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A FINANCIAL CONDITIONS INDEX FOR ICELAND

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A Financial Conditions Index for Iceland*

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Abstract

In this paper we remedy the lack of formalized relations between financial health and economic activity via a Financial Conditions Index for Iceland (FCI). We use a broad spectrum of financial information including price, spread, volatility and quantity variables, for the period 2002-2023. Variable selection is in line with broad consensus in the relevant literature. In addition, we include variables that are shown to have prediction properties vis-à-vis growth of real GDP over the horizon of two and four quarters ahead. The FCI is constructed using principal component analysis and is normalized such that a positive value indicates that financial conditions are looser than the historical average, while a negative value suggest that financial conditions are tighter than the historical average. We show that fluctuations and extreme events in historical real economic activity is captured by the FCI, implying that it is potentially a leading indicator of GDP developments.

Keywords: Financial Conditions Index, Principal Component Analysis, Iceland.

JEL Classification: E44**,** E52, E61, E65

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1 Introduction and literature review

Financial markets are an important part of any developed economy and well-functioning financial markets contribute to the efficient allocation of capital. A Financial Conditions Index (FCI) is intended to measure households' and companies' access to capital to invest, produce or consume goods and services. Financial shocks can affect the real economy as became apparent in the global financial crisis in 2008 which affected Iceland heavily. The domestic banking crisis, the sharp decline in the foreign exchange rate, the correction in asset prices and the contraction in the supply of bank credit led to a deep recession in the real economy. An index which accurately captures developments in financial conditions, whether they inhibit growth, encourage it or even encourage financial excess, should therefore be able to support and inform macroeconomic policy.

To achieve its macroprudential targets, the Central Bank of Iceland uses various tools, including restrictions on at-origin loan to value, debt to income and debt service to income ratios of mortgage loans to consumers. Furthermore, it imposes requirements on regulated entities regarding capital buffers, liquidity, stable funding, and foreign exchange balance. These tools are designed to reduce fluctuations and prevent financial conditions from becoming either too expansionary or too contractionary. Financial conditions are also the subject of regular analysis of economic activity, on which monetary policy is based. Many other factors, including fiscal policy, affect financial conditions so it is important for central banks to understand the interplay between financial conditions, central bank policy and the economy.

An FCI measures the possibilities for financing and conditions for financial intermediation in financial markets and the financial system. This type of indicator aims to reflect financial conditions by summarizing various information regarding important submarkets in the financial system. FCIs are usually composed of many underlying data series, such as information on prices and quantities, spreads, and volatilities. The data series can be related to e.g., indebtedness in the economy and to major asset markets, such as housing, stock, and bond markets. An FCI is used as a way of examining the stability of the financial system and the relationship between financial conditions and activity in the economy in general. Thus, an FCI may have forecasting potential, especially for economic activity in the near future. It can therefore be used to assess the potential impact of monetary policy decisions on the real economy and to assess the extent of systemic risk. FCIs can also be used to gain a historical perspective when comparing looseness or tightness of financial conditions and to achieve greater understanding of macro-financial linkages. However, it has been pointed out that since a financial conditions index has no natural unit, it is difficult to compare financial conditions over long periods. FCIs have been used elsewhere for various purposes, e.g., to predict economic activity, investment, financial pressures, or inflation.

FCIs must not be confused with the extensive literature on the financial cycle. Borio (2014) describes 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". The term is therefore related to the concept of the financial system's pro-cyclicality (Einarsson et al., 2016). In relation to GDP growth, the financial cycle is suited to capture the medium-term development while an FCI is usually more dynamic and is therefore better suited to forecast economic activity in the near future. Historically, most FCIs seem to have adequate leading indicator properties. Swiston (2008) constructed a "leading FCI" where any information contained in the index would be available to forecasters with at least six months of lead time. The leading FCI would have given forecasters advance notice of the 2001 US recession and an accurate indication of the timing of the recovery. The financial cycle is however considered to have longer lead time as an early-warning indicator, often ranging from one up to five years (Ragnarsson et al., 2019).

First attempts at constructing FCIs were built on Monetary Condition Indices (MCIs) developed and used first in the 1990s when effects of monetary policy on the economy were increasingly recognized through several channels. It became widely accepted that the transmission channels of monetary policy included interest rates and their effect on investment and savings along with the exchange rate and its effect on demand for locally produced goods and services. However, FCIs contain a much wider range of variables than MCIs, not only the interest rate and exchange rate (Gerlach and Smets, 2000).

FCIs are also related to Financial Stress Indicators (FSIs) which are generally used to analyze financial stability. FSIs identify periods of fragility in financial markets and can facilitate early recognition of stress. On the other hand, FCIs are more useful when exploring macro-financial linkages (Carlson, et al., 2012). An FCI focuses more on interest rates, risk premia and prices while an FSI focuses more on indicators that represent risk exposures on the balance sheets of various economic agents, such as banks or households. However, these two indices are often closely related and have similar variables as inputs. The relationship between FCIs and FSIs is discussed in more detail by Kliesen, Owyang and Vermann (2012).

FCIs have been built for many countries and many different methods have been used in their construction. One approach is to construct an index as the simple average of several variables which influence the financial system's health. Another approach is to construct the index as a weighted average and to employ Principal Component Analysis (PCA) to assign a weight to each variable in the underlying dataset. Factor Analysis (FA) has also been used to determine weights for each indicator. A few other methods, such as VAR models have been used, but in this paper, we develop FCIs with three methods: PCA, FA and a simple average. First, the PCA method is a widely used statistical method in the literature (Angelopoulou, et al., 2013, Fransson and Tysklind, 2017 and Bowe, et al., 2023). It is useful for capturing the variance in variables in order to reduce the number of variables into a smaller set and can provide individual weights for the variables included. Secondly, the FA method is used which is related to PCA, but it focuses more on explaining the covariances or the correlations between the variables

(Suhr, 2020). Thirdly, the simple average method is used as a baseline representation of financial conditions.

In this working paper we develop a financial conditions index for Iceland with the purpose of measuring financial conditions and explore macro-financial linkages in Iceland. We theorize that the index could be used as a leading indicator for short-term economic activity and help in decision-making for both monetary policy and financial stability. It should provide us with a greater understanding of the overall state of financial conditions for households and companies. The paper is organized as follows: section 2 contains a description of the data series used and how each series is incorporated into the index based on its effect on financial conditions. In section 3, the methodologies used to combine the data series into an FCI are discussed as well as the resulting indices' correlation with GDP developments. Section 4 presents the final index and provides a historical overview of financial conditions in Iceland during the observed period.

2 Data selection

Many different variables have been used to describe financial conditions in the extensive literature on FCIs. They often include prices, spreads, quantities, survey data, and monetary statistics. Financial conditions are affected by various market participants such as households, non-financial corporations, intermediaries, and the government. The FCI constructed for Iceland is meant to measure financial conditions on the aggregate in such a way that it contains at least some explanatory power for changes in the real economy.

Households' balance sheets are dominated on the asset side by housing and on the liability side by mortgages. Changes in house prices and the quantity of mortgages therefore have a large effect on households' financial conditions. Direct participation of households in the stock and/or bond markets is limited in Iceland compared with neighboring countries and the largest effect of stock and bond markets on households is through pension funds.

Non-financial corporations are mainly financed through bank loans, cash flow and equity. With 29 companies on both the main Icelandic stock market and growth market in August 2023, only a small proportion of Icelandic companies are funded through the stock market (Nasdaq Nordic, 2023). The main bond issuers are the government, municipalities, financial corporations and corporations in the real estate, energy, and seafood sectors. It is however increasingly common that companies are debt funded through the shadow banking system and the number of companies that have been registered on the Icelandic stock market has been steadily increasing in recent years.

Financial intermediaries such as commercial banks and other depository institutions, pension funds and the shadow banking system are important for financial conditions, in addition to being affected by the conditions themselves. Changes to interest rates, bank liquidity and other money market conditions

affect households and non-financial corporations through interest rates on loans and mortgages or changes in the provision of credit.

The government, often considered the risk-free debtor in the economy, sets a benchmark for yields on bonds and other securities. Government bonds are also used to calculate the interest rate differential with other currency areas. Monetary policy affects the market both directly and indirectly through policy instruments and market transactions (Pétursson, 2001).

As mentioned before there is a variety of variables used in the literature on FCIs, but what variables should be selected to proxy financial conditions in Iceland? The small size of Iceland's economy, the resulting concentration of its financial system and the shallowness of its financial markets limit the access to corresponding data compared to larger economies. Potential variables were selected from the available data for the Icelandic market and corresponding to prior literature. The term *available data* refers to data, which is collected for Icelandic financial markets, fits the sample period, and represents in our opinion the Icelandic financial markets. Data collection consists of price, quantity, spread, volatility, and ratio variables which are described in the following paragraphs. In addition, to help guide the selection of variables for the Icelandic FCI and gauge their link to the real economy, we perform prediction tests with single-variable financial indicators based on a method used by Hatzius et al. (2010) and Fransson & Tysklind (2017).

First, we take into account price variables. Changes in house and stock prices and the exchange rate are included in the dataset. Rapidly rising prices generally signal looser financial conditions. Households are affected by rising asset prices through a wealth effect, increased ability to refinance debts and increased access to credit (Chodorow-Reich, Nenov & Simsek, 2019; Calcagno, Fornero & Rossi, 2009; Modigliani, 1971; Kiyotaki & Moore, 1997). For non-financial companies, increasing stock prices ease fundraising through equity. With rising stock prices, corporations' demand for investment increases which tends to magnify an economy's output gap, and vice versa in times of decreasing prices (Bernanke & Gertler, 1989; Goodhart & Hofmann, 2000; Goodhart & Hofmann, 2002). Increasing asset prices are therefore expected to signal looser financial conditions for both households and non-financial corporations.

Secondly, quantities are taken into account. Changes in the size of the credit stock to households and non-financial corporations measure whether the availability of credit is increasing or decreasing and if households and non-financial corporations are raising more funds through debt. Contrary to Alsterlind et al. (2020) an increase in new lending to households and non-financial corporations is expected to signal increased access to credit and more expansionary financial conditions. This difference in approach is perhaps understandable when the difference in prevailing private sector debt levels between Sweden and Iceland is considered. In circumstances where indebtedness is excessively high, further debt accumulation can logically be taken as a sign of worsening conditions. However, as indebtedness

among both households and non-financial corporations is quite moderate in Iceland, especially in a historical perspective, contrasted with the high indebtedness in Sweden, it may be appropriate to assign a loosening effect to increased credit. Household debt has increased for a long time in Sweden and households are considered highly indebted, both from a historical perspective and in international comparison (Sveriges Riksbank, 2019). This approach is in agreement with Angelopoulo et al. (2013) where higher rates of growth of credit provision are assumed to signal looser financial conditions for the euro area FCI.

Third, we look at the spreads. The yield curve is captured, both its level and shape, through various spreads. The yield curve is an important indicator of market participants' expectations of risk premia, future interest rates, inflation, and duration risk. Inactivity on the Icelandic interbank market and secondary market for treasury bills limits the number of variables which appropriately measure the money market. The bond market also suffers from limited issues and limited trading of corporate bonds. Thus, only the government side of the bond market is properly measured. Spreads on lending and deposit rates contain information regarding the willingness of financial intermediaries to provide credit and their profitability. Including interest rate levels also captures how monetary policy decisions affect financial conditions. Increasing interest rates and spreads are expected to have a tightening effect on financial conditions.

Fourth, it is important to take volatility into account. Unpredictable and sharp price movements are captured with volatility variables. Volatility has a tightening effect on financial conditions as sudden movements in prices indicate, and potentially induce, uncertainty among market participants. In addition, market corrections with their sharp negative changes in asset prices, which feed into volatility variables, can weaken balance sheets, and cause financial distress that can lead to a further decline in asset prices (Bernanke & Gertler, 2000).

Fifth and last is the ratio variable. The ratio of household interest expense to income, is often used as an early warning indicator. It has been shown to be a useful indicator of banking crises at shorter horizons. When the ratio is high it signals that households are overextended and a decrease in income will prevent households from smoothing consumption or making new investments and if the decrease in income is large it could lead to an increase in defaults (Drehmann & Juselius, 2014). However, it is not free from fault, as both the numerator and denominator of the variable are cyclical, and their movements have the potential to cancel each other out. This happened in Iceland when a similar variable, debt service to disposable income, completely missed the Icelandic crisis of 2008 and performed very poorly as an early warning indicator (Ragnarsson, et al., 2019). An increase in the ratio is expected to have a tightening effect on the financial conditions of households and intermediaries but it is necessary to keep an eye on cyclical movements of income.

2.1 Prediction tests with single-variable financial indicators

The method of Hatzius et al. (2010) is replicated to look at the individual ability of the variables to predict, over the horizon of two and four quarters ahead, the growth of real GDP. The sample data is quarterly and spans the period from the first quarter of 2002 to the fourth quarter of 2019 excluding the data for the pandemic years as the drop in GDP over that time was exogenous to financial conditions. By taking the autoregressive structure of GDP into account the predictive ability of each financial variable is judged with the coefficient of partial determination and an F-test.

The regression specifications are as follows:

$$y_{t+h} - y_t = \beta_0 + \sum_{i=1}^{p_y} \phi_i \Delta y_{t+1-i} + \sum_{i=1}^{p_x} \gamma_i x_{t+1-i} + e_{t+i}$$

where y_t denotes the natural logarithm of real GDP and x_t denotes the individual financial variable. The term $y_{t+h} - y_t$ is the percentage change between real GDP at any given time t and real GDP with an h-quarter lead, where h takes values 2 and 4. The parameters p_y and p_x indicate the number of lagged values of Δy and x included in the regressions, which is fixed at $p_y = p_x = 4$. The financial variables are expressed differently in each regression according to the nature of each variable. Level interest rates and ratios are expressed as the first difference, spreads are expressed in levels and other variables are expressed as first difference of the log-transformed variables. The regression is estimated, and the coefficient of partial determination $R^2_{x/\Delta y}$ is evaluated using an F-test which jointly tests if the coefficients of the lags of x are zero. By using the coefficient of partial determination for the lags of x the proportion of the overall variance in real GDP that is explained by the financial variables is isolated, excluding the variance explained by the autoregressive structure of real GDP.

The single-variable regression provides insight regarding which variables to include in the FCI but is not the sole criterion for selection. Variables which show significant explanatory power for variation in GDP are house and stock prices, household interest expense to income, levels and spreads on the bond market, and three out of the six money market variables. This gives further support to include these variables in the FCI. As mentioned previously there has been limited activity in the Icelandic money market since the financial crisis. Therefore, we consider it sufficient to include the Central Bank's key interest rate and the spread of the key rate and 3-month REIBOR to represent the money market excluding levels and spreads on mortgage, deposit and lending rates. The key rate sets the benchmark for other interest rates and represents a change in the cost of capital for a broader range of participants. On the other hand, variables that don't show significant explanatory power are the key rate and its spread on 3-month REIBOR, loans to households and non-financial corporations, stock volatility, the nominal effective exchange rate, and the interest rate differential between Iceland and Germany.

Table 1

Series	$R^2_{x/\Delta y}$	F-test*	$R^2_{x/\Delta y}$	F-test*

	h=2		h=4	
House prices	0,16	2,782* (2,097)	0,15	2,596* (2,097)
Loans to households	0,04	0,548 (2,097)	0,05	0,858 (2,097)
Household interest expense to income	0,17	3,086* (2,097)	0,05	0,641 (2,097)
Loans to non-financial corporations	0,12	1,667 (2,138)	0,02	0,193 (2,138)
Stock price	0,23	4,299* (2,097)	0,11	1,897 (2,097)
Volatility	0,12	2,089 (2,097)	0,05	0,728 (2,097)
Level: Key interest rate	0,06	0,99 (2,097)	0,01	0,14 (2,097)
Spread: Key interest rate & REIBOR 3m	0,06	0,92 (2,097)	0,07	1,138 (2,097)
Spread: Mortgage & deposit rate	0,14	2,484* (2,097)	0,18	3,283 (2,097)
Spread: Lending & deposit rate	0,09	1,479 (2,097)	0,06	0,95 (2,097)
Level: Mortgage rate, inflation indexed	0,16	2,897* (2,097)	0,03	3,283* (2,097)
Level: Mortgage rate	0,14	1,098 (2,097)	0,35	3,683* (2,097)
Level: Yield on 10-year government bonds	0,18	3,227* (2,097)	0,02	0,326 (2,097)
Level: Yield on 10-year government bonds, inflation indexed	0,15	2,64* (2,097)	0,04	0,549 (2,097)
Spread: Yield on 10 year and 2-year government bonds	0,15	2,606* (2,097)	0,12	1,964 (2,097)
Spread: Yield on 10 year and 2-year government bonds, inflation indexed	0,24	4,778* (2,097)	0,11	1,766 (2,097)
Nominal effective exchange rate	0,11	1,886 (2,097)	0,08	1,292 (2,097)
Interest rate differential, Iceland-Germany	0,08	0,954 (2,143)	0,05	0,585 (2,143)

Notes: Table 1 shows F-statistic (critical value in parenthesis) and is marked significant (*) when it exceeds the critical value at alpha=0.05.

Including changes to the credit stock serves as a measurement of credit availability for households and non-financial corporations. Volatility in the stock market captures times of uncertainty or reactions of market participants to new information and is therefore important when assessing financial conditions.

Iceland is a small open economy, and it is essential to proxy foreign exposure through both the foreign exchange rate and the interest rate differential.

Below is a list of the financial variables included in the analysis and how they affect financial conditions in Iceland. All data is in the form of monthly time series which span the period from January 2002 to July 2023 and *Figure 1* shows the development of stated time series during the period.

Table 2. Variables categorized by markets

Series	Effect on financial conditions
Housing market	
House prices	+
Household interest expense to income	−
Stock market	
Stock prices	+
Volatility	−
Credit market	
Loans to households	+
Loans to non-financial corporations	+
Bond and money market	
Key interest rate	−
Spread: Key interest rate and 3-month REIBOR	−
Level: Yield on 10-year government bonds	−
Level: Yield on 10-year inflation-indexed government bonds	−
Spread: 10-year and 2-year government bonds	−
Spread: Inflation-indexed 10-year and 2-year government bonds	−
Foreign exchange market	
Nominal effective exchange rate (NEER)	+
Interest rate differential between Iceland and Germany	−

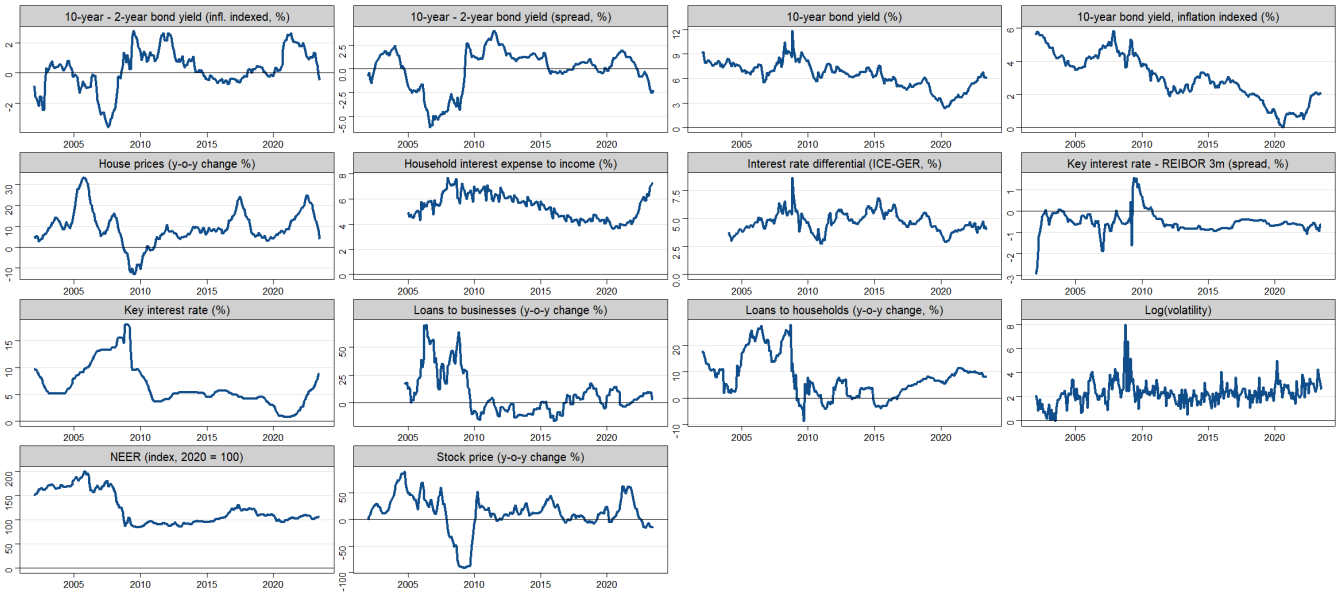

Figure 1. The development of the chosen time series during the observed period

3 Methodology

3.1 Principal component analysis

When it comes to constructing an index that aims to capture financial conditions, PCA is one of the most widely used statistical methods in the literature; see, for example, Angelopoulou et al. (2013), Fransson & Tysklind (2017) and Bowe et al. (2023). PCA is primarily a data dimensionality reduction process as the data is compressed without much loss of information. The first principal component which is subtracted from the dataset accounts for a maximal amount of total variance in the observed variables while each of the following principal components accounts for a maximal amount of the dataset´s remaining variance. In the context of monitoring financial conditions, this feature is desirable, as it means that more weight in the index may be placed on variables which have historically been systemically important (Angelopoulou et al., 2013). However, PCA has its disadvantages as variables become less interpretable and since it is purely a statistical method, the weight of each variable does not necessarily reflect the real impact the variable has on Icelandic financial conditions (Alsterlind et al., 2020). Similar to the methods, an order of judgement of the variables and their weights is necessary. A more in-depth explanation of the method can be found in the appendix.

The main goal is to identify the primary driving forces in the dataset, while also capturing different aspects of financial conditions. Therefore, it is important to strike a balance regarding how many

components to include, as it reveals how large a part of the variation in the dataset the final index entails. Based on other studies, for example Fransson and Tysklind (2017), the threshold for the share of total variance explained is set at 70%. By this threshold, the first three principal components are sufficient to summarize the data set. The FCI is then constructed by summing the selected principal components weighted by the share of total variability explained by each of them.

The main drivers of the PCA-based FCI are revealed by the contribution of each series to the first three principal components of the dataset. The weight of each variable in the three components along with the share of total variance explained by each component are shown in *Table 3*. The variables are sorted in descending order according to their aggregated weight.

Table 3. Weight of each variable along with the share of total variance explained by each component

Series	PC1	PC2	PC3	Aggregated weight (absolute value)
10 year – 2 year spread, Government bond yield	-39.5	-18.9	5.1	19.6
10 year – 2 year spread. Government bond yield, inflation indexed	-28.5	-22.4	-28.7	19.4
Nominal effective exchange rate	27.6	29.6	0.8	18.2
Loans to households	31.9	27.2	-25.7	16.6
House prices	7.9	45.1	8.6	15.1
Key interest rate	43.2	-15.9	-0.8	12.8
Loans to non-financial corporations	34.1	5.1	-36.6	11.0
Government bond yield, 10 years, inflation indexed	33.3	-17.3	17.9	10.4
Key interest rate – REIBOR 3m	0.06	-0.25	-32.5	9.4
Stock market index (OMXI10)	-8.5	38.1	27.9	8.9
Interest rate differential Iceland – Germany	16.7	-18.5	45.7	6.3
Government bond yield, 10 years	27.8	-33.0	22.3	4.8
Volatility of stock prices	12.0	-7.3	-46.9	2.6
Household interest expense to income	19.1	-36.6	11.5	0.5
Share of total variance explained	38.8	24.8	9.7	73.3

In principal component analysis, the standard procedure is to look for patterns in the loading weights that reflect different influences in the data. With that in mind, the first component, which explains 38.8% of the variance in the data set, includes a range of variables, where bond yields, the key interest rate, and loans to both households and non-financial corporations play an important role. Therefore, the first component primarily reflects domestic interest rates and credit system. The second component explains a further 24.8% of the variance. Asset prices stand out in this component, that is the nominal effective

exchange rate, house prices and the stock market index. An argument can be made that the second component is therefore a market sentiment component of some sort, as the foreign exchange and stock markets are highly sensitive to market participants' expectations. House prices do not necessarily fall under that category, however, as they are considered stickier. Despite being stickier than both the exchange rate and stock market, it must be noted that there was a housing market bubble during the observed period. The third and last component consists mainly of the interest rate differential between Iceland and Germany and can be considered primarily as an Iceland-specific risk component. Noticeably, however, the third component explains slightly more of the variation in house prices than the first. It is hard to see why the Iceland-specific risk premium is more related to house prices than the domestic interest rate. Therefore, one must proceed with caution when interpreting the components. *Figure 2* graphs the first three principal components.

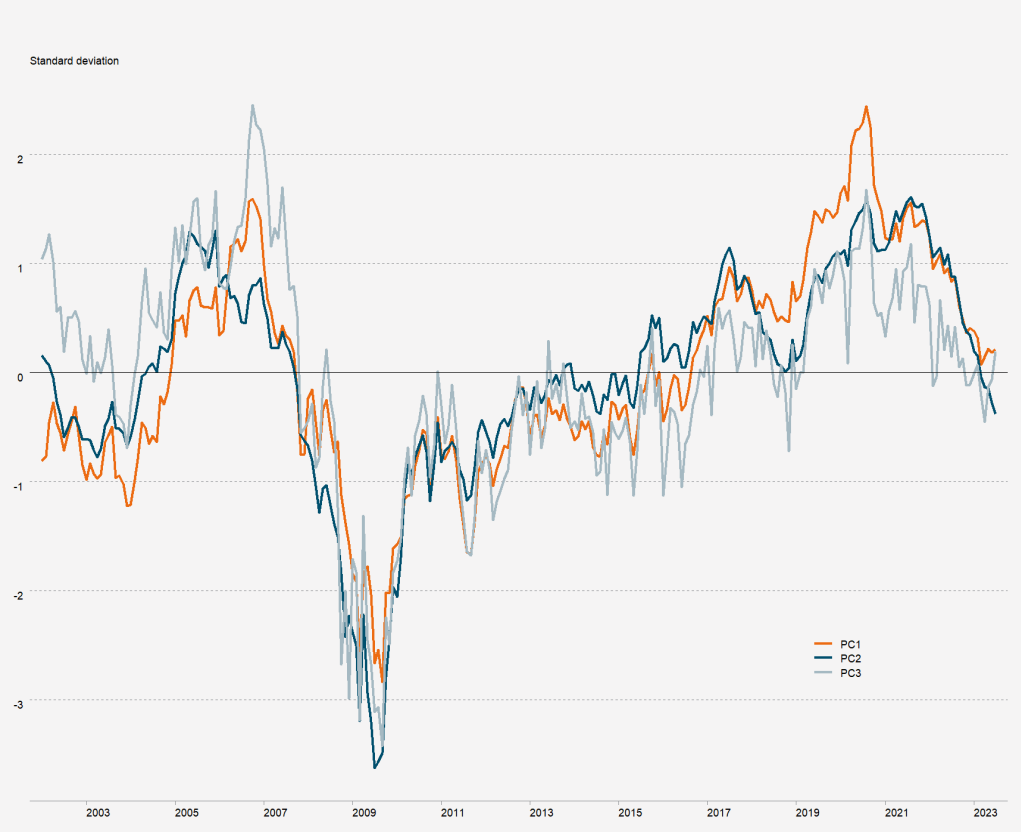

Figure 2. The first three components of the dataset

The aggregate weight of the variables that make up the FCI is equal to the weighted sum of the loadings on each variable across the three principal components and is shown in the final column of *Table 3*.

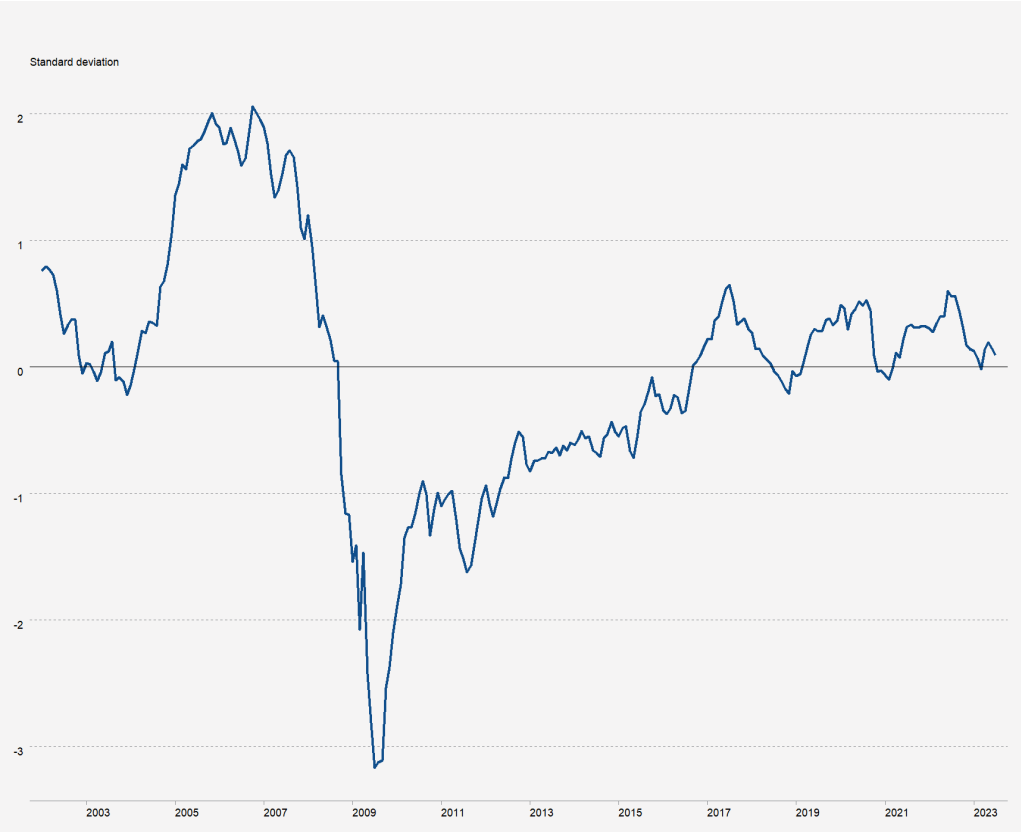

Figure 3. FCI constructed using principal component analysis

Figure 3 graphs the financial conditions index constructed using principal component analysis. The index is on a monthly basis from January 2002 until July 2023. The index measures Icelandic financial conditions in relation to its historical average and it has an average value of zero and a standard deviation of one. According to the PCA FCI, financial conditions in Iceland were close to the mean in the early 2000s but turned expansionary in late 2004. During the observed period, financial conditions were most expansionary in 2006-2007, prior to the financial crisis. It is interesting to note that at the end of 2007 and beginning of 2008, financial conditions tightened rapidly and when the financial crisis hit in late 2008, they became tighter than they had ever been during this period. In late 2009, they hit rock bottom at minus 3 standard deviations from the mean. It took the Icelandic financial system several years to recover from the crisis and financial conditions didn't turn expansionary again until 2017. As the housing market cooled somewhat in 2017-2018, financial conditions tightened, but recovered fast as the key interest rate was gradually lowered in 2018-2019. Financial conditions then became more expansionary during the Covid-19 pandemic as interest rates were lowered, the countercyclical capital buffer was lowered, and the government of Iceland announced various measures to mitigate the economic effects of the outbreak. Since early 2022 the tables have turned again as contractionary Central Bank policy, aimed at containing both inflation and systemic risk, is coming into effect. The main elements in the development of the index over the last two decades thus appear reasonable and in line with economic history, which we discuss further in section 4.

The 14 variables that make up the dataset can be grouped into five different sub-markets to show each market's contribution to the development of Icelandic financial conditions. The sub-markets are the bond and money market, credit market, foreign exchange market, housing market, and stock market.

Figure 4 shows the respective sub-market´s contribution to the FCI over time. When analyzing the figure, the dominance of both the credit market, and the bond and money market stands out during most of the observed period. These markets' contribution to the PCA FCI were quite expansionary in 2006-2008, during the years before the financial crisis when bond yields were low and the non-financial private sector's access to credit was extremely easy. The contribution from the credit market to the index has diminished in recent years, but after interest rates were lowered during the pandemic, house prices soared. The housing market's effect is therefore very noticeable in recent years. It is also noticeable that the stock market does not get much weight in the index.

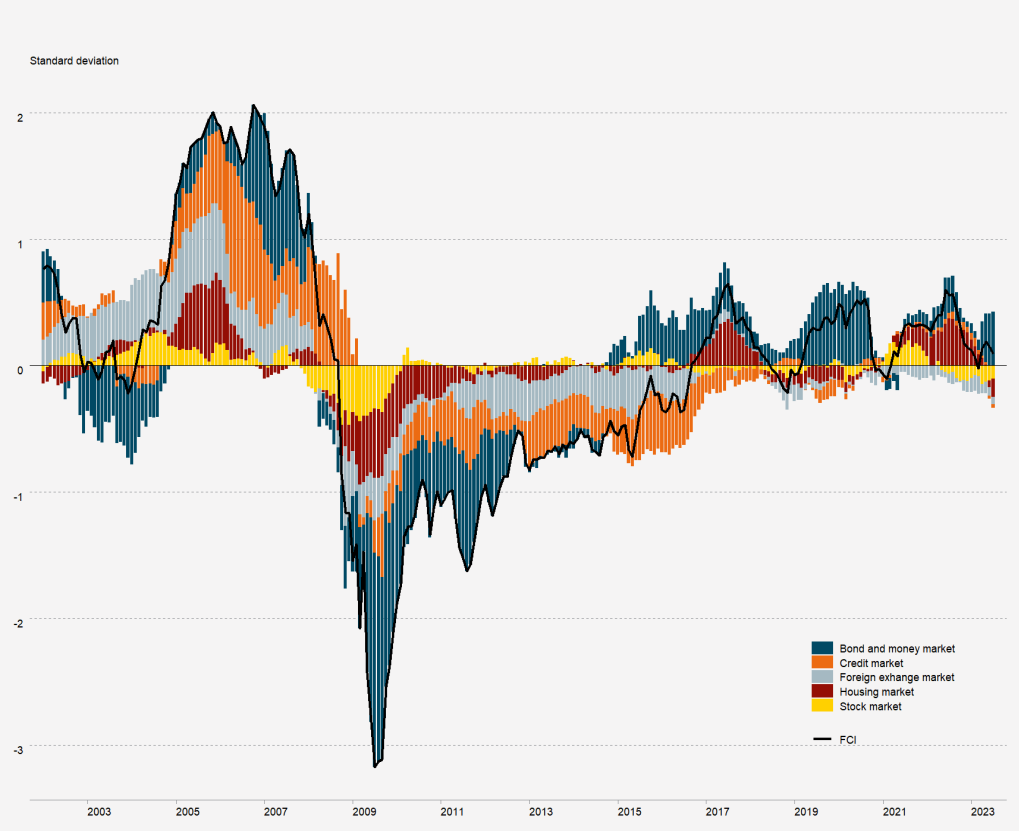

Figure 4. Contributions of the sub-markets to the PCA-based FCI

3.2 Factor analysis

The main goal of factor analysis (FA) is to represent a set of observed variables in terms of a number of common factors and a factor which is unique to each variable. FA and PCA are therefore related methods. Factor analysis sorts the studied variables into groups with high within-group correlation. Thus, FA accounts only for their common variance, while PCA reduces the number of variables while retaining as much of the total variance as possible.

Factor analysis seeks to estimate the proportion of the variance of the variable in question which is accounted for by the common factors. This is known as a communality. A large communality for each variable is usually associated with a successful factor analysis solution (Taylor, 2001). A more in-depth description of the model underlying factor analysis can be found in the appendix.

One debate when it comes to factor analysis is how many factors should be extracted. Specifying too few factors will result in the loss of important information by ignoring a factor or combining it with another. Likewise, specifying too many factors may lead to an overcomplicated structure with many minor factors consisting of one or very few observed variables. A rule of thumb for determining the number of factors to retain is Kaiser´s criterion. This criterion suggests retaining all factors with an eigenvalue larger than 1. However, it has been argued that Kaiser´s criterion may result in overestimation of the number of factors extracted (Young and Pearce, 2013). As can be seen in *Table 4*, four factors satisfy Kaiser´s criterion in our dataset.

Table 4. The Eigenvalue and the proportion of variance explained by each of the four factors

	Factor1	Factor 2	Factor 3	Factor 4
Eigenvalue	3.3	3.2	1.8	1.6
Proportion Var	0.2	0.2	0.132	0.112

Similar to Ho and Lu (2013), the relative weight of each variable in the factor-based FCI is based on the estimated communality found in *Table 5*. The variables have been sorted in descending order, based on the communality of each variable. For example, the communality for the Central Bank's key interest rate is 99.5 which implies that the common factors explain 99.5% of the variance in the key rate. In other words, a substantial part of the factor-based FCI reflects developments in the key rate which correlates well with preconceived ideas about Icelandic financial conditions. The factor-based FCI is also driven to a large extent by bond market variables, the nominal effective exchange rate, loans to households, and house prices.

Table 5. The communality of each variable

Series	Communality
Key interest rate	99.5
Government bond yield spread, 10 – 2 years	98.0
Inflation-indexed government bond yield, 10 years	91.6
Government bond yield, 10 years	91.5
Inflation-indexed government bond yield spread, 10 – 2 years	91.2
Loans to households	85.1
Nominal effective exchange rate	83.9
House prices	81.0
Loans to non-financial corporations	78.6
Household interest expense to income	68.5
Stock market index	56.5
Key interest rate – REIBOR 3m	30.0
Interest rate differential Iceland – Germany	27.3
Volatility of stock prices	11.8

As pointed out earlier, the sum of the squared loadings over factors for a given variable shows the communality for that variable, which is the proportion of the variable's variance explained by the common factors and therefore the relative weight of each variable in the factor-based FCI. Most of the variables have high communality, which is the desired outcome.

Like the PCA FCI, the factor-based index is on a monthly basis from January 2002 until July 2023. *Figure 5* displays the similarity of the FCI derived with PCA on the one hand and FA on the other. Most of the discussion about the PCA-based FCI is also applicable to the factor-based one. However, there are some notable differences. According to the factor-based FCI, financial conditions in Iceland were contractionary in the early 2000s. As with its PCA-based counterpart, conditions turned expansionary in late 2004 and were at their most expansionary in 2006-2007, preceding the financial crisis.

In agreement with the PCA-based FCI, financial conditions hit rock bottom at minus 3 standard deviations from the mean in late 2009 and only turned expansionary again at the beginning of 2016. However, until just in recent months, financial conditions have continuously been expansionary since 2016 according to the factor-based FCI. Bond and money market variables receive considerably more weight in the factor-based FCI than when using PCA. That explains why the factor-based FCI fell while the

PCA-based FCI was still on the rise in the beginning of 2022 as bond yields increased substantially. These developments are discussed further in section 4.

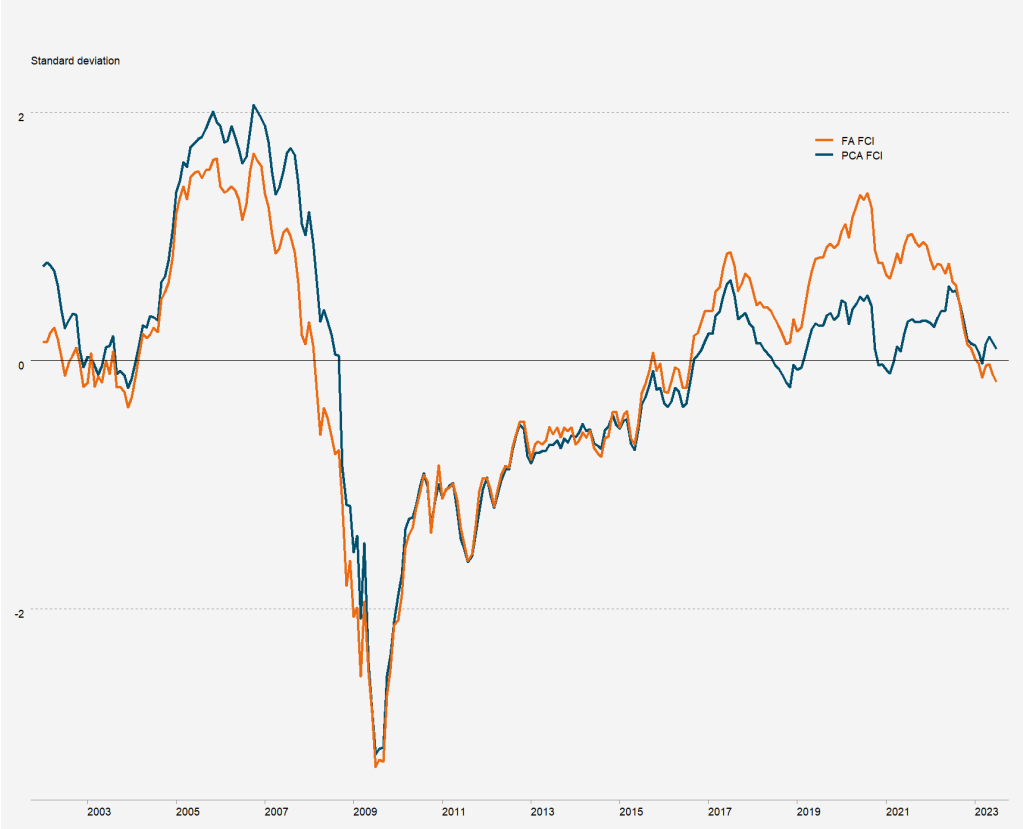

Figure 5. Factor-based FCI compared to the PCA FCI

Figure 6 shows the factor-based FCI, and the contribution made by the different sub-markets. It provides an indication of which markets have been important over different periods. This shows just how dominant the bond and money market are in the index, as the five heaviest weighing variables belong to that market. This large weight explains why the factor-based FCI shows consistently less expansionary conditions in the years 2002 to 2008, and consistently more expansionary conditions since 2016. Since the money market moved in the opposite direction to the other markets in the years before the financial crisis, due in part to the abundant supply of foreign currency denominated credit and associated capital inflows which fueled a currency appreciation and rising asset prices, the factor-based FCI is less expansionary than the PCA-based FCI during this period. The bond market is also more noticeable in the factor-based FCI, especially in recent years (2020-2022). Since bond yields have been low during long stretches of this period, it explains why the factor-based FCI has indicated looser conditions these past few years compared to the PCA-based FCI.

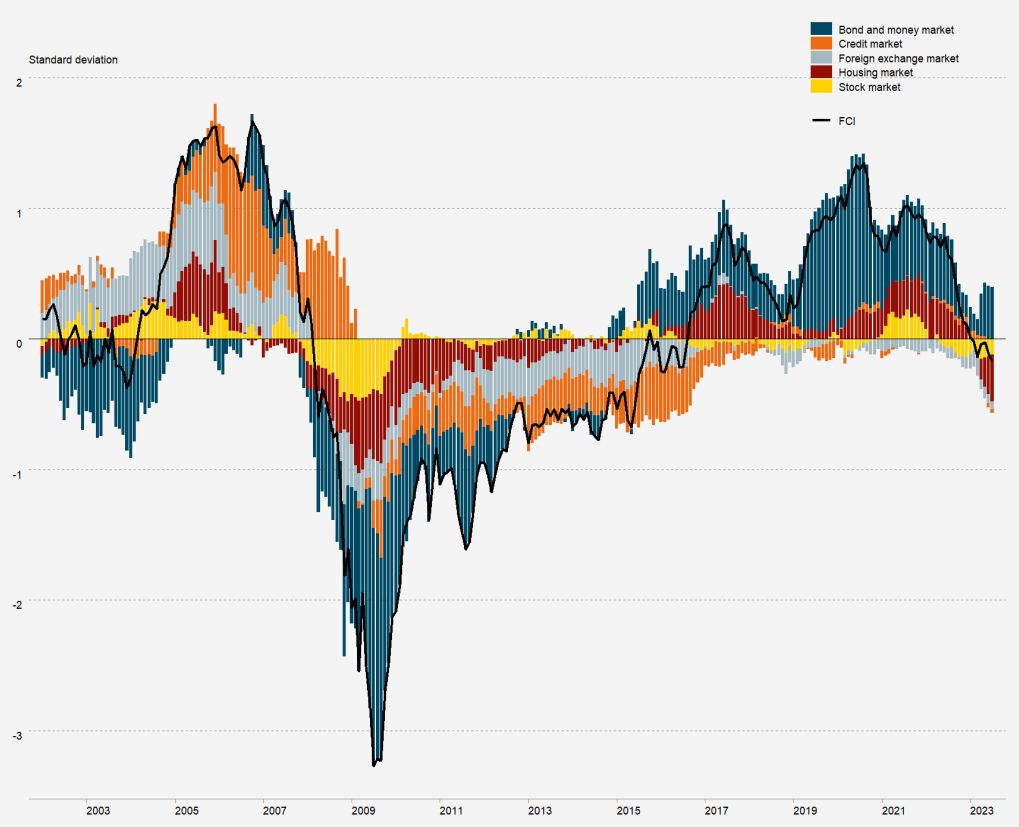

Figure 6. Contributions of the sub-markets to the FA-based FCI

3.3 Simple average method

Finally, an FCI is constructed with a simple average to see, among other things, whether the aforementioned statistical methods are needed. This simple approach of constructing a financial conditions index is based on Alsterlind et al., (2020). This approach assumes that each variable has the same weight and is equally important when it comes to describing financial conditions. In accordance with the other two FCIs, the first step is to normalize all the variables to a common scale to gain comparability between them. However, this approach is simpler than PCA and FA, as factors are created as an average of the indicators representing each sub-market. The final index is then created as the sum of the five factors that mirror the developments on each sub-market:

$$FCI = \sum_{j=1}^{5} \overline{f}_t^j$$

In the equation above, $\overline{f}_t^j$ is factor j. This method results in an index that is simple to interpret and can be replicated without using a complicated statistical model. The advantages of this approach are the simplicity of calculation and interpretation. However, there are some disadvantages. In the construction

of the Swedish FCI, one major argument for the use of a simple average approach to construct the index is that the underlying markets are similar in size in Sweden (Alsterlind et al., 2020). This is not the case in Iceland as can be seen in *Table 6* and the corresponding coverage in section 2. On top of that, the variables could also influence each other in a way which is not accounted for in this approach.

Table 6. Size of markets (end of 2021)

Exposure group	ISK billions	Share %
Stocks	2.556	13,81
Housing	10.464	56,55
Bonds	3.013	16,29
Bank deposits	2.470	13,35
Total assets	18.502	100
Exchange rate risk	925-1.850[1]	5-10

[1] 925 is 5% of the total assets and 1.850 is 10%.

Figure 7 shows the simple average FCI from January 2002 to July 2023 compared to the PCA-based FCI. As can be seen in *Figure 7*, short-term fluctuations are more noticeable in the simple average FCI, making it harder to interpret whether financial conditions have loosened or tightened between any two points in time. *Figure 8* shows the contributions from each sub-market to the FCI. All variables are assigned equal weights in the simple average FCI, so it is easy to see why the index is noticeably different than the PCA-based FCI. The housing market and the bond and money market get more weight in the PCA-based FCI compared to the simple average FCI, which is why the latter is less expansionary prior to the financial crisis with low bond yields and extremely high house prices. The stock market gets more weight in the simple average FCI compared to other two, which explains why it shows tighter conditions during the height of the financial crisis in 2008 when stock prices plummeted and looser conditions at the beginning of 2020 when stock prices soared.

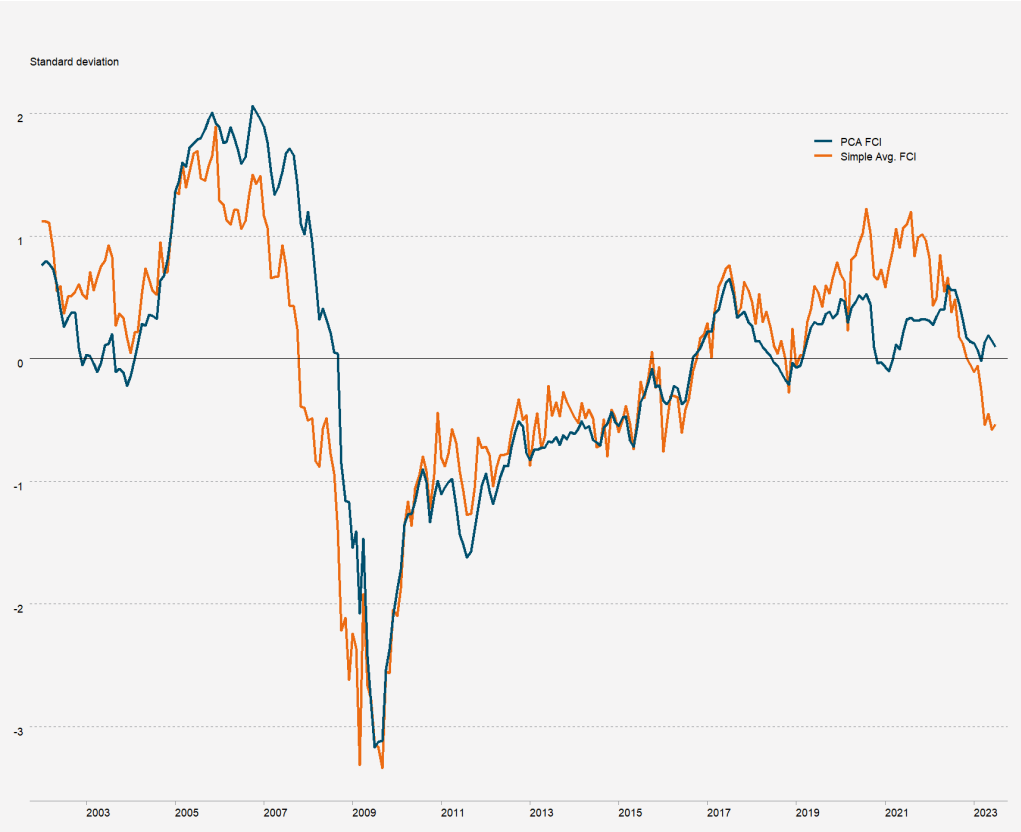

Figure 7. Simple average FCI compared to the PCA FCI

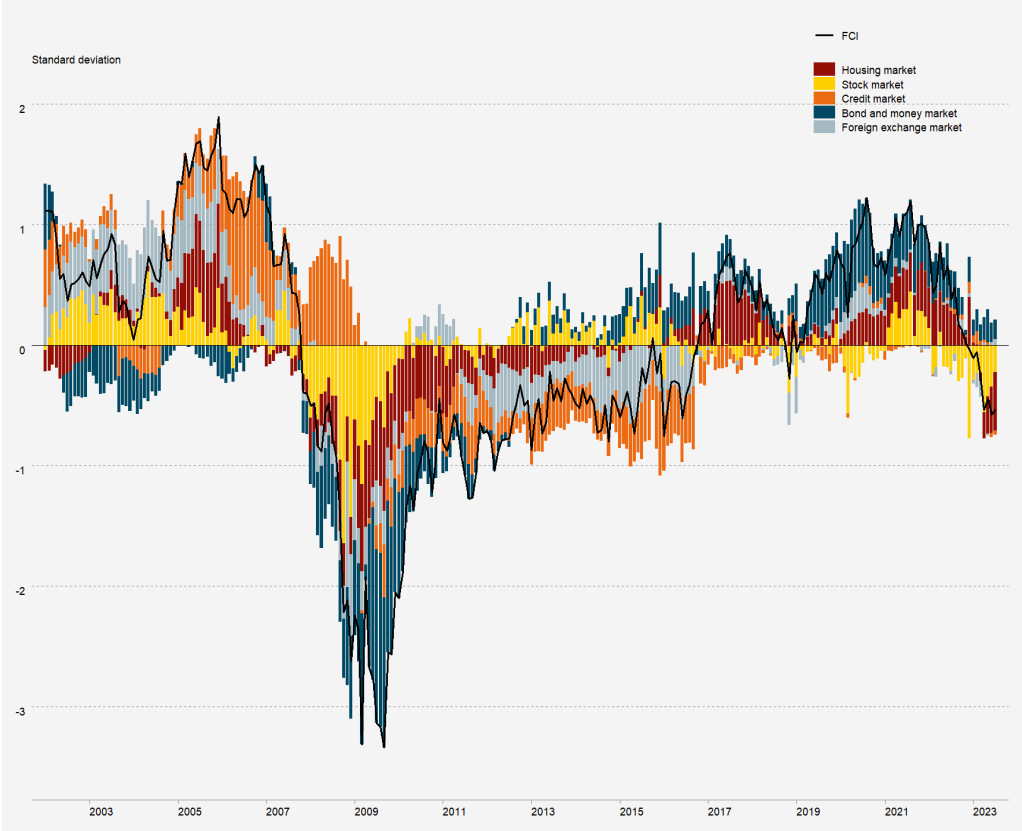

Figure 8. Contribution of the sub-markets to the simple average FCI

3.4 How do the FCIs relate to GDP developments?

None of the three methods used in this paper to construct an FCI are optimized to covary with GDP development. However, as stated in section 2, a number of variables in our selection for the index have a strong connection to GDP developments. Therefore, it is plausible that the indices may contain information which is useful to predict developments in the real economy. *Figures 9-11* show the constructed FCIs alongside the quarterly year-on-year change in GDP. A three-month moving average is shown for the FCIs to match the observation frequency of GDP. The FCIs tend to lead GDP developments marginally, so they are projected forward by one month. This comparison between the FCIs and GDP developments is based on previous studies, e.g., Fransson and Tysklind (2017). As *Figures 9-11* display, the FCIs seem to follow the development of GDP quite closely. This applies especially to the FCI constructed using PCA. This is highlighted in *Table 7.* The correlation between those two series is 0.61 which is well above the other two FCI's correlation with GDP developments. These results are similar to other papers as the correlation between the factor-based FCI Ho & Lu (2013) constructed for Poland and four-quarter-ahead growth rate was 0.52. The correlation between the PCA FCI Fransson and Tysklind (2017) constructed for Sweden and GDP developments was 0.64. Despite how well the three indices seem to capture GDP developments during the observed period, it is noticeable that none of the indices capture the impact Covid-19 had on GDP in 2020. However, that is to be expected as the shock from Covid-19 was exogenous and therefore not related to the financial system which hints that the FCIs function as envisioned.

Table 7

Method	Correlation with GDP
PCA	0.61
FA	0.48
Simple average	0.46

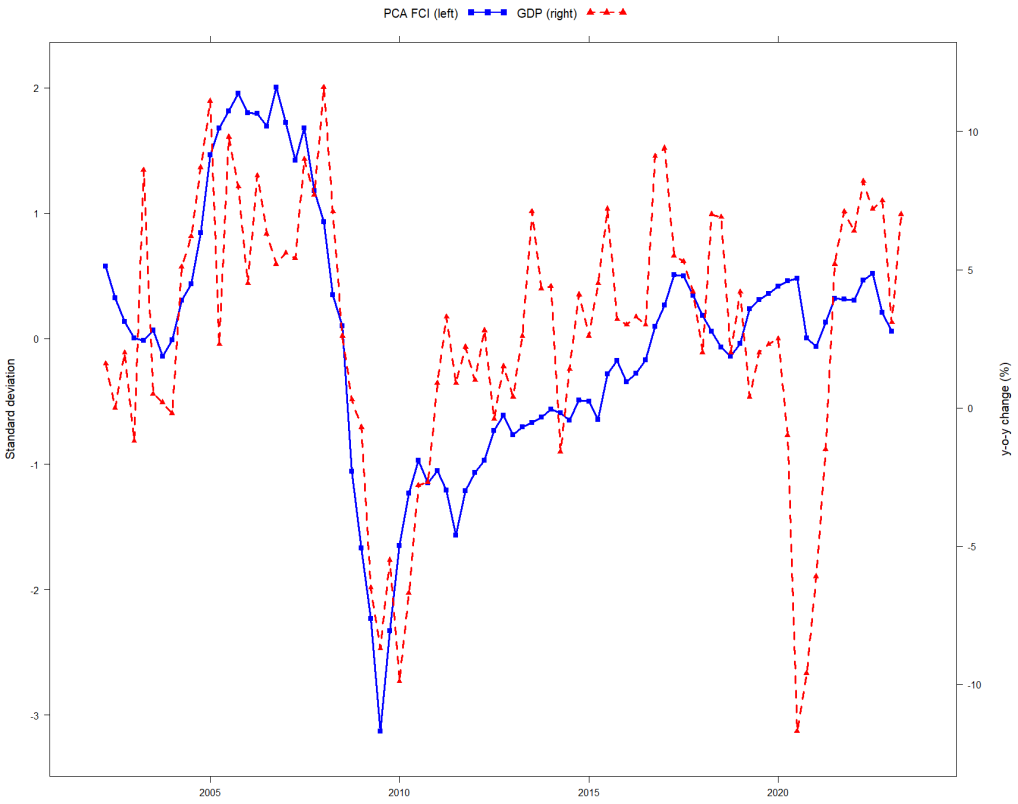

Figure 9. Principal component analysis-based FCI and GDP year-on-year change

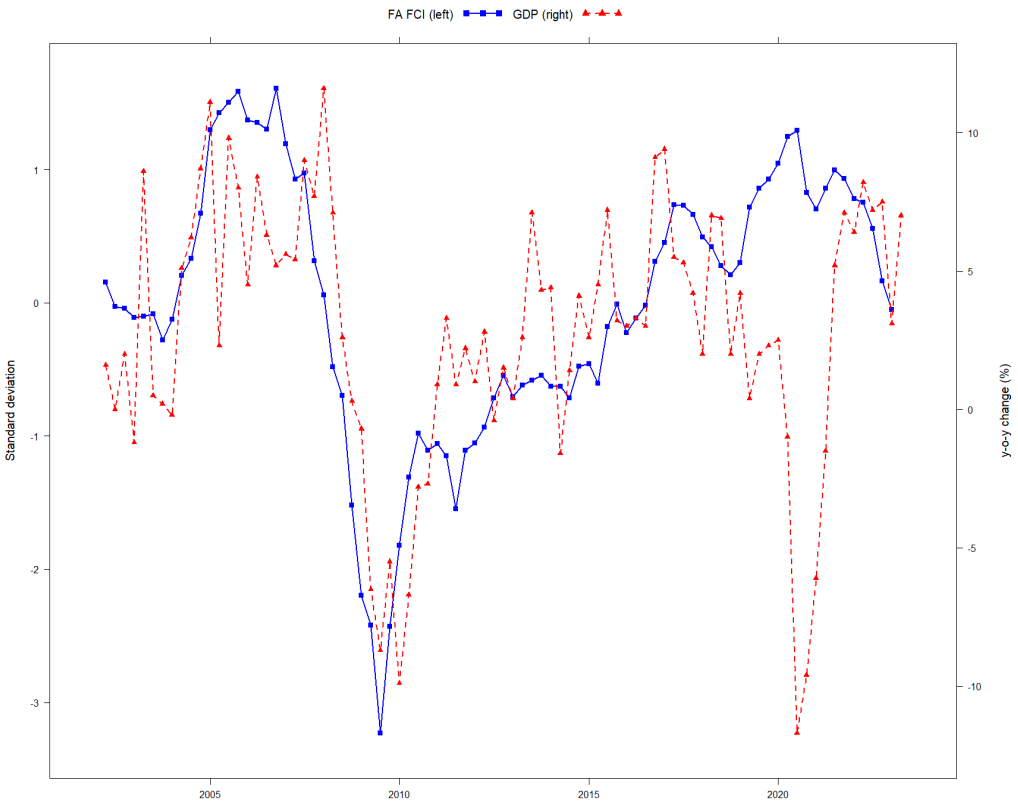

Figure 10. Factor analysis-based FCI and GDP year-on-year change

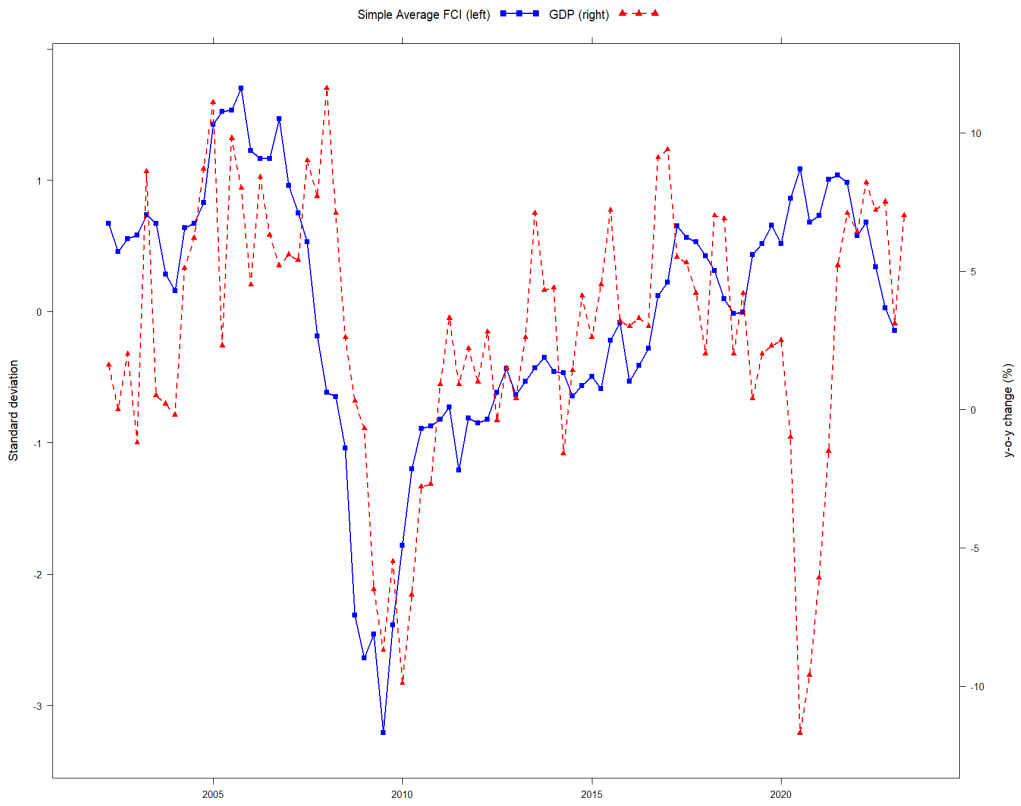

Figure 11. Simple average-based FCI and GDP year-on-year change

4 A historical overview

As section 3.4 shows, the FCI constructed using principal component analysis outperforms the other two FCIs and is therefore the index we have chosen to analyze Icelandic financial conditions.

Financial conditions turned very expansionary in 2005, which is apparent in *Figure 12*. In 2004, the mortgage system changed with amendments to law on the Housing Financing Fund where second mortgages were expunged and instead mortgages with up to 90% loan-to-value ratios were made available to the public. The role of the fund was changed, as it was now to use government guarantees to provide the public with loans at the lowest interest rates possible to expand people's ability to own or rent a dwelling in an affordable way (Parliamentary investigative committee, 2013). Shortly after this policy change, the newly privatized banks, which had previously stayed mostly out of mortgage lending, stepped forcefully into the mortgage-market, offering loans on better terms with lax lending standards. As this harsh competition played out rapid growth of household debt and a housing bubble followed (Central Bank of Iceland, 2005). Due to the events described above, financial conditions loosened rapidly from 2004 onwards.

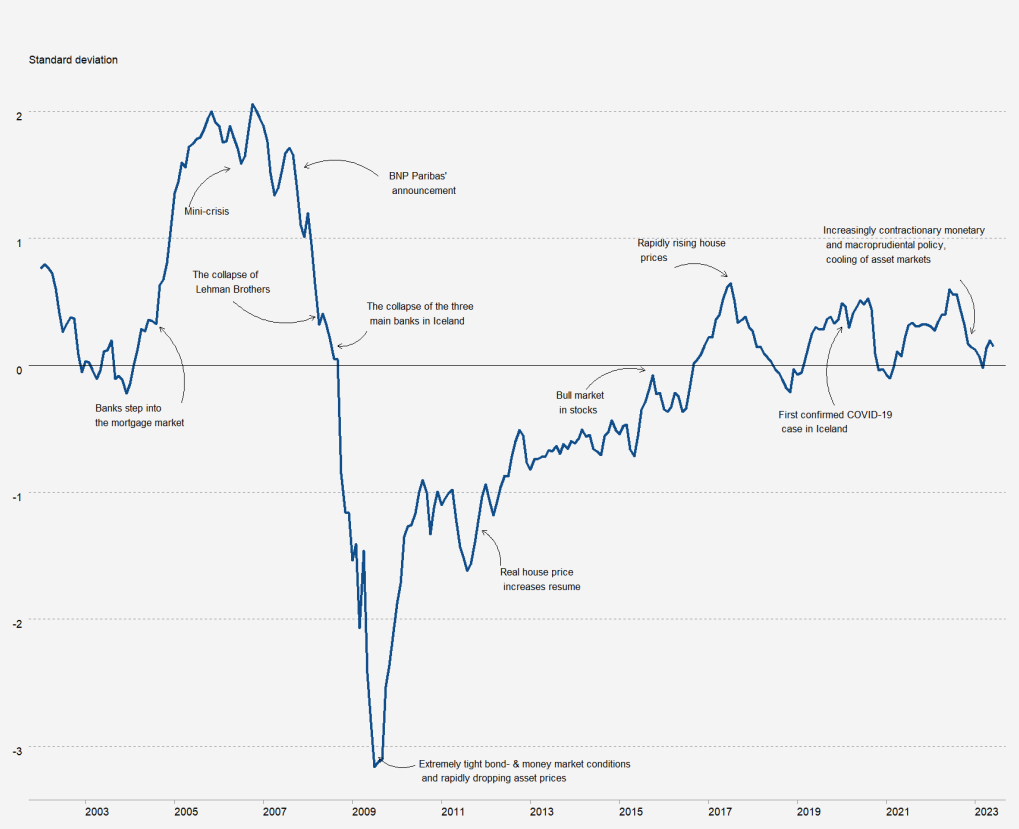

Figure 12. The chosen financial conditions index

Households' equity and access to credit had increased as housing prices soared. In the short term, this was also beneficial for non-financial corporations as one of their main funding sources was through loans and loan terms were favorable at the time. At this time, household's equity seemed to be strong, and it appeared as if they could weather financial shocks.

Another reason for highly expansionary financial conditions at this time is that in the years 2004-2006 the Icelandic banking system grew rapidly as international wholesale funding markets were very accessible. With Iceland's capital account fully liberalized in 2001, banks could exploit low interest rates abroad to fund their domestic lending, accumulating foreign liabilities in the process. Given the large interest rate differential between Iceland and its main trading partners, large capital inflows, both through banks and in the form of foreign direct investment, commenced, with an effect on the exchange rate, asset prices, and bond, money and credit market conditions.

In 2006, there was a so called mini-crisis. At the beginning of the year the nominal effective exchange rate was very low (i.e., the krona high-priced) but criticism of the economy's fragility mounted, due to rising external debt. The krona depreciated rapidly in March 2006, accompanied by a slight drop in real house prices, but in the middle of that year the situation had calmed. The FCI seems to show the effects of this mini crisis as it dips down in the first half of 2006.

The international financial crisis began in the summer of 2007, as is reflected in *Figure 12* where the FCI starts to plummet in the middle of 2007. In August that year, the French international banking group BNP Paribas announced that it was no longer able to estimate the value of the subprime mortgages in its sponsored funds. This can be described as one of the first recognitions of the fact that risk had been seriously mispriced in the months and years before and that banks did, in some cases, not fully understand the products under their management (Bernanke, 2018). This event and others led to further doubts about the soundness of the subprime bond market. From there it spread to other asset classes and ultimately led to greater uncertainty over the soundness of the international financial system. This hit the Icelandic banks hard right away, as they had relied heavily on international funding markets and faced large maturity and currency mismatches on their balance sheets (Parliamentary investigative committees, 2010).

Following the onset of the international crisis, housing prices started declining, and the krona depreciated. This is reflected in *Figure 12* where the index takes a rapid turn towards tighter financial conditions. At the time, international financial conditions had worsened. There was a sharp increase in mortgage rates, a decrease in the supply of credit and the liquidity of financial corporations tightened in Iceland (Central Bank of Iceland, 2008a). During the financial crisis, households' equity and access to credit was low in Iceland as both households and firms struggled financially.

In October 2008, a systemic banking crisis occurred. The credit market tightened severely and tested the resilience of the banks, a test they ultimately failed. Due to uncertainty and growing risk aversion, access to funding became very limited. Housing prices kept on decreasing and, along with that, households' equity shrunk. The prediction at the time was that the financial position of households would be tight in the upcoming years (Central Bank of Iceland, 2008b).

As part of the government's response to the systemic banking crisis, strict restrictions were placed on capital movements between countries and related foreign exchange transactions. These capital controls were aimed at stabilizing the exchange rate and improving financial conditions (Central Bank of Iceland, 2011a). Later that fall, positive effects from the capital controls on financial conditions were observable. The krona appreciated in December and continued to do so, albeit at a slower pace than expected (Central Bank of Iceland, 2009a).

In the first half of 2009, the Central Bank's key rate was almost halved from 18% to 9.5%, stock prices rose, and the interbank market showed signs of activity after almost completely shutting down during the height of the crisis. Still, tight financial conditions persisted as the exchange rate of the króna remained weak, and weaker than expected in the third quarter of 2009. Inflation declined at a slower rate than expected, access to credit worsened and house prices decreased rapidly in 2009. This led to financial conditions reaching their tightest stance in the middle of 2009 (Central Bank of Iceland, 2009c).

In the second half of 2009, financial conditions loosened and a recovery period had begun (Central Bank of Iceland, 2009b). This is reflected in *Figure 12* which shows a large rise in the FCI from mid-2009 to the end of the first quarter of 2010. Inflation had subsided somewhat, the krona appreciated, and the decrease in house prices slowed down. This created more room for continued interest rate cuts. Inflation and interest rates continued decreasing for the rest of the year. Still, uncertainty regarding households' finances remained. Household indebtedness was still high and house prices still on the decline (Central Bank of Iceland, 2010). Furthermore, legal disputes were ongoing over foreign currency denominated and exchange rate linked bank loans to households. Court cases stemming from these disputes were largely settled before the Supreme Court of Iceland in July 2010 and February 2011, followed by amendments to law by parliament, and resulted on the whole in debt relief for households of at least 260 billion Icelandic krona by early 2011, at current prices (14,7% of 2011 GDP) (Government of Iceland, 2012). These events may be counted as a contributing source of volatility in the FCI from 2010 to 2012, as court dates partly coincide with drops in the index, driven primarily by temporarily worsening bond and money market conditions and currency depreciation. The beneficial effects for households enter the FCI as a credit contraction, and thus do not contribute to a higher FCI. Additionally, this effect was not realized instantly, but rather implemented over a number of months following each court ruling.

In 2011, inflation expectations worsened because of a depreciating krona and higher commodity prices. In April, a referendum was held on a draft legislation regarding the so-called Icesave-dispute, an international dispute concerning deposit accounts at subsidiaries of one of the Icelandic banks in the United Kingdom and the Netherlands. This entailed exchange rate risk, and the result could also affect the process of lifting capital restrictions. On the other hand, housing prices increased year-on-year for the first time since 2008 (Central Bank of Iceland, 2011c).

Job prospects had been weak since the crisis and companies remained more inclined to reduce their workforce than hire more workers. During the second part of 2011 the krona appreciated, access to credit eased and money aggregates grew. The default rate of firms was still high, though (Central Bank of Iceland, 2011b). These generally benign developments are reflected in a large rise in the FCI in the second half of 2011.

Financial conditions recovered slowly but steadily until 2015, when stock market recovery delivered the first post-crisis bull market. This is reflected in the FCI with a significant rise in the latter half of that year. Real estate markets also gained momentum until 2017, when an increasing supply and demand mismatch and the associated rapid price increases spurred talk of growing cyclical systemic risk. As of 2017, the financial position of the non-financial private sector had improved greatly, banks enjoyed a good capital position and their continued restructuring and restoration contributed to favorable bond, money and credit market conditions. All this corresponds well with the FCI moving into positive territory by the third quarter of 2016 and by mid-2017 indicating similarly loose financial conditions as in the latter half of 2004.

In March 2017, most capital restrictions were lifted. Households and businesses were then no longer subject to the restrictions that the Foreign Exchange Act placed on, among other things, foreign exchange transactions, foreign investment, hedging, and lending activity. Furthermore, the foreign currency repatriation requirement was abolished. As *Figure 12* displays, this coincides with a rapid loosening of financial conditions largely driven by the housing market, according to the FCI. Restrictions remained on derivatives trading for purposes other than hedging, foreign exchange transactions between domestic and foreign parties not carried out through financial intermediaries and in certain cases on domestic lending to foreign parties in foreign currency (Central Bank of Iceland, 2017a; Central Bank of Iceland, 2017b). This change may have contributed to the FCI's consequent slide toward tighter conditions from 2017 to 2018, by allowing for increased short-term fluctuations in the exchange rate as well as enabling capital outflows. Nonetheless, a cooling down of the real estate market played the main role in this development.

As *Figure 12* displays, financial conditions became gradually more expansionary from 2018 until early 2020. The bond and money market played a big part in these developments, first and foremost due to the key interest rate being lowered by 3 percentage points during this period, from 5.75% to 2.75%.

In February 2020, the COVID-19 pandemic hit Iceland. This shock rattled financial markets all over the world and is the first large macroeconomic shock within the observed period of a purely non-financial nature. According to the Central Bank of Iceland, rising unemployment, declining GDP and an 80% drop in tourist arrivals were predicted that year. The krona depreciated after the pandemic spread to Iceland, but commodity prices also decreased. Firms in service sectors such as transportation, tourism, catering, and entertainment, along with their workforce, were at the greatest risk of losing their incomes (Central Bank of Iceland, 2020b).

The Central Bank, already in the process of cutting rates since May 2019, continued to do so after the pandemic's onset with increased forcefulness, lowering the key rate from 2.75% to 1% in the span of three months. Furthermore, it announced its intent to commence secondary market purchases of Treasury bonds and use the foreign exchange reserves to mitigate exchange rate volatility (Central Bank of Iceland, 2020c; Central Bank of Iceland, 2020d). In addition, capital requirements were lowered, and action taken to ensure ample liquidity in the financial system (Central Bank of Iceland, 2020e). Financial institutions' access to liquidity remit was increased and several measures taken by the government to support the credit access of households and businesses. The krona depreciated by 8% from the pandemic's spread to Iceland until mid-March 2020, while stock prices fell and the housing market cooled. Investors, including banks, shifted to more secure and liquid assets. As the situation developed quickly during the pandemic's onset, the initial market reaction is not separable from the effects of the Central Bank and government's reaction in *Figure 12*, except for a minor drop in the FCI between February and March 2020. That movement is mainly driven by declining stock prices.

At the end of the third quarter of 2020, the measures which the authorities had resorted to had supported demand and reduced the impact of the economic shock. Banks remained liquid, while their equity position remained strong (Central Bank of Iceland, 2020a). This corresponds well with a higher FCI value in September than in February. The FCI fell sharply, however, between September and November, driven almost exclusively by tighter conditions in the bond and money market. Treasury-bond yields rose markedly during the fall of 2020, to some extent caused by marginally increased inflation, but probably to a greater extent by concerns over public debt accumulation during a pandemic which was proving to be a protracted one.

The key interest rate reached an all-time low in November 2020 at 0.75%. In hindsight, this can be argued to have had a strong effect on financial conditions through multiple markets, making them looser, as is seen in *Figure 12*. First, by further encouraging lenders to offer very favorable mortgage rates, thus contributing to real estate price increases and credit growth. Prices surged and turnover in the real estate market was at its highest in March 2021 (Housing and Construction Authority, 2022). Second, lower rates led to an increase in stock prices and eased bond and money market conditions.

The Central Bank began raising interest rates in May 2021 with inflation on the rise, not least due to the steep climb of house prices, which contributed heavily to headline inflation. The increase in house prices proved out of line with determining factors such as wages, disposable income, rent prices and building costs. Thus, an imbalance in the residential real estate market had grown along with household debt. Although this improved homeowning households' equity position it was also considered a sign of growing cyclical systemic risk (Central Bank of Iceland, 2020b; Central Bank of Iceland, 2020c).

In 2022, a positive output gap had formed, job numbers were above their pre-pandemic levels, and unemployment decreased. However, February marked the beginning of the Russian invasion of Ukraine which sparked negative economic effects. Inflation increased sharply, not least due to the continued increase of house prices and a rapid growth in commodities prices due to the war. Investors shifted their portfolios towards safer assets once more, due to uncertainty, which was accompanied by decreasing stock prices.

In the first half of 2023, financial conditions were still slightly looser than the historical average, according to the FCI, but they have been tightening fast. This is to be expected, mainly because the Central Bank had vigorously applied the tools at its disposal in the fight against inflation and systemic risk, both by raising interest rates and by tightening borrower-based measures for residential mortgages. The key interest rate was at 9.25% in August.

5 Conclusion

We have constructed an index, using principal component analysis, that aims to capture financial conditions in Iceland from 2002 to 2023. The main goals are to provide an overall picture of financial conditions, create an indicator that has forecasting properties for short-term economic activity, and support the decision-making of monetary and macroprudential policy. Summarizing financial conditions into a single index can provide an overview of many different financial markets and provide consistency in the Central Bank's communication on financial conditions.

Numerous variables were tested individually in relation to GDP and approximately half of them showed evidence of significant explanatory power of its variance. A couple of other variables are still considered important for financial conditions as they are important measures of the cost and provision of credit, foreign exposure, and uncertainty and are therefore also included in the index.

Icelandic markets are diverse and vary in size. This is why a statistical method, rather than a simple average, was chosen to determine the weights of the variables in the FCI. Since the index constructed using principal component analysis seems to capture GDP developments better than the FCI constructed using factor analysis over the observed period, it is the preferred FCI.

Our analysis shows that the resulting index has an intuitive appeal, fitting well with a historical narrative of Icelandic financial conditions since the beginning of the 21st century. During the observed period the preferred FCI manages to explain economic fluctuations and capture the major events in financial markets relatively well. It has also been shown that the FCI does have some explanatory power for changes in the real economy.

Therefore, it is safe to say that the FCI, as a quantitative measure that helps describe different financial channels, can be a useful tool for both monetary and macroprudential policy-making. As with other economic models there is uncertainty regarding the method and data used. It is difficult to compare the values of a financial conditions index over long periods as it has no natural unit, but as long as the FCI is interpreted with a degree of caution, it can provide valuable information. It is known that the financial system will change over time which will lead to new patterns and therefore it is important to constantly update the FCI and reconsider the variables and method. The indices constructed with the three different methods discussed in the paper, are displayed in *Figure 13.*

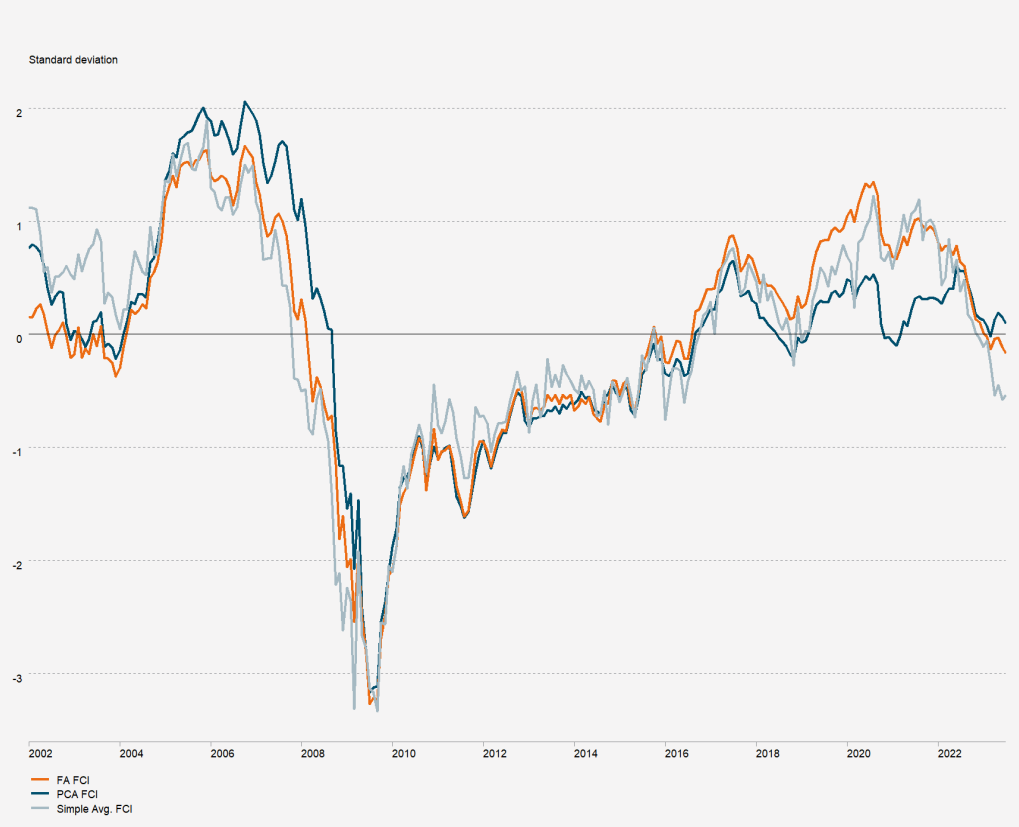

Figure 13. The three FCIs

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7 Appendix A

Table A1. List of variables

Variable	Source & description	Transformation
1. Housing prices	Whole country index, Housing and Construction Authority via Central Bank of Iceland Economic Indicators, chart VI-4	Y-o-y change (%)
2. Loans to households	Central Bank of Iceland, Economic Indicators, Chart VII-2	Current prices, y-o-y change (%)
3. Household interest expense to income	Central bank of Iceland and Statistics Iceland. Weighted average interest rates applied to stock of loans to households to calculate interest expense.	Divided by monthly income. Y-o-y change (%)
4. Stock prices	Nasdaq OMX Iceland. Total index for the main market. Monthly average of daily closing values.	Current prices, y-o-y change (%)
5. Volatility	Nasdaq OMX Iceland. Volatility of the total index for the main market. Central Bank of Iceland calculations.	Logarithm. Within-month-sum of squared deviations of daily price changes from within-month-average price change, divided by the no. of trading days within month, multiplied by square root of 252.
6. Interest rate	Central bank of Iceland key policy rate	%
7. Interest rate – REIBOR 3m	Central Bank of Iceland. 3-month interbank offered rate (REIBOR 3 month) and CBI key policy rate differential	%

8. Loans to non-financial corporations (NFC)	Central Bank of Iceland.	Current prices, y-o-y change (%)
9. 10-year LEVEL	Central Bank of Iceland, Economic Indicators, Chart VIII-13. Yield on 10-year non-indexed bond issued by Icelandic government. Treasury bond spread.	Monthly average of daily closing yield, %
10. 10-year indexed LEVEL	Central Bank of Iceland, Economic Indicators, Chart VIII-13. Yield on 10-year inflation-indexed bond issued by Icelandic government.	Monthly average of daily closing yield, %
11. 10-year – 2-year spread	Central Bank of Iceland, 10-year and 2-year non-indexed government bond yield differential.	Monthly average of daily closing yield, %
12. 10-year – 2-year spread, inflation indexed	Central Bank of Iceland, 10-year and 2-year inflation-indexed government bond yield differential.	Monthly average of daily closing yield, %
13. Nominal Effective Exchange Rate (NEER)	Central Bank of Iceland. Nominal effective exchange rate of the Icelandic króna.	Index
14. Interest rate difference between Iceland and Germany	Refinitiv Datastream via Central Bank of Iceland Economic Indicators, Chart VIII-12. Long-term interest rate differential between Iceland and Germany, using yields on 10-year non-indexed government bonds.	Monthly average of weekly data, %

Method - PCA

PCA as an exploratory data analysis method involves a dataset with observations on p numerical variables, for each of n entities. These values define a $n\ x\ p$ data matrix $\mathbf{X}$, whose column j is the vector $\mathbf{x}_j$

of observations on variable j. PCA aims for a linear combination of the columns of matrix **X** with maximum variance. These linear combinations are given by

$$\sum_j^p a_j x_j = \mathbf{Xa} \quad (1)$$

where **a** is a vector of constants: $a_1, a_2, \dots, a_p$. Each linear combination has a variance given by

$$var(\mathbf{X_a}) = \mathbf{a'Sa} \quad (2)$$

where **S** is the sample covariance matrix linked to the dataset. Further restrictions are required for this problem to have a well-defined solution. The restrictions in question are usually unit-norm vectors, i.e., requiring $\mathbf{a'a} = 1$. This is equal to maximizing

$$\mathbf{a'Sa} - \lambda(\mathbf{a'a} - 1) \quad (3)$$

where λ is a Lagrange multiplier and differentiating produces the equation

$$\mathbf{Sa} = \lambda\mathbf{a}. \quad (4)$$

Therefore, **a** must be an eigenvector, and λ the eigenvalue of the covariance matrix **S**. The most interesting aspect is the largest eigenvalue, λ_1, and the matching eigenvector $\mathbf{a}_1$, considering the eigenvalues are the variances of the linear combinations defined by the matching eigenvector

$$\mathbf{a}: \text{var}(\mathbf{X_a}) = \mathbf{a'Sa} = \lambda\mathbf{a'a} = \lambda. \quad (5)$$

However, it is important to note that *equation 4* also remains accurate if the eigenvectors are multiplied by -1, therefore the signs of all loadings are arbitrary and only their corresponding magnitudes and sign patterns are meaningful. A Lagrange multipliers approach can be used to display that the full set of eigenvectors of **S** are the solutions to the problem of obtaining up to p new linear combinations

$$\mathbf{Xa}_\text{k} = \sum_{\text{j}=1}^{\text{p}} \text{a}_\text{jk}\text{x}_\text{j} \quad (6)$$

which respectively maximize variance, based on uncorrelatedness with preceding linear combinations. The linear combinations that are in question, $\mathbf{Xa}_\text{k}$, are called the "principal components" of the dataset, hence the name of this statistical method, principal component analysis. In the PCA terminology, the fundamentals of the eigenvectors $\mathbf{a}_\text{k}$ are usually called the PC loadings, while the fundamentals of the linear combinations $\mathbf{Xa}_\text{k}$ are called the PC scores (Joliffe and Cadima, 2016).

Method – Factor Analysis

There is a clearly stated model underlying factor analysis, while that is not the case for principal component analysis. For the observed variables $X_1, X_2, \dots, X_n$, in factor analysis, the common factors are $F_1, F_2, \dots, F_m$ and the unique factors are $U_1, U_2, \dots, U_n$. These variables can be expressed as linear functions of the factors:

$$X_1 = a_{11}F_1 + a_{12}F_2 + a_{13}F_3 + \cdots + a_{1m}F_m + a_1U_1$$

$$X_2 = a_{21}F_1 + a_{22}F_2 + a_{23}F_3 + \cdots + a_{2m}F_m + a_2U_2$$

$$\ldots$$

$$X_n = a_{n1}F_1 + a_{n2}F_2 + a_{n3}F_3 + \cdots + a_{nm}F_m + a_nU_n$$

With factor analysis, we seek to estimate the coefficients $a_{11}, a_{12}, \ldots, a_{nm}$ which best reproduce the observed variables from the factors. The coefficients are called loadings and when the factors are uncorrelated, the sum of the squares of the loadings for variable X_1, that is $a_{11}^2 + a_{12}^2 + \cdots + a_{nm}^2$, shows the communality that is used as weights in the factor analysis.

The FCI with data from 2010-2023

The global financial crisis in 2008 is a big outlier in our dataset and therefore it would be interesting to see how the final FCI would look like if the crisis is excluded in our analysis. We have therefore constructed another version of the FCI with data from 2010-2023. The FCI and the contribution of the submarkets are shown in *figures A1* and *A2*.

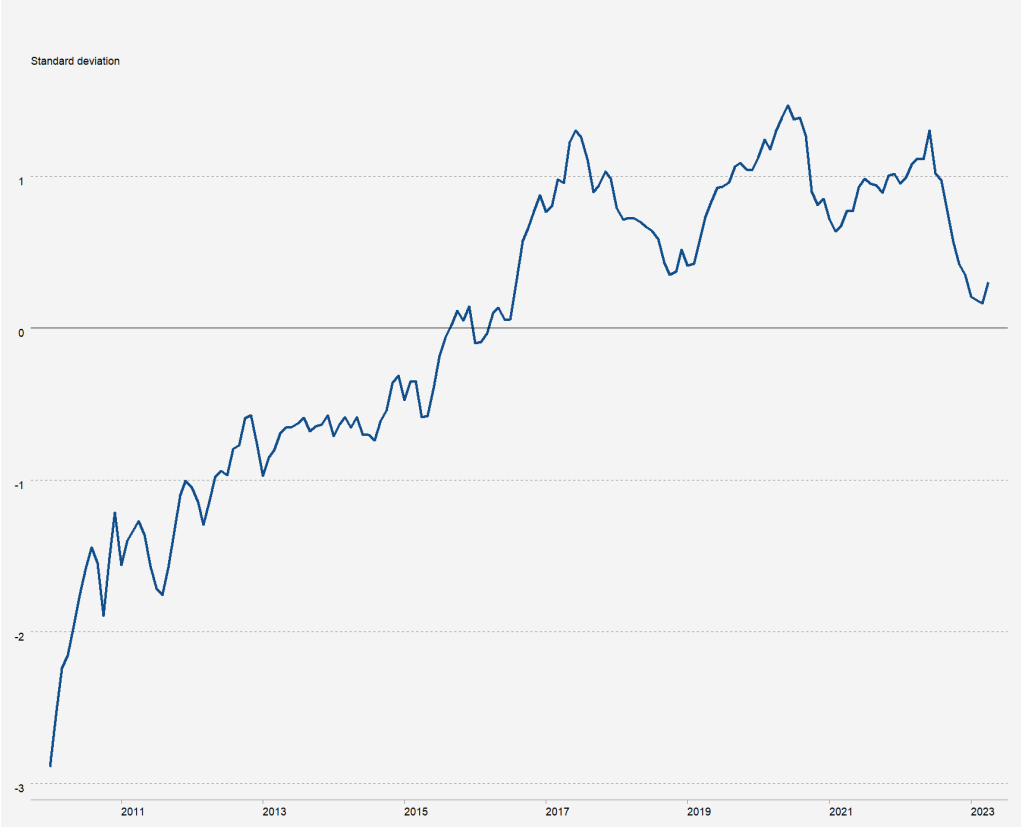

Figure A1. The final FCI constructed with PCA using data only from 2010-2023

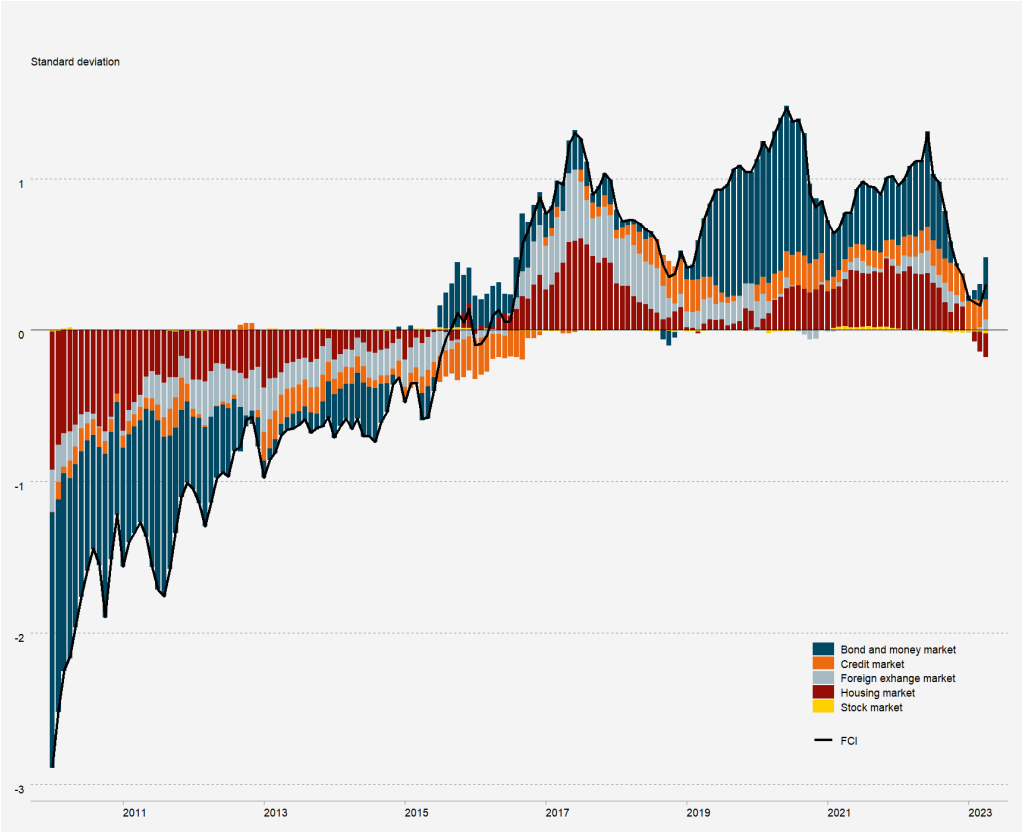

Figure A2. Contribution of the sub-markets to the PCA FCI from 2010-2023

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