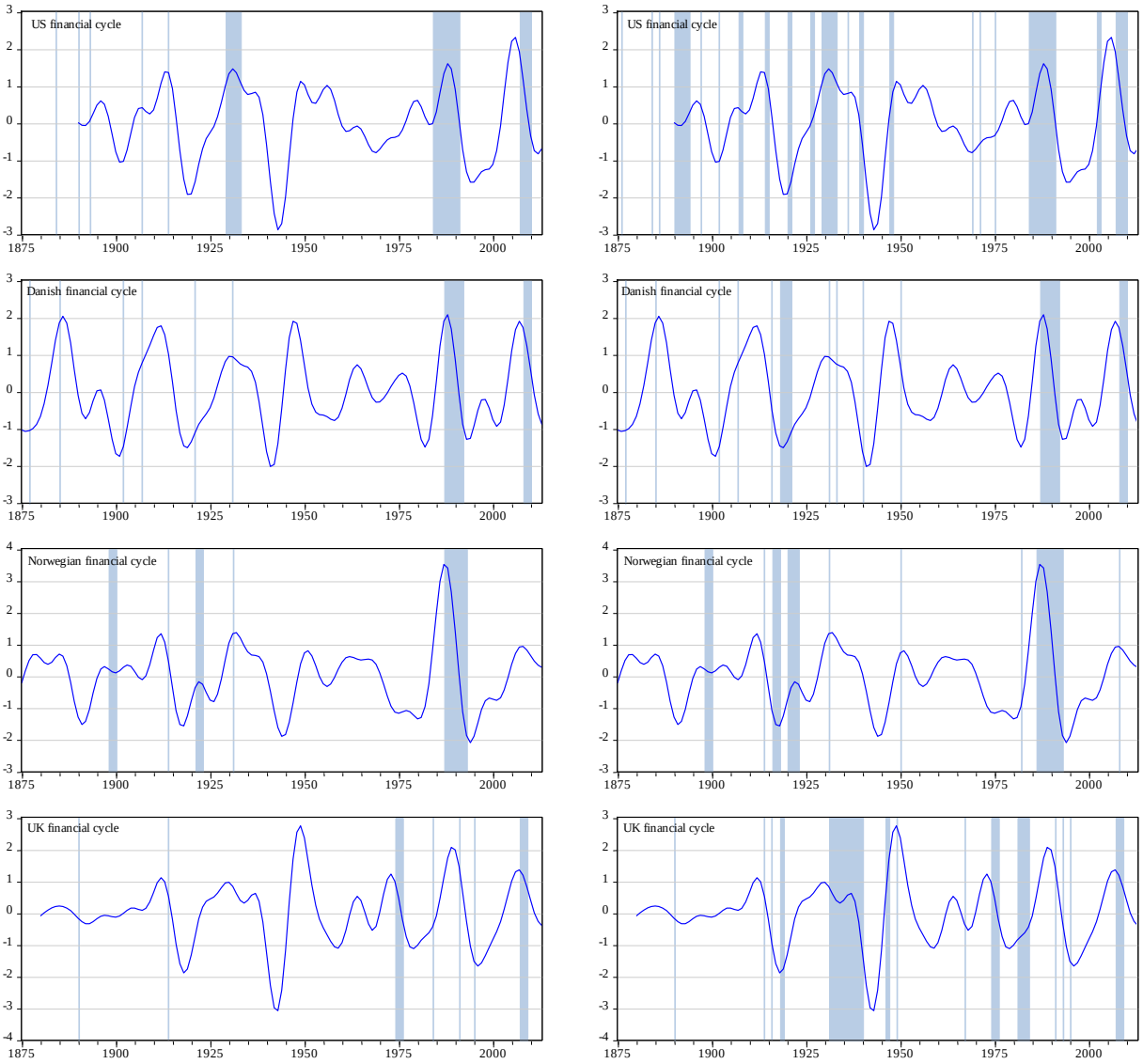
Inspection of the figure suggests that the cycles across these four countries tend to move together over time, with peaks and troughs more often than not coinciding. This visual perception is confirmed by the concordance index which suggests that over the whole sample period the four cycles tend to be in the same phase from almost 60% (the US and Norwegian cycles) to close to 80% (the Danish and the US and UK cycles, respectively) 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.[29]

[28] 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).

[29] 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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