Staff memo

A new indicator of risks and vulnerabilities in the Swedish financial system

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Summary

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The Riksbank analyses stability in the financial system on a continuous basis to enable the early detection of changes and vulnerabilities that may lead to a crisis. As part of this work, the Riksbank is continuously developing tools, methods and models that are used in the analysis. This staff memo presents a new indicator of risks and vulnerabilities in the Swedish financial system - *the systemic risk indicator.* The indicator tracks risks and vulnerabilities in different sectors and markets that are important from a financial stability perspective: the household sector, the non-financial corporate sector, the banking sector and the property market. We analyse leverage and resilience in the household and corporate sectors, and we track the banking sector's size, leverage, liquidity, interconnectedness and foreign funding activities. The property market is important for households, firms and banks alike, and we analyse prices and construction activities for both residential and commercial properties. Besides households, firms, banks and the property market, the indicator also captures other risks that might hamper financial stability. We focus on a set of variables that are relevant for financial stability in Sweden, but without referring to a particular sector or market in the financial system. This set of variables is referred to as the external environment and captures external leverage, government debt and policy uncertainty, in Sweden and globally.

Apart from the main systemic risk indicator, we also present five separate sectoral indicators that track risks and vulnerabilities in the above-mentioned sectors and markets. By combining the information contained in many different time series across various sectors, we are able to provide a broader picture of the development of risks and vulnerabilities in the Swedish financial system over time.

The financial system plays an important role in the economy. It is necessary to have a stable and smoothly running financial system for the economy to function and grow. A crisis in the financial system leads to extensive economic and social costs. The new systemic risk indicator helps provide policy makers with a snapshot of the stability outlook, which can serve as a starting point for in-depth analyses.

[1] The authors would like to thank colleagues at the Riksbank for useful and valuable input. The opinions expressed in this staff memo are those of the authors and are not necessarily shared by the Riksbank.

1 Introduction

Determining whether the financial system is stable today and will remain stable in the future is a difficult task. In fact, financial stability is perhaps easiest defined by the absence of financial instability. In the middle of a banking crisis, when large losses, or even defaults, threaten the banking sector, the financial system is unable to support the real economy, and propagates rather than absorbs shocks. The banking crisis in the early 1990s in Sweden is a typical example; back then, everyone realized the importance of a stable banking system, as the lack thereof had major repercussions on households, firms and the government. Likewise, the global financial crisis of 2008-09 revealed how stress in the financial system can affect real economic activity negatively.

The financial system plays an important role in the economy and it is necessary to have a stable and smoothly running system in order for the economy to function and grow. Financial stability is simply a necessary condition for sustainable economic growth. At the same time, the financial system is sensitive and has built-in vulnerabilities. These arise as a natural consequence of economic and financial players performing their basic functions. Different parts of the system are also closely linked to one another, which means that problems arising in one part of the system quickly can spread to other parts and threaten financial stability. The combination of built-in vulnerabilities and interconnection means that the financial system is susceptible to systemic risk, and a crisis, which leads to financial instability, will have extensive economic and social costs.

The Riksbank defines financial stability as the financial system being able to maintain its three basic functions: the mediation of payments, the conversion of savings into funding, and risk management – and also having resilience to shocks that threaten these functions. However, the financial system is sensitive due to vulnerabilities in central parts of the system, for example concerning households, banks, firms and markets. At the same time, Sweden is a small and open economy, which means that developments abroad may also have considerable impact on Swedish financial stability.

The Riksbank has several tools at its disposal to deal with financial crises (see Sveriges Riksbank, 2020, for an overview of measures taken during the 2007-2010 period). One important crisis management tool is the provision of loans to solvent banks and credit institutions[2]. Such loans (or liquidity assistance) help banks to bridge periods with insufficient means to repay investors, manage credit shortages and to avoid a bank run. In normal times, the Riksbank monitors the financial system and communicates the risks to financial stability in its publications and dialogues with the private sector and other authorities. Monitoring and analysing financial stability on a continuous basis is of crucial importance to central banks in order to enable the early detection of changes and vulnerabilities that may lead to a crisis.

This staff memo supports the monitoring toolkit of the Riksbank by presenting a new indicator for risks and vulnerabilities in the Swedish financial system. The systemic risk indicator serves to give a first glance of the level and change in the risks relevant for financial stability. Changes in the risk outlook can focus attention on the monitoring and in-depth analysis of the drivers of this change, especially when the indicator signals elevated risks. We construct the indicator so that higher levels indicate greater risks and vulnerabilities. The systemic risk indicator can be viewed as a further developed version of a financial fragility indicator developed by the Riksbank in 2017.[3]

The systemic risk indicator tracks risks and vulnerabilities in the most important parts of the financial system: the banking sector, the household sector, the non-financial corporate sector and the property market. These sectors are represented by separate sectoral indicators, and are further combined together to form the overarching systemic risk indicator. We analyse leverage and resilience in the household and corporate sectors, and we track the banking sector's size, leverage, liquidity, interconnectedness and foreign funding activities. The property market is important for households,

[2] In exceptional circumstances, the Riksbank may, with the aim of supporting liquidity, grant credits or provide guarantees on special terms to banking institutions and Swedish companies subject to the supervision of Finansinspektionen. See Chapter 6, Article 1, first paragraph of the Sveriges Riksbank Act and to a Swedish company under the supervision of Finansinspektionen, see Chapter 6, Article 8 of the Sveriges Riksbank Act.

[3] See Giordani, Spector and Zhang (2017).

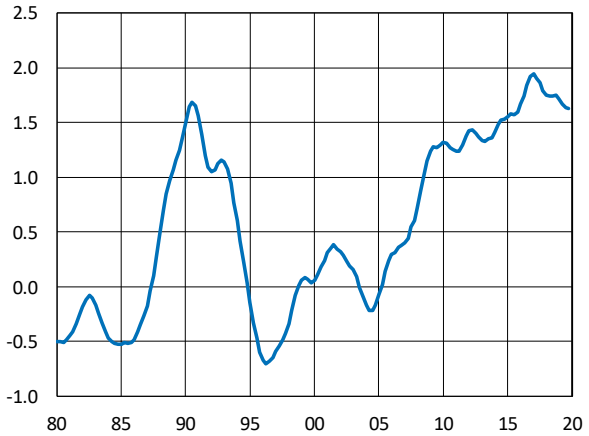
firms and banks alike, and we analyse prices and construction activities for both residential and commercial properties. The systemic risk indicator also monitors risks from outside the Swedish financial system, focusing on fiscal affairs (government debt) and policy uncertainty in Sweden and abroad, and Sweden's net borrowing position with respect to other countries.

We discuss the variables and the construction of the systemic risk indicator and its components in detail in the chapters that follow. Overall, we present six different indicators: one for each part of the financial system (the household indicator, the non-financial corporate indicator, the property indicator, the bank indicator and the external environment indicator, jointly referred to as sectoral indicators), and the overarching, main *systemic risk indicator*, which takes the previous five as inputs. Our hope is that both the sectoral indicators and the main systemic risk indicator capture the main risks and vulnerabilities facing the sector and the financial system, by providing frequent (at least quarterly) updates on the state of affairs.

Chart 1 plots the main systemic risk indicator derived in this staff memo. The indicator is expressed as standard deviation from its mean since 1870, when the first data series started.[4] Higher levels indicate more risks and vulnerabilities in the Swedish financial system. The indicator rises ahead of major historical events, such as the 1990s crisis and the more recent global financial crisis of 2008-09. This is a desirable feature, and suggestive of the capability of the indicator to give "early-warning" signals.

Even after the 2008-09 financial crisis, the indicator keeps rising, reflecting, amongst other things, more debt in the corporate and household sectors, and higher housing prices. By the end of 2019, the indicator reaches a level of around 1.6 standard deviations above its historical average. The indicator thus signals somewhat lower risks today compared to 2016, mainly due to a slowdown in credit growth and housing prices.

Chart 1 Systemic risk indicator (indicator of risks and vulnerabilities)
Standard deviation



Note. The chart depicts the indicator of risks and vulnerabilities in the Swedish financial system (short name: systemic risk indicator) during the period 1980-2019, on a quarterly basis. A higher value indicates a higher level of risks and vulnerabilities.

Source: The Riksbank

It is important to emphasize that the systemic risk indicator has not been specifically designed to predict crises nor is it a perfect indicator of risks and vulnerabilities. It is also not an indicator of stress. We believe that our indicator is helpful in monitoring factors that *are important* when assessing the probability and size of future systemic financial crises, and how these develop over time. Vulnerability

[4] Because the indicator is normalised, the main systemic risk indicator has a mean of zero and standard deviation of 1 over the full sample period, 1870-2019. In chart 1, the mean appears to be higher, which is due to the indicator only having been plotted since the 1980s. Chart A3.1 in appendix 3 plots the indicator since 1870.

levels can remain elevated for long periods of time, but crises tend to be deeper and more costly when they occur after a long period of rising vulnerabilities.

The outline of the staff memo

The next chapter (Chapter 2) begins with an illustrative description of the systemic risk indicator and documents how the indicator and its components are constructed. Next, we discuss important choices and assumptions concerning the variables to include, the data transformations needed to be able to include variables, and the weighting scheme to aggregate the transformed individual variables to sectoral or overarching indicator(s). This methodological section aims to provide the reader with a practical framework and facilitates the interpretation of the sectoral indicators and the systemic risk indicator. In Chapter 3, we present each of the five sectoral indicators that make up the systemic risk indicator. The construction of each sectoral indicator is presented and input variables are discussed and motivated from a financial stability perspective. The final part of Chapter 3 concludes with the main systemic risk indicator and describes its current and past developments. Chapter 4 presents a sensitivity analysis where some of the assumptions underlying the data transformations are altered. In Chapter 5, we discuss similar work done by the Riksbank and other institutions previously. Chapter 6 concludes. The appendix collects time series and a list of all input variables that have been used in the indicator(s).

2 The structure and construction of the systemic risk indicator

Our goal is to construct an indicator that tracks risks and vulnerabilities in the most important parts of the Swedish financial system. The systemic risk indicator hence aggregates the information contained in five sectoral indicators, where each sectoral indicator represents one specific part of the financial system. An overview of the systemic risk indicator and its components is presented below in figure 1. We have divided the Swedish financial system into five separate parts: the banking sector, the household sector, the non-financial corporate sector, the property market and the external environment[5]. These sectoral indicators are presented in more detail in Chapter 3. In this chapter, we first start by briefly presenting the main indicator, and then proceed with some methodological details.

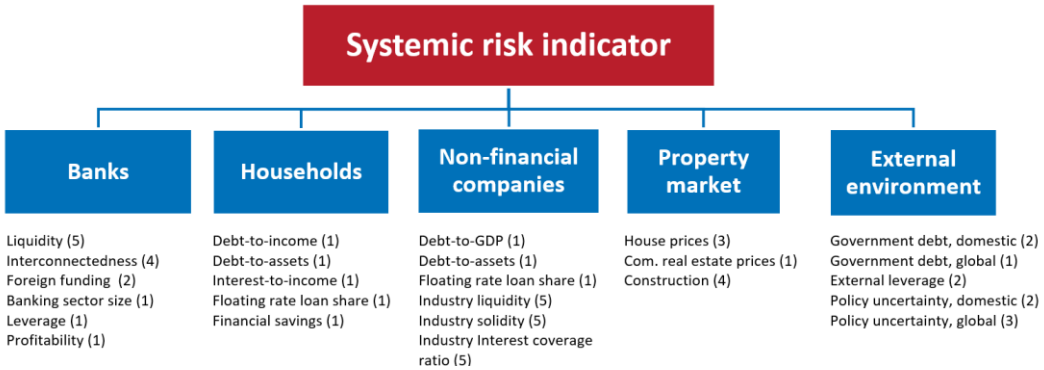


Figure 1 The figure illustrates the structure of the systemic risk indicator. Below each sectoral indicator are input variables that are used when creating the sectoral indicators. Each sectoral indicator, as well as details about weights, is described in more detail in Chapter 3. The numbers in the parentheses signal that the variable is constructed from several similar variables that have been weighed together.

Figure 1 illustrates how the indicator is structured. The blue boxes represent the five sectoral indicators that together form the overarching systemic risk indicator (red box; the time series of the main indicator is illustrated in chart 1 on the previous page). Each sectoral indicator consists of a set of variables that

[5] A detailed list of the variables included in the indicators and their time series can be found in appendix 1 and 2, respectively.

are listed below each blue box. For example, the household sectoral indicator consists of five input variables: households' debt-to-income and debt-to-assets ratios, the interest-to-income ratio, the floating rate loan share and financial savings. Again, the sectoral indicators will be discussed in more detail in chapter three and only a brief clarification of the framework is presented at this time.

The listed variables entering each sectoral indicator go into the sectoral indicator with equal weights. In some cases, the sectoral indicators also include sub-indicators, grouping similar variables together before they enter the sectoral indicator. For example, the property sectoral indicator consists of three variables that each receive a weight of one third when forming the property sectoral indicator. One of these input variables is a variable called *House prices (3).* The number three in parenthesis, (3), signals that the series is constructed from three underlying series, that have been put together, each receiving an equal weight of one third, to create the *House prices* variable. Similarly for *Construction (4)* – it consists of four underlying variables that have received a weight of one fourth each to form the *Construction (4)* sub-indicator, which in turn goes into the property sectoral indicator.

One immediately notices that variables that are inputs in sub-indicators receive a lower weight than a stand-alone input variable. The reason we choose this weighting scheme is that, as a principle, a variable's weight should not depend on how many proxies we use for a certain variable. To continue the example above, we measure construction activity by following building permits (separately for houses and commercial properties), housing starts and housing investment in relation to GDP. Each of these four series measures construction activity in the economy on its own, but we would argue that the combination of the four series gives an even better description of construction activity. Choosing four series to measure construction should however not mean that construction gets a four times larger weight than commercial real estate prices, for which we have one measure available. As a principle, we choose *equal weights* throughout. By creating mentioned sub-indicators, we can still include multiple measures of the variables we are interested in. Chapter 3 discusses the final weighting scheme for the main and sectoral indicators in more detail.[6]

2.1 Data transformations

As described in the previous section, the systemic risk indicator is an aggregation of many underlying variables and data series. To arrive at an indicator, we need to make several choices along the way in terms of data transformations, and dealing with trends, missing data and various units of measurement. Different choices will result in different indicators, and therefore we discuss our choices here.

Different starting dates: chained indices

The systemic risk indicator is based on data covering various sample periods. For example, we use data that dates back to 1870, but the large majority of variables have starting dates between 1950 and 1980. An apparent drawback is that the indicator will not be based on the same underlying data during the whole time period that we wish to cover, and this in turn affects both the construction and interpretability of the indicator. Another drawback is when the underlying population changes and data series are added to the indicator as more data becomes available over time. This may lead to distortions in the dynamics of the indicator that are not necessarily associated with changes in vulnerabilities and risks. For example, if we want to compute how the indicator changes between a time period *t* and *t+1*, we need to have comparable data available for both these periods. If more information is added at time *t+1* then the change from *t* to *t+1* will be biased either up or down in comparison to the "true" change. As the sample period gets longer, and/or more series are added, this bias may become large and

[6] An alternative to equal weighting would be to set weights based on expert judgement, based on correlations between the variables (such as a principle components approach) or based on a variable's ability to forecast recessions or financial crises. We choose the equal weighting approach for simplicity, and leave alternative weighting schemes for future research.

significant. We resolve this problem by using a chained index whenever we weigh series together in a sub-sectoral or in the main indicator.[7]

The chain index eliminates any jumps in the indicator when new series become available over time. To achieve this, we partition variables entering an indicator according to their starting date, and in each partition include all variables available. For example, for a sub-indicator with 3 variables each with a different starting date, the first partition will include all three variables for the time period that all three series are available. The second partition will include the two variables for the entire period these two are available. And the third partition includes only the variable with the longest history available. We first compute an index using the first partition. Working backwards in time, we chain this index to an alternative index computed using the second partition. Finally, we chain the resulting (chained) index to another alternative index from the third partition. This algorithm can be applied to any number of variables entering a (sub-)indicator, with any number of starting dates, and ensures smooth dynamics around the time new series become available.

While chaining introduces a certain complexity in the final systemic risk indicator, we choose this approach to make use of the most information possible for the assessment of vulnerabilities today. Some variables, such as the Basel Liquidity Coverage Ratio (LCR) for banks, are only available starting in 2011. One approach would therefore be to only use data as of 2011 for the entire banking sector indicator. We discard this option, as the banking sector indicator at the very least should be based on a period including a banking crisis, such as the 1990s crisis in Sweden. Another approach would be to ignore the LCR ratio altogether. We also exclude this option, since the LCR is a good proxy to measure banks' resilience to short-term liquidity risks, and therefore want to include the LCR in our indicator. The chained index allows us to include the LCR and still use long enough series to make a reasonable assessment of risks and vulnerabilities in the banking sector.

Different units of measurement: standardizing

We wish to aggregate the information contained in a number of variables to an indicator. Yet the input variables might have different units of measurement, different scales, or both. For instance, construction activity includes the number of housing starts, as well as housing investment as a percentage of GDP.[8] Both the unit of measurement (number and per cent) and the scale differ between these two variables. Before aggregating the input series into variables and sub-indicators, we *standardize* them. The standardization of variables allows us to easily compare variables with each other as the unit of interpretation will now be the same.[9] A variable is standardized by subtracting the series' mean, $\bar{x}_i$, from each observation, $x_{i,t}$, and dividing by the standard deviation, s_i. Each variable, $z_{i,t}$, is now expressed in terms of standard deviations away from its mean:

$$z_{i,t} = \frac{x_{i,t} - \bar{x}_i}{s_i}$$

In computing the mean and standard deviation, we employ the full sample available. This generates a so-called forward-looking bias when working with historical data. For example, by computing the mean and standard deviation for the entire period from 1950 until today, we base the level of historical vulnerabilities upon information available today. The forward-looking bias is only relevant however when the goal is to make statements about vulnerabilities in, for instance, the year 2000. It is not a relevant bias when we want to assess vulnerabilities today, which is the main purpose of our systemic risk indicator. Finally, the forward-looking bias can in part be assessed by computing recursive means

[7] An alternative choice would be to impute all data historically using statistical techniques, such as the Kalman filter. As we use many series over a very long time period, we would need to impute more data points than we have available, which would make the indicator less robust than if we use the chain indexed indicator.

[8] As mentioned before, construction activity also includes building permits for residential and commercial properties, respectively. These are measured in million square meters.

[9] An alternative choice would be to re-scale variables to fall in the interval between zero and one. Since we do not wish to claim that our indicator tells the probability of a financial crisis (which the [0,1] interval might seem to imply), we prefer standardized variables.

and standard deviations before standardizing, including only historical information available at each point in time.

Varying frequencies: temporal (dis)aggregation

As a principle, the frequency with which a variable is measured should not determine whether the variable is included in our risk assessment. Instead, the variable's relevance should determine its inclusion in the indicator. The variables that we include have daily, monthly, quarterly and annual frequencies. To arrive at an indicator at the quarterly frequency, we interpolate yearly data to quarterly, when needed.[10] Daily and monthly data is aggregated up to quarterly observations, by taking either a sum or average, whichever is relevant. We believe that a quarterly indicator can be updated sufficiently often (compared to an annual indicator) to be informative for policymakers, especially since we focus on (relatively) slow-moving variables such as credit or housing prices. Higher frequency data (such as daily or weekly data) often shows considerable noise, which is naturally reduced by our quarterly indicator.

As there is usually a lag in the reporting of data, national accounts data in particular, or non-synchronous reporting of data for any other reason, our data matrix will sometimes suffer from "ragged edges", meaning that some series will have observations at the most recent date and others will not, at a given point in time. In these cases, the missing, most recent, values are imputed; we assume that the variable has remained unchanged since its last observation.[11]

Trending series: statistically filtered observations

Some of our variables, for example household debt, house prices and bank assets, display strong trends, even after scaling them by GDP or disposable income. As pointed out by Giordani et al. (2017), these variables have shown a clear upward trend especially since the 1980s, a period which is often referred to as "the great leveraging" or "financial deepening" (Taylor, 2014), where the widespread availability of mortgage credit to households is considered as the most distinguished feature of this period (Giordani et al., 2017). These variables are de-trended using a (two-sided) local level filter model.[12] The estimated trend is, in almost all cases, based on a gliding window of fifteen years.

The trends using this local level filter are rather sluggish in their development over time, meaning a slowly moving trend computed over a relatively long period when compared to, for instance, the Hodrick-Prescott filter. We therefore attribute most of the rise in, for instance, household debt, to rising vulnerabilities, rather than to changes in the "equilibrium" level of debt. This choice can be motivated by our purpose of informing a risk-averse policymaker, who cannot (in real time) differentiate between a permanently higher level of debt without any additional risks to financial stability, and a high current level of vulnerabilities. We nevertheless de-trend to reflect changes in structural features of the Swedish economy, such as declining interest rates, which should affect the stock of debt, and might be permanently lower. As a rule, we de-trend variables that are formed by ratios between stock and flow variables, such as the variables that were exemplified before.

[10] We linearly interpolate from annual to quarterly frequency when needed. In some cases, we are able to interpolate an annual series using the dynamics of a quarterly proxy variable. For instance, banks' equity to asset ratios use historical data from Hortlund (2005) and Statistics Sweden. Missing quarters are interpolated using equity ratios for the major banks, for which we have data from 2004 onwards. The final series therefore combine linear interpolation until 2004, with major-bank-based interpolation afterwards.

[11] An alternative could be to use now-casting or forecasting models to impute the latest values, which we leave for future research. As we employ many series, often consisting of multiple economic quantities per variable, we have decided to go for the simpler alternative of assuming constant developments recently. Whenever new information does become available, our indicator will be revised to include the most recent information available. Note also that we never impute more than the last few (typically 3-4) quarters available.

[12] This is the same filtering technique as in Giordani et al. (2017), to which we refer for technical details.

3 The structure and construction of sectoral indicators

In this section, we describe and discuss each of the five sectoral indicators that form the overarching systemic risk indicator. We explain why these sectors are relevant to financial stability and how we can capture developments in risks and vulnerabilities in each sector by the chosen input variables.

3.1 The banking sector

Banks are at the core of the financial system, by intermediating funds from savers and investors to borrowers. By lending money to households and firms, banks are exposed to credit risk, which materializes if borrowers cannot meet their debt obligations. And by issuing demand deposits or debt instruments with short maturities, banks are exposed to liquidity risk, which materializes when banks' liquid assets are not sufficient to repay debt investors and depositors.

Credit and liquidity risks are inherent to the banking business, and make banks fragile. Having sufficiently high levels of capital and liquid assets available can reduce such risks. On top of these intrinsic risks, the Swedish banking sector is large in relation to GDP, concentrated, interconnected and reliant on foreign wholesale funding. These features make the banking sector systemically important.

The bank indicator tracks developments in the banking sector's size, leverage, liquidity, interconnectedness and foreign funding. The indicator is the equal-weighted average of standardized input series, which we discuss in turn. Figure 2 below gives a schematic outline of the sectoral indicator for the banking sector.

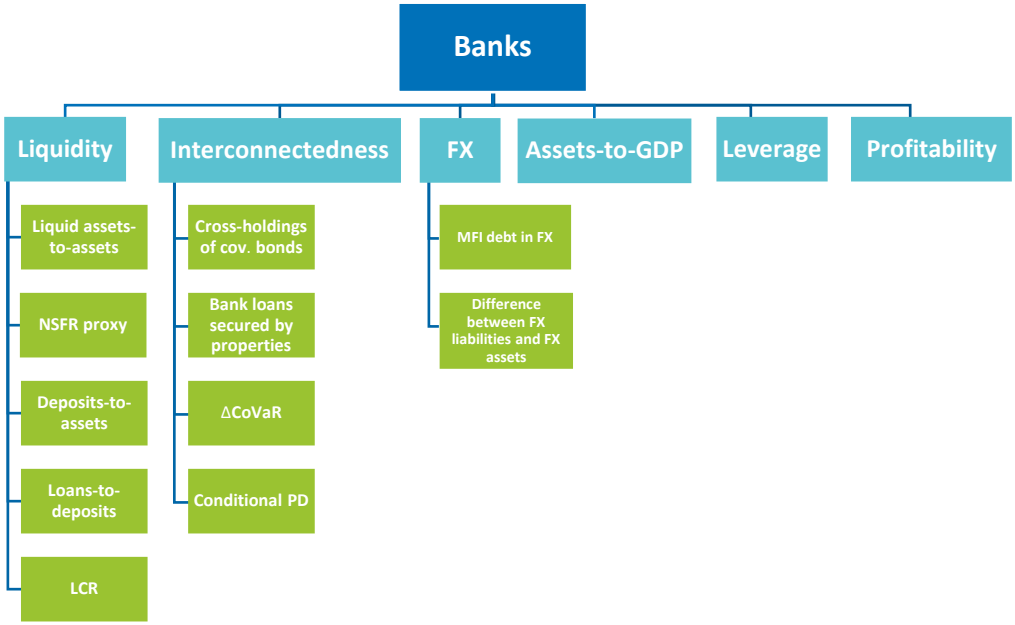


Figure 2 The figure illustrates the structure of the sectoral indicator representing the banking sector. The sectoral indicator for banks consists of an equally weighted average of six sub-indicators (turquoise boxes). If the sub-indicator in turn consists of more underlying variables, these are represented by the green boxes in the figure.

Assets-to-GDP. Size is an important component of systemic risk, since a larger banking sector facing distress can contribute to larger disturbances to the real economy, all else equal (Brownlees and Engle, 2017). The Swedish banking sector is large in relation to the size of the Swedish economy, partly due to lending within Sweden but also to substantial operations abroad.

We measure the size of the banking sector by the total assets of banks and credit market companies (monetary financial institutions, henceforth MFI). We use Swedish GDP to scale the banking sector's total assets. The data series start in 1870, and has an annual frequency. Historical data is from Hortlund (2005) for bank assets and Edvinsson (2014) for GDP, and data from Statistics Sweden is used for the

most recent decades. As bank assets-to-GDP is a ratio between a stock and a flow variable, we de-trend the series in line with our common methodology (see section 2), before standardizing.

Leverage. Bank capital (or net worth) measures the capacity of banks to absorb losses, which can, for example, arise when borrowers are unable to repay their bank loans or when banks make losses on financial investments. A higher loss-absorption capacity (higher bank capital) can reduce net systemic risk, as banks will be less likely to need to de-lever in contractionary times. Such deleveraging can create a credit crunch, when banks stop lending to the real economy, amplifying the downturn in the economy (see e.g. Brunnermeier, 2009; Iyer et al, 2014).

We measure banks' leverage by the size of bank capital (book value of equity) in relation to its assets. Capital ratios for banks are often expressed as bank capital in relation to risk-weighted assets, as in the Basel capital accords.[13] Due to the many changes in the definitions of capital and risk-weighted assets, it is difficult to have consistent time series for this metric. Moreover, the available data series have a rather short history, and risk-based capital ratios tend to be procyclical (Kashyap and Stein, 2004; Repullo and Suarez, 2012; Behn et al, 2016), making a risk-weighted capital ratio less suitable as a vulnerability metric. Instead, equity-to-assets is a more robust measure of bank leverage, and is similar to Basel III's leverage ratio.

Historical data comes from Hortlund (2005). For recent years, we use book equity plus 70 per cent of untaxed reserves to measure bank capital, following the same source, using data from Statistics Sweden. The series is available on an annual frequency since 1870. We use quarterly equity-to-asset ratios of Nordea, Swedbank, Handelsbanken and SEB to impute leverage ratios for the entire banking sector, for quarters 1, 2 and 3 since 2004. [14]

Profitability. Profitable banks can build up capital by retaining their earnings. A sound business model, supported by proper credit risk tools and management, can support earnings for banks. Therefore, we also include the banking sector's return on average assets (ROAA) as input to the bank indicator. We compute ROAA as annual profits after loan losses divided by the average of total assets in the previous and current year, using data from Statistics Sweden since 1976. Higher profitability contributes to lower banking sector vulnerabilities.[15] In principle, higher profitability could stem from excessive risks taken by banks, such as lending to high-risk customers at higher interest rates, or by trading in financial markets for the banks' own account. Such behaviour would imply that higher profitability should *increase* rather than decrease banking sector vulnerabilities. However, we argue that, over long periods of time, such as the time period we study, higher profits are mostly a feature of a sound business model and good credit risk management, and hence higher profits are contributing to lower vulnerabilities in the banking sector.

Liquidity. Bank liquidity measures the capacity of banks to repay investors and depositors. Debt investors might be unwilling or unable to renew their funding in commercial paper or (un)secured bonds, and households might withdraw money from their deposit accounts. Banks should have sufficient cash, or cash-like instruments, at their disposal to fulfil such requests. More cash, or liquid cash-like instruments, as well as longer funding maturities therefore reduce liquidity risk, all else equal.

We use five different proxies for banks liquidity, reflecting the various ways to assess whether banks' balance sheets are sufficiently liquid. These are 1) the average of major banks' liquidity coverage ratios (LCR); 2) liquid assets (cash, central bank balances and treasury bills eligible for central bank funding) to

[13] The Basel capital accords refer to the banking supervision accords Basel I-IV.

[14] The leverage ratios of the entire Swedish banking sector (measured in Statistics Sweden data) follow a similar pattern to the leverage ratios for the 4 major banks.

[15] Banks usually pay out a substantial part of net profits to shareholders in the form of dividends. This practice implies that most earnings are not retained to provide additional loss absorption capacity. We nevertheless focus on return on assets, and not the growth of retained earnings, to capture the soundness of banks' business models and their potential to generate additional equity buffers.

total assets; 3) an NSFR-like ratio between liquid assets and runnable liabilities[16]; 4) deposits to total assets and 5) loans to deposits. We include the last two since (retail) deposits are usually seen as a stable source of funding, with lower liquidity risk. A higher share of deposits to total assets, and a lower ratio between loans and deposits are therefore often positive from a liquidity perspective. The LCR is available since 2011 at quarterly frequency, whereas the remaining series are available from 1975 at an annual, quarterly or monthly frequency. The liquidity indicator is a chained index of the above five series.

Interconnectedness. Banks are interconnected through various channels, such as the interbank market (where banks lend and borrow from each other, usually with short maturities), through common exposures to risk factors (such as the housing market or other asset classes) or through common or similar investors (such as money market mutual funds). While such interconnections can help to smooth out smaller shocks (for example, by reallocating liquidity from banks with a surplus to a bank with a deficit at the end of a business day), they can also spread disturbances to individual entities to other actors in the financial system (a.o. Diamond and Dybvig, 2005; Glasserman and Young, 2015; Elliott et al.,2014). This can amplify the risks, with potentially systemic consequences.

It is generally difficult to measure the degree of interconnectedness, and hence we allocate some time to discuss our measures. We use four proxies of interconnectedness to make up our interconnectedness sub-indicator. These are 1) the share of covered bonds issued by Swedish mortgage institutions held by Swedish banks; 2) the share of bank loans secured by properties; 3) the ΔCoVaR measure proposed by Adrian and Brunnermeier (2012) and 4) the probability of default for major Nordic banks conditional on a major Nordic bank defaulting. The interconnectedness indicator is a chained index of these four series.

Crossholdings of covered bonds (proxy 1) is a direct measure of interconnectedness within the system. Covered bonds are a liquid instrument in most states of the world, and banks hold these, for example, as a part of their liquidity reserves.[17] Yet an erosion of investor confidence in a specific covered bond issuer can have repercussions for its holders. Crossholdings of such covered bonds by other banks can thereby be a channel through which one bank's problems affect other banks in the system. The data comes from Statistics Sweden.

The housing market is one market to which all major Swedish banks are exposed. Aggregate shocks affecting house prices affect the collateral value for bank loans, with possible spillover effects on banks' funding costs. In general, collateral is a positive element of loan contracts, as it helps banks to recover their investment in loans gone sour, and helps the borrower get more credit at lower interest rates (see a.o. Cerquiro et al., 2016). But a high share of loans collateralized by a similar type of collateral can be an amplification mechanism, which our second proxy attempts to quantify. The data come from Statistics Sweden.

Adrian and Brunnermeier's ΔCoVaR (proxy 3) is an interconnectedness measure derived from stock prices. It estimates the 95th percentile of return losses on a portfolio of shares, when a specific bank faces a large shock. Loosely speaking, we can interpret this as the capital depletion in the rest of the financial system in a severe scenario where one bank's capital is sharply reduced. For this bank, CoVaR is a measure of its systemic importance: the more systemic a bank, the larger the loss we would expect for the rest of the financial system. As banks' stock returns tend to co-move even in normal times, ΔCoVaR subtracts the median return loss to focus on crisis events. We use 4-year rolling window

[16] The Basel-III NSFR measures available stable funding in relation to required stable funding, where available stable funding is a weighted average of the liability side of a bank's balance sheet and required stable funding is a weighted average of the asset side of a bank's balance sheet. In a similar vein, we measure liquid assets as the weighted average of banks assets, with weights increasing in the liquidity of the asset class; this is roughly the inverse of required stable funding. And we measure runnable liabilities as the weighted average of banks' liabilities, with weights increasing in maturity and stability; this is roughly the same as available stable funding. The ratio between liquid assets and runnable liabilities is therefore a proxy to the NSFR, calculated for Swedish banks and mortgage institutions on an aggregate level.

[17] See Sandström et al. (2013) and Hellström et al. (2019) for more detailed analyses of the Swedish covered bond market.

quantile regressions on weekly share price data[18] to estimate tail-dependencies across 6 major Nordic banks (Nordea, Handelsbanken, Swedbank, SEB, Danske Bank and DNB). Our final ΔCoVaR measure is the average across banks within a quarter.

The conditional default probability (proxy 4) estimates the likelihood of a banking crisis conditional on a major bank default. We define a banking crisis as two or more bank defaults. The model, taken from Lucas et al. (2017), is estimated using daily CDS price data for 5 major Nordic banks (Nordea, Handelsbanken, Swedbank, SEB and Danske Bank), and takes into account time-varying volatility and interlinkages between banks. Individual, joint and conditional default probabilities are obtained by simulating the model many times. We use the average conditional banking crisis probability across banks and within a quarter as our fourth proxy for interconnectedness.

Foreign currency funding. Besides deposits and equity, Swedish banks finance their operations on international capital and debt markets, including operations in euros, dollars and other currencies. A diversified funding profile can be beneficial from a stability perspective, as it allows smoother transitions across currencies should market conditions deteriorate in some parts of the world. During some periods, banks profit from arbitrage opportunities, where it for instance becomes cheaper to borrow in dollars compared to borrowing in Swedish kronor, even after converting the dollars to kronor through currency swaps. However, banks can also tailor their funding profile to investors, by borrowing in other currencies than needed for their operations, creating a reliance on well-functioning derivative markets. Moreover, foreign investors might be more prone to stop renewing their funding to Swedish banks compared to domestic investors in case of distress, and hence foreign exchange funding or swaps might be harder to obtain in times of stress (see e.g. Baba and Packer, 2009a,b and Baba et al., 2008).

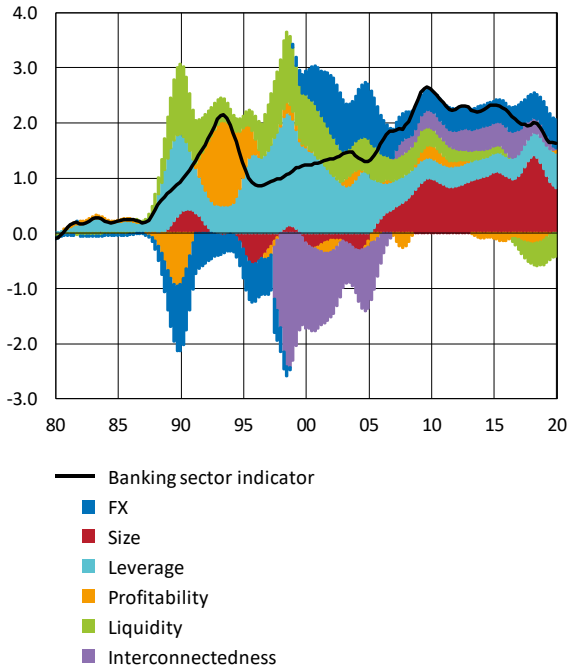
We use two proxies for foreign funding: 1) the share of MFI's outstanding debt securities in currencies other than Swedish kronor, and 2) the difference between foreign exchange (henceforth FX) liabilities and FX assets, as a per cent of total (SEK + FX) assets. The first measure directly tells us whether banks are increasing or decreasing their reliance on FX funding, whereas the second measure takes into account that banks also lend out abroad (in FX) or hold foreign currency denominated financial assets, and therefore focuses only on the FX liabilities in excess of FX assets. The foreign currency indicator is the chained index of the above two series.

The banking sector indicator and its decomposition

The sectoral indicator for the banking sector, illustrated in chart 2, is an aggregation of the input variables that we have just described. Each sub-group receives an equal weight, according to the illustration of the structure in the beginning of this section. We plot the indicator, and its decomposition, as of 1980, and use the full sample of data available (start 1870) to calculate means, standard deviations and trends where used.

[18] Share prices are purged from 3-month yields on Swedish government bonds, the term spread (10 year minus 3 months yields) and the TED spread, to make stock returns (and the resulting Value-at-Risk measures) more countercyclical. For instance, the low interest rate environment has contributed to rising and less volatile stock prices (for banks and other stocks), resulting in low Value-at-Risk of bank stocks. By residualizing the share price from interest rate effects, we obtain much higher Value-at-Risk even in the low interest rate environment, in line with stability assessments at the Riksbank and other institutions.

Chart 2 The banking sector indicator and its decomposition
Standard deviation



Note. A higher value indicates a higher level of risks and vulnerabilities. Coloured areas represent each of the six sub-indicators that together form the banking sector indicator. An area above (below) zero means that the corresponding sub-indicator contributes positively (negatively) to, i.e. increases (decreases), risks and vulnerabilities in the banking sector at a given point in time. 31 Jan 1980 – 31 Dec 2019.

Source: The Riksbank

The black line represents the banking sector indicator and depicts the level of risks and vulnerabilities in the Swedish banking sector, where a higher level flags higher risks and vulnerabilities. The unit of interpretation is the number of standard deviations away from the historical mean of the indicator, which in this case means that risks and vulnerabilities today are around two standard deviations above their level historically, which is considered a high level.

We observe that the banking sector's current size, leverage and reliance on foreign currencies are elevated, whereas profitability and interconnectedness are around their historical average. In recent years, banks' liquidity reserves (in terms of LCR and cash plus cash-like instruments) have become larger, hence contributing to overall resilience of banks to shocks and materialization of risks. We also note that the risks related to a large banking sector relative to Swedish GDP have decreased, following the move of Nordea's headquarter to Finland. Nevertheless, the Swedish banking system is still large even without Nordea, hence contributing to higher banking sector vulnerability.

Historically, the banking sector indicator increased sharply prior to the 1990s banking crisis (see a.o. Englund, 1999, for a narrative of the banking crisis in Sweden). In this period, the Swedish banking sector was deregulated, which resulted in lower liquidity buffers and lower capital. At that time, Swedish banks also started doing more operations in foreign currencies; however, as we lack good data on FX activity prior to the 1980s, the indicator shows low levels of FX risk relative to today, which might be somewhat counterintuitive, but is a natural result of the constraints we face with data availability. Also noteworthy is that the indicator keeps increasing up until 1993, when the banking crisis already materialized. The reason here is that profitability dropped sharply, contributing to higher risks in that period, even when capital was being injected and leverage declined.

3.2 The household sector

Households' saving, spending and borrowing decisions are important for the economy. In this context, household debt accumulation has traditionally been seen as an important driver of consumption and GDP growth in the short run while driving vulnerabilities in the long run (Lombardi et al., 2017).

A high and rising level of household indebtedness constitutes a risk to financial and macroeconomic stability. Experience shows that financial crises and housing price falls have previously led to deeper and more permanent consequences if they have been preceded by sharply rising indebtedness (Schularick and Taylor, 2009). Excessive debt accumulation therefore may become a problem if market conditions deteriorate. For example, Arcand et al. (2015) study whether there can be "too much finance" in the sense that credit growth in the private sector starts to dampen output growth. Their results indicate that this tipping point occurs when credit to the private sector reaches around 80-100 per cent of GDP. A more detailed analysis of credit to the household sector suggests that household debt indeed increases long-term real GDP growth, but as household debt increases, the effect weakens and eventually becomes negative (IMF, 2017). The inability of households to pay their debt in a timely manner may also have a negative effect on banks' balance sheets, which in turn can lead to financial instability (Drehmann and Juselius, 2012). For these reasons, our indicator for the household sector focuses on developments related to household debt and debt servicing abilities.

Our household sectoral indicator includes several variables that are common in the literature (see for example Ampudia et al., 2016; Michelangeli and Rampazzi, 2016; Bank of England, 2016; OECD, 2019 to name a few) and that aim to measure household risk, vulnerability and resilience. These variables are the stock of household debt, both as a share of income and total assets, the interest-to-income ratio, the saving rate and the share of mortgages with a variable interest rate.[19] We divide the variables into indicators of risks and vulnerabilities, or resilience. The debt-to-income ratio is a typical indicator of risk, where a higher level of debt-to-income equals a higher level of risk for the individual household and makes it more vulnerable to adverse economic conditions. We further argue that the interest-to-income ratio, the saving rate, the share of mortgages with a variable interest rate and the debt-to-assets ratio are indicators of resilience in the household sector. For example, a higher saving rate, lower interest payments and lower leverage imply higher resilience to income, interest rate and housing price shocks. In the sectoral indicator, we therefore weigh these four variables together into one sub-index. This sub-index is subsequently combined with the debt-to-income ratio to form the household sector indicator. Figure 3 presents a schematic illustration of the sectoral indicator and its components.

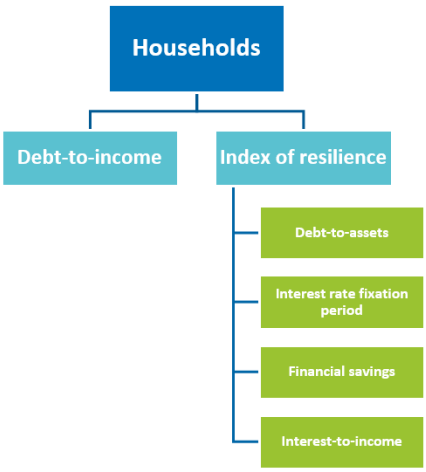


Figure 3 The figure illustrates the structure of the household sectoral indicator. The indicator is an equally weighted average of two sub-indicators: debt-to-income and an overall resilience indicator that in turn consists of four variables, in the green boxes.

[19] A rate fixation of up to three months is considered a variable interest rate.

Debt-to-income. The debt-to-disposable income ratio refers to the total debt of households as a percentage of yearly net disposable income. Total debt is the sum of credit from monetary financial institutions plus debt to other sectors (such as student debt).[20] Data on household debt commences in 1950 where we estimate debt by observing the loan-to-income ratio and net disposable income of households. From 1980 and onwards, household financial debt and disposable income is collected from Statistics Sweden. Net disposable income is calculated as a moving sum of four quarters and is adjusted for capital depreciation. The debt-to-income ratio is further de-trended using the local level filter model described in Chapter 2.

Indebtedness in the Swedish household sector has been rising for a long time and is currently around 190 per cent of household disposable income.[21] This level of indebtedness is argued to be high both from a historical and international perspective. The sharp and steady increase from around 1994 to 2008 can be attributed to, among other things, the fact that Swedish households own their houses to a higher degree today than 25 years ago. This development is due to a series of structural changes that, for instance, led to the disappearance of government-subsidized secondary mortgages and that public housing companies were given similar funding conditions to private participants in the market.

Increased indebtedness among households can also be attributed to falling interest rates. Nominal and real interest rates have fallen worldwide over the last twenty years and mortgage rates are very low in a historical perspective.[22] Correspondingly, we therefore also observe that households' interest payments in relation to their disposable income remain at historically low levels. However, a high level of indebtedness, combined with low and variable interest rates, means that changes in the interest rate have a faster and larger impact on household disposable income.

Debt-to-assets. The debt-to-assets ratio refers to the total debt of households as a percentage of total assets, defined as real household wealth (owner-occupied dwellings and housing, at market prices). When analysing risks embedded in households' debt levels, it is important to look not only at debt in relation disposable income but also at the assets of the household; in most cases the housing leverage. In principle, the macroeconomic risks of high debt in relation to income ought to be lower if a household has sufficient assets that can be sold or collateralized in order to avert a deteriorating cash flow.

The long-term trend of the debt-to-assets ratio on an aggregate level has been decreasing since the late 1980s. As the ratio captures households' resilience against house price declines, this downward trend is contributing to a decrease of vulnerabilities and risks. The decrease in the ratio is largely attributed to the increase in the value of real assets during this time period. While debt has increased, asset values have increased even more. The higher the debt-to-assets ratio, the higher the level of household leverage. Higher (lower) leverage thus implies weaker (stronger) financial resilience of the household.[23]

Interest-to-income ratio. By analysing debt servicing abilities we may assess the impact of changes in interest rates and income on the cash flow of the household sector. Debt servicing ability is assessed here by looking at the interest-to-income (henceforth ITI) ratio that is calculated as households' net (after-tax) interest expenditures in relation to gross disposable income.[24] A high ITI means that a large share of a household's income is spent on servicing the debt. A high ITI therefore makes a household vulnerable as it indicates a higher risk of personal bankruptcy, especially if household income decreases significantly or interest payments increase due to rising interest rates. Despite high debt relative to income, the ITI ratio is presently historically low, meaning that households currently have a good

[20] The debt of tenant-owned associations is not included in our measure of household debt, even though households service this debt through monthly fees to the association. Including this debt would raise the household debt-to-income ratio by around 20 percentage points. Following the classification of Statistics Sweden, the debt of associations is included in the corporate sector discussed in the next sections.
[21] As of 31 Dec 2019.
[22] See The long-term repo rate. Article in Monetary Policy Report, February 2017, Sveriges Riksbank.
[23] We use the term debt-to-assets and leverage as synonyms.
[24] Gross disposable income here refers to disposable income before interest payments and depreciation.

payment capacity. This is not surprising, however, considering that interest rates offered to households are also low.[25] Currently, a low interest-to-income ratio is helping to decrease vulnerabilities from the household sector. This counterbalances the risk of rising debt when interest rates rise, which we have already captured by the debt-to-income ratio.

Interest rate fixation period. Closely related to the interest-to-income ratio are rate fixation periods on loans, that is, whether a household has a fixed or variable[26] interest rate on its loan. Currently the share of household mortgages with a variable interest rate is roughly 60 per cent in the total stock of debt in Sweden.[27] Recently the ratio has decreased, perhaps due to expectations of higher interest rates among households, but it is on a high level in a historical perspective. The share of loans with a variable interest rate is estimated by computing mortgage credit institutions' (excluding those from non-profit institutions serving households (NPISH)) loans to households with a rate fixation of up to three months in relation to total loans from mortgage credit institutions (excl. NPISH). Floating rate loans are typically a bigger problem for households that are highly indebted as a household's ITI may change significantly if interest rates rise fast, and income is fixed. Rising rates do not only come from policy rate changes, but also other types of disturbances, such as shocks in financial markets. If investor confidence in Swedish banks, which are the primary lenders to Swedish households, is undermined, banks' funding costs and ultimately household loan rates may become higher.

Financial savings. Household financial savings are defined as the difference between income and consumption, excluding collective savings and net investment in housing, as a percentage of disposable income. Savings constitute a natural buffer for households; it makes households more resilient to different types of shocks and acts as a cushion to address expected or unexpected events. Savings have traditionally also been recognized as a source of investment that fuels the long-term growth of an economy, and that provide stable sources of financing, in the form of deposits, to banks. Higher saving rates are therefore better from a financial stability perspective.

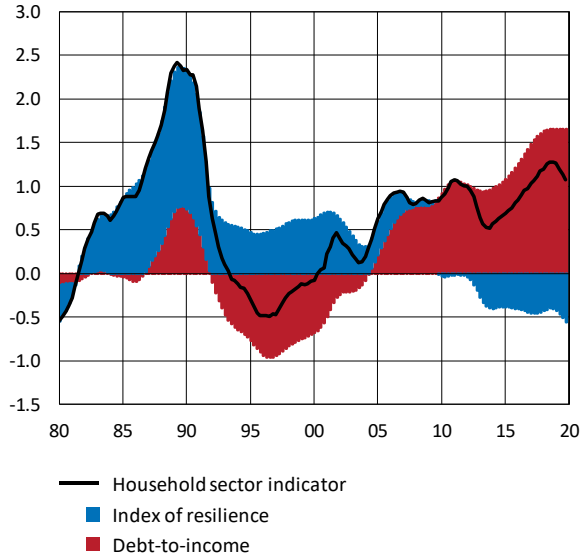
The saving rate in Sweden has been negative, implying net consumption of existing assets, and declined ahead of the crisis in the early 1990s. Even up to 2013, the saving rate was negative, although on a positive trend. Currently, the saving rate is positive, contributing to the build-up of financial buffers.

The household sector indicator and its decomposition

We now present the aggregated sectoral indicator for the household sector, which takes the variables described in the preceding section as inputs. As previously defined, we partition the input variables into the debt-to-income metric to describe vulnerabilities, and the resilience factor to describe leverage, interest coverage and savings. The former is represented by the red area in chart 3 below. The black line represents the aggregated household indicator reflecting risks and vulnerabilities in the household sector.

[25] For example, the average interest rate on new mortgages is 1,52 % (as of January 2020, Statistics Sweden, Financial market statistics)
[26] The variable interest rate is an interest rate that is fixed for up to 3 months.
[27] As of 31 Dec 2019.

Chart 3 The household sector indicator and its decomposition
Standard deviation



Note. A higher value indicates a higher level of risks and vulnerabilities. Coloured areas represent the two sub-indicators that together form the household sector indicator. An area above (below) zero means that the corresponding sub-indicator contributes positively (negatively) to, i.e. contributes to increase (decrease), risks and vulnerabilities in the household sector at a given point in time. 31 Jan 1980 – 31 Dec 2019.

Source: The Riksbank

Developments in the indicator suggest that risks and vulnerabilities in the household sector have been slowly rising for the past decade, even though a decrease can be observed during the most recent years. These developments are strongly related to household indebtedness that has increased, in tandem with rising house prices and lower interest rates. As a result, households' payment capacity, especially to service their debt, has been strong. After a large drop in personal financial savings, due to the crisis in the 1990s, household savings have recovered and are currently back at pre-crisis levels, which contributes to the resilience of households to, for example, loss of income and unemployment. Overall, the household indicator signals relatively high risks and vulnerabilities.

3.3 The non-financial corporate sector

Non-financial companies play an important role for both the real economy and financial stability. They are responsible for a large share of economic activity by producing goods and services and by employing a large share of the Swedish labour force. Strong activity combined with low financing costs, in Sweden and abroad, has resulted in favourable conditions for non-financial companies. Consequently, Swedish non-financial companies' debt has risen substantially. Equally, banks' exposure to these firms has increased. Currently around one third of banks' lending to the Swedish non-financial private sector is to non-financial companies[28]. Historically this sector also accounts for the majority of Swedish banks' credit losses. High indebtedness in this sector therefore constitutes a risk from a financial stability perspective. A shock to another part of the system, such as the banking sector or internationally, can also affect non-financial companies by limiting credit supply in which case these firms may experience liquidity shortages and reduce investment or production as a result.

In the non-financial company indicator (henceforth corporate indicator), we choose to include several variables related to indebtedness and debt servicing abilities in order to capture the resilience

[28] See Financial market statistics March 2020, Statistics Sweden.

to shocks and the developments of risks and vulnerabilities. Similar to the household indicator, we include the debt-to-income (here captured by debt-to-GDP) and assets, and the share of loans with a variable interest rate. Additionally, we include measures of solidity, liquidity and interest coverage ratios of the five most indebted industries in the Swedish non-financial corporate sector.[29] Each of these three measures hence includes five series, one for every industry. These five industry series are weighed together by using each sector's share of the total debt stock in these sectors in 2016 as weights, to form a series that represents industry solidity (equity relative to total assets), liquidity (current assets less inventories relative to current liabilities) and interest coverage (earnings (EBIT) to interest expenditures). To avoid double-counting, we group the (inverse of the) solidity variable with the debt-to-assets variable, as both measure leverage. To represent interest-rate sensitivity, we combine the interest coverage ratio variable with the share of loans with a floating interest rate. We also have data on defaults among non-financial companies as a whole and within each sector. We choose not to include this information in the indicator because defaults typically happen as a result of prolonged, or sudden, stress, rather than of vulnerabilities as such.

The structure of the variables included in the corporate indicator is presented below. Each turquoise box below gets an equal weight of one-half in the sectoral indicator for non-financial companies.

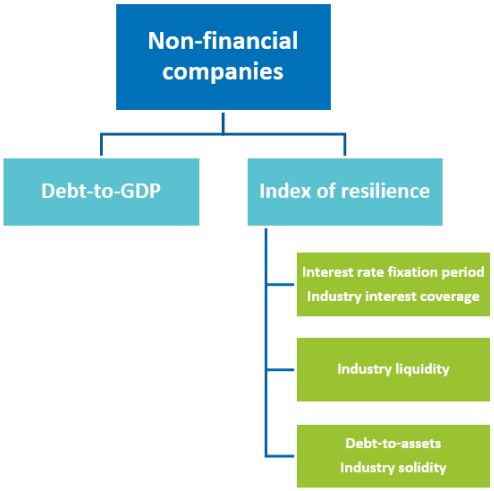


Figure 4 The figure illustrates the structure of the sectoral indicator representing non-financial companies. The sectoral indicator is an equally weighted average of two sub-indicators; the debt-to-GDP ratio and a resilience indicator. These in turn consist of three inputs (green boxes), where the first and third boxes are mergers of two inputs each, as stated in each box.

Debt-to-GDP. The debt-to-GDP ratio measures indebtedness of non-financial companies. The use of debt-to-GDP as an indicator of risk is fairly common in the financial stability literature. A high level of debt is regarded as a concern from a stability perspective, especially in wake of low interest rates. We calculate total debt by summing credit from banks and other financial institutions, other loans (excluding inter-company loans) and outstanding bonds. We scale total debt by GDP as our preferred income measure. The series is available from 1975 on a quarterly basis, and we take out the local level trend to compute debt-to-GDP gaps, which are subsequently used in the corporate indicator.

The debt-to-GDP ratio is characterized by an upward trend since the beginning of the sample period in 1975, and demonstrates a sharp peak during the banking and housing crisis of the 1990s in Sweden. Recently the ratio has been increasing and it is currently at levels that were observed during the crisis in early 1990s. Credit growth has been the largest within the property sector, and especially so since the global financial crisis in 2008-09. Borrowing among non-financial companies has increased in recent years in both issued securities and bank loans.

[29] The sectors are construction, trade, real estate, energy and transport.

Debt-to-assets (leverage). The debt-to-assets ratio, or more commonly known as corporate leverage, indicates the share of a firm's assets that is financed by creditors. This measure complements the debt-to-GDP ratio, as it takes into account how many assets are acquired by the firms. Large companies often fund fixed assets (buildings, equipment etc.) with credit, as investments are often large, and credit allows them to purchase such assets and repay the loan over time.

Historically, we have observed a declining leverage ratio. Swedish companies are less levered now compared to the beginning of our time series, which is positive from a stability perspective. After all, lower leverage reduces the likelihood of default, and as assets can be liquidated upon default, lower leverage reduces losses given default. Since the overall debt level has increased, the decrease in the leverage ratio can likely be attributed to an increase in the value of assets.

Interest rate fixation period. Just like households, non-financial companies are sensitive to changes in the interest rate and therefore exposed to interest rate risk, especially when loans and securities have variable rates. The impact of interest rate movements can affect a firm in several ways. For example, interest rate movements have a direct effect on the market value of both real and financial assets as well as the firms' cash flows, such as interest payments. We define the share of loans with a variable rate as the loans that have a fixation period of up to one year in relation to total loans by MFIs to non-financial companies.[30]

Industry ratios – liquidity, solidity and interest coverage. We complement the aggregate data above with data at industry level, as aggregated data does not allow us to infer what companies in the non-financial sector are the most vulnerable or what companies constitute the biggest credit risk for banks. For this reason, we narrow the outlook on the non-financial sector and pick the five sectors that are the most indebted[31] and therefore more vulnerable from a financial stability perspective: the construction, property, energy, transportation and trade sectors.[32] We calculate additional measures of liquidity, solidity and interest coverage ratios for these five sectors. Each sectoral measure is the median amongst firms with at least 20 employees, to focus on bigger firms.

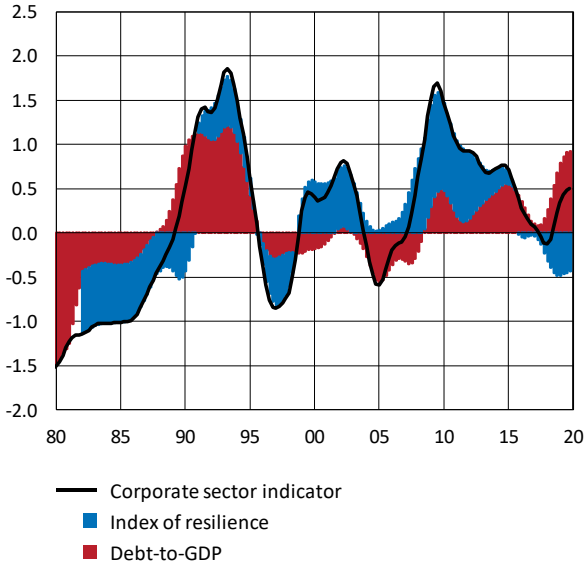
Liquidity signals if, and how well, companies will be able to meet their short-term obligations. A benchmark is typically 100 per cent, which means that the firm can cover all of its short-term obligations with available liquid assets. Liquidity is measured by relating current assets (minus inventories and prepaid expenses) to current liabilities. Solidity measures a firm's long-term stability and soundness, and illustrates how much of its assets are funded by equity rather than debt. The interest coverage ratio is defined as earnings before interest and taxes (EBIT) divided by interest expenditures. An interest coverage ratio above one means that firms make enough profits to pay for their debt service costs. All five sectors have had stable or increasing levels of liquidity, solidity and interest coverage since around 2005.

The corporate sector indicator and its decomposition

Chart 4 presents the aggregated indicator for the non-financial corporate sector and its decomposition. The black line represents the corporate sector indicator, and the input variables have been partitioned, similar to the input variables in the household sector, to represent risk by the debt-to-GDP ratio (red area), and to represent vulnerabilities (inverted) and resilience by solidity, liquidity and interest rate coverage.

[30] We could in principle include the fixation periods of outstanding debt securities. As the Swedish corporate bond market is still small relative to bank lending, we expect the fixation period on loans to be a good proxy for overall interest rate sensitivity.
[31] Using 2016 aggregate debt levels as criteria.
[32] The sectors refer to SNI02 (Swedish Standard Industrial Classification) codes 45, 70, 40, 34 and 35, and 50, 51 and 52 respectively.

Chart 4 The non-financial corporate sector indicator and its decomposition
Standard deviation



Note. A higher value indicates a higher level of risks and vulnerabilities. Coloured areas represent the two sub-indicators that together form the non-financial corporate sector indicator. An area above (below) zero means that the corresponding sub-indicator contributes positively (negatively) to, i.e. contributes to increase (decrease), risks and vulnerabilities in the non-financial corporate sector at a given point in time. 31 Jan 1980 – 31 Dec 2019.

Source: The Riksbank

Corporate indebtedness relative to GDP is the main contributing factor to the increasing vulnerabilities in the non-financial corporate sector. Debt levels have been gradually increasing after the sharp drop during the 1990s crisis, and the most recent increases are primarily due to companies in the residential and commercial real estate sector. A high level of debt is seen as a concern from a stability perspective, especially in the wake of low interest rates. Over time, the corporate indicator captures well the rising vulnerabilities ahead of the 1990s crisis, the "dot-com" bubble in 2000 and the global financial crisis. Currently, non-financial firms seem to be doing well in terms of their debt servicing capacities and equity cushions which contributes to lowering risks and increasing resilience. Overall, the corporate indicator reveals mildly high levels of vulnerabilities.

3.4 The property market

The property sectoral indicator (henceforth property indicator) attempts to capture developments in the Swedish residential and commercial real estate markets. These markets have often played a significant role in financial crises, both in Sweden and abroad. In Sweden, problems in the commercial property sector contributed to major credit losses and difficulties for the Swedish banking system during the crisis in the 1990s. The commercial property sector is a capital-intensive industry and property companies often have a large proportion of borrowed capital, both bank loans and market financing, which exposes them to both interest rate risks and refinancing risks. Shocks to asset values can therefore severely affect the banking sector and other institutional investors. Households typically borrow to finance their purchase of homes, and housing constitutes a significant part of households' balance sheets. Developments on the property market are therefore also important for the developments of household indebtedness. Similarly, the property market is important for construction companies and other firms, as real estate is often used as collateral for loans. Therefore, the property

indicator can be viewed in isolation to grasp housing price developments, but should also be considered jointly with the other sectoral indicators to study financial system vulnerabilities.

The property indicator is divided into three parts: prices of residential properties, prices of commercial properties, and construction activity, as illustrated in figure 5 below. The construction component includes variables linked to building permits (in square metres), both residential and commercial, the number of housing starts (for tenant-owned apartments and single-family houses) and housing investment relative to GDP. Each of these series measures construction activity in the economy on its own, but we argue that the combination of the four series included in the construction sub-indicators gives an even better description of the construction activity. The figure illustrates how the property indicator and included sub-indicators are composed and we describe the input variables in more detail below.

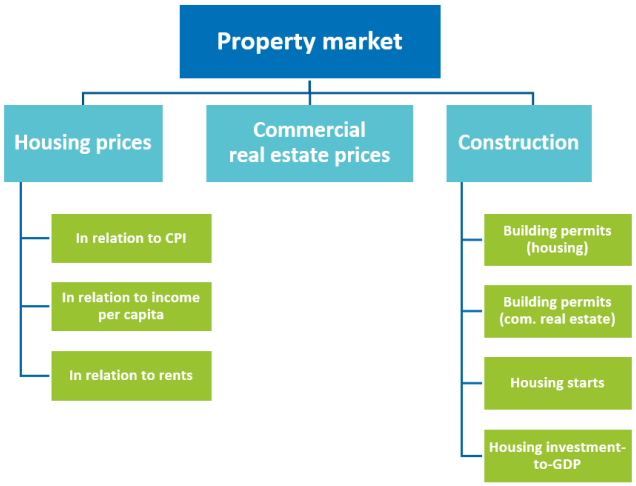


Figure 5 The figure illustrates the structure of the sectoral indicator for the property market. The sectoral indicator consists of three sub-indicators; housing prices, commercial real estate prices, and construction. The housing prices and construction sub-indicators consist of additional underlying variables as indicated by the green boxes.

Housing prices. Throughout history, the development of the property market has played an important role in economic crises. The Swedish crisis of the 1990s and the recent global crisis of 2008-09 are only two examples of how falls in property prices have caused major disruptions to both the financial sector and the economy as a whole. One common feature for property-related crises is that they are, in principle, always preceded by longer periods of rising house prices and increasing household indebtedness. Recessions that occur in combination with falling house prices tend to be deeper and longer. A higher downside risk to housing constitutes a higher downside risk to GDP and economic activity.

Housing price developments can foster different types of risks for households, firms and banks. For example, high housing prices will typically increase the debt burden of households purchasing new properties, especially first-time buyers. A house price correction will then increase the likelihood of negative home equity, which the household can offset by sharply reducing its consumption spending. If many households behave in this way, such deleveraging patterns increase volatility in aggregate consumption and GDP, with repercussions for private sector firms. Relatedly, when house prices keep rising, households will be wealthier, and part of this extra wealth can be monetized by increasing mortgage balances. Such equity withdrawals lead to an increase in household debt and make the household more vulnerable should prices fall[33].

The analysis of risks and vulnerabilities connected to housing prices also depends on what are the factors driving the price changes. If prices are rising fast and beyond what can be explained by economic

[33] See Li, J.,van Santen, P. and Zhang, X. (2020) Home equity extraction activities in Sweden, *Staff memo*, Sveriges Riksbank

fundamentals, such as income growth of households or developments in rental prices, then there might be a higher risk of prices to experience a correction in the future. Yet even for price increases that seem justified by economic fundamentals (such as the current interest rate and tax scheme), it is important to remember that fundamentals can change, and sometimes change rapidly.

In Sweden, housing prices have increased to historically high levels. Real single-family house prices have more than tripled since the mid-1990s and the price increase has been even larger for tenant-owned apartments. Recently introduced macro-prudential tools (the loan-to-value cap of 85% since 2010 and the amortization requirements[34] in 2016 and 2018) have probably contributed to lower house price growth rates (Finansinspektionen, 2019).

The housing price part of the property indicator consists of three series that represent house price dynamics. We consider the real house price index, defined as Swedish housing prices for owner-occupied one- and two-dwelling buildings for the whole country, deflated by the CPI. This measure is available since 1975, with historical price data for the period 1875-1957 from the Portal for Historical Statistics (Edvinsson, 2014). We also relate house prices to households' disposable income per capita and to rental prices. Rents are defined as the cost of shelter for renter-occupied housing, which is a component of the CPI market basket for housing-related expenses.[35] The price-to-rent measure is an internationally often-used metric for studying housing valuations. In Sweden, rent regulations make this measure less useful for this purpose, and therefore we study the three series together to assess valuations. All three series are de-trended using the local level filter.

Commercial real estate prices. Commercial property prices play an important role in driving booms and busts in the financial cycle. For example, the 1990s crisis in Sweden was triggered by a drop in commercial real estate prices and the majority of banks' credit losses during this time can be attributed to commercial real estate. Loans to commercial property firms constitute around one fifth of banks' lending to the public, or 40 per cent of banks' lending to the non-financial sector (Finansinspektionen, 2019). As opposed to households and their homes, commercial properties are mostly owned by firms. Therefore, in cases of property firms defaulting, lenders will become owners of these properties. Selling the properties to other commercial real estate firms, especially during adverse market conditions, can result in credit losses. For example, the Swedish (and Norwegian, and Japanese) experience of the 1990s crisis was that households did not default on their mortgages, rather they reduced consumption, but firms on the other hand defaulted on their loans. Commercial property is an investment, the value of which is determined by the discounted value of future rents net of maintenance costs. This makes the commercial property sector exposed to macroeconomic conditions, which, if weakened, may lead to higher vacancy rates, lower rents and ultimately cause prices to fall (BIS, 2003). Problems that arise in this sector may therefore lead to severe problems for the banks and for financial stability. Note that the company indicator, and not the property indicator, includes series (liquidity, solidity and interest coverage) for real estate firms specifically.

We use commercial property prices for Stockholm. We believe that these price series capture, on the one hand, the broader dynamics in the country, but also the more risky price developments in the business districts of Stockholm. The data on real commercial property prices is collected from MSCI, and we use the capital growth index for offices in Stockholm central area[36], deflated by the consumer price index. The data is available on an annual frequency since 1983.

[34] In Sweden, the FSA (Finansinspektionen) introduced an amortization requirement in 2016, where new mortgages with a loan-to-value ratio above 70 per cent must be amortized by at least two per cent of the original loan amount each year. If the loan-to-value is below 70 per cent, the amortization requirement is set to 1 per cent until the loan-to-value ratio reaches 50 per cent. In 2018, the FSA implemented a stricter requirement for households with high debt-to-income ratios. According to the stricter requirement, mortgagors who take out mortgages that are 4,5 times larger than their annual gross income must amortize at least 1 per cent.

[35] The housing part of the consumer price basket corresponds to around 25%.

[36] Stockholm central includes Södermalm, Kungsholmen, Gamla stan, the CBD (central business district) area, Vasastan, Östermalm and Ladugårdsgärdet.

Construction. Housing construction activity is often seen as a leading indicator for recessions. Experiences in Ireland and Spain, for example, showed very high activity in the construction sector ahead of the global financial crisis of 2008-09. The same is true for Sweden ahead of the 1990s crisis. One reason is that (real) interest rates might have been low, and many investors and households were keen on entering the housing market, in expectation of further increasing prices. We therefore deem periods with high construction activity to be risky from a financial stability perspective. Furthermore, high construction can put pressure on real estate prices, and contribute to the risk of house price declines.[37]

In Sweden, construction activity had picked up in recent years, after many years with low levels of activity in relation to economic and demographic developments. During the last two years, however, housing construction in Sweden has been decreasing and confidence indicators suggest a weak development in the sector. Smaller housing developers in particular have had problems with profitability and difficulties in starting new projects. Overall construction continues to be high in a historical perspective, but is still low in relation to population growth and housing needs estimated by the National Board of Housing, Building and Planning. The construction sub-indicator of the property indicator is formed by considering building permits, both residential and commercial, housing investments relative to GDP, and housing starts, both residential and commercial, in square metres. As stressed before, each of these indicators would by themselves be suitable for measuring construction activity. However, by combining them we can obtain an even better description of construction activity in Sweden.

Housing investments. Housing investment in Sweden follows investment in the business sector to a large degree. Variations in housing construction are thus often due to variations in economic activity and the economic conditions for construction companies. Variation in construction activity is, and has been, also related to Swedish housing policy including, for example, taxes being changed or government subsidies being introduced for housing construction. Economic activity in Sweden strengthened during 2014-2017, and the construction of housing was an important driving force. However, in the time period that followed, demand for housing declined, housing prices fell in autumn 2017 but construction continued to increase. This dampened developments in housing investment and thereby GDP growth (Sveriges Riksbank, 2019). Housing investment relative to GDP has nonetheless increased from 3.5 per cent in 2013 to around 5.7 per cent in 2018, whereby it dropped to 5.5 per cent in the end of 2019. We track housing investment relative to GDP, using quarterly data available since 1981.

Housing starts (construction). We consider the number of housing starts[38] for multiple-unit dwellings (i.e. apartment) and detached houses (i.e. single-family houses). Vulnerabilities associated with housing starts follow those associated with housing investments. Furthermore, building houses takes time, and the uncertainty that demand will be lower at the time of completion is a risk factor. We follow housing starts since 1975 on a quarterly basis. Construction activity has been high, especially in the aftermath of the 2008-09 financial crisis. Recently, construction activity has started to decline, but remains high in a historical perspective, with an estimate of 45 000 new housing objects[39] during 2020.[40]

Building permits*.* Building permits are expressed in (million) square metres per type of object. We consider both residential (single-family houses and apartments) and commercial (offices, shops, hotels) building permits. The data is available on a quarterly frequency since 1996. Building permits go hand in

[37] Housing investments can be negative for financial stability both if they are too low and if they are too high. Too much housing investment will eventually lead to excess housing which increases the risk for housing price falls. Similarly, too little housing creates a shortage where an increased demand for housing increases the probability of housing price surges. As we already capture the latter through housing prices, we focus on risks for house price falls caused by high levels of construction activity.

[38] Current year's quarters estimated outcome according to Statistics Sweden.

[39] Apartments and single-family houses.

[40] Riksbank estimate.

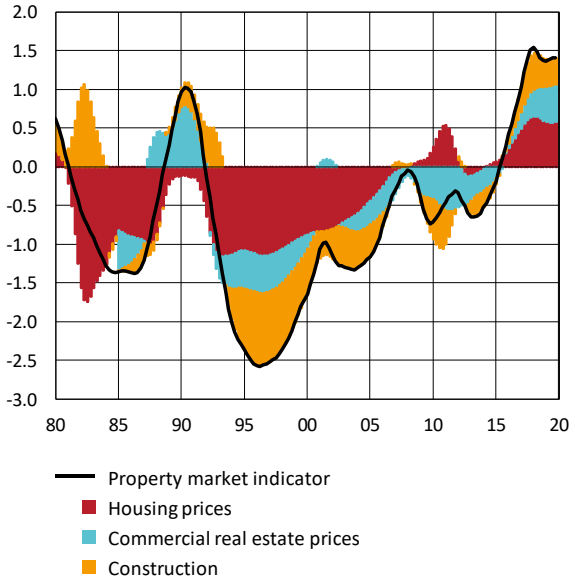
hand with housing starts, with a short lead. Typically, anyone who applies for a building permit may first apply for an advance notice, that is, a preliminary notice before the building permit application is made. This may shorten the time period between when the actual building permit is granted and when construction begins. Building permits for residential properties reached a historically high level in 2018; building permits for 8 million square metres were submitted in that year.

The property market indicator and its decomposition

The resulting property indicator and its components are presented in chart 5 below. The black line corresponds to the aggregated property market indicator, and the coloured areas represent housing prices, commercial real estate prices and a set of variables related to construction, respectively. Recent developments suggest that housing prices have the largest contributions to risks and vulnerabilities in the property market, with commercial real estate prices and the construction facility also contributing, but to a smaller extent.

Chart 5 The property market indicator and its decomposition

Standard deviation



Note. A higher value indicates a higher level of risks and vulnerabilities. Coloured areas represent the three sub-indicators that together form the property market indicator. An area above (below) zero means that the corresponding sub-indicator contributes positively (negatively) to, i.e. increases (decreases), risks and vulnerabilities in the property market at a given point in time. 31 Jan 1980 – 31 Dec 2019.

Source: The Riksbank

Prior to the 1990s crisis, vulnerabilities were rising sharply, as both residential and commercial prices were increasing. When the crisis and its aftermath ended, vulnerabilities have been building up gradually over time, as often emphasized in the Riksbank's publications. Vulnerabilities stemming from the property sector have increased during the last five years, but the development seems to have stabilized somewhat. A dampened increase in risks and vulnerabilities is likely a result of lower growth in house prices and lower activity in the construction sector. Yet the indicator remains at a high level.

3.5 The external environment

Our last sectoral indicator is a composite of factors that are relevant for financial stability in Sweden, without referring to a particular market or sector of the financial system. We use the term external

environment to refer to these factors. Although there are many such potential factors, we have chosen a handful of relevant measures, to keep the external environment indicator manageable and interpretable.

As our measures, we choose Sweden's net borrowing position from other countries, public debt and policy uncertainty indices. Sweden is a small and open economy, and therefore we include the last two measures both for Sweden and abroad. In total, there are five sub-indices that make up the external environment indicator, each with an equal weight (see figure 6 below for an overview). We describe these in turn.

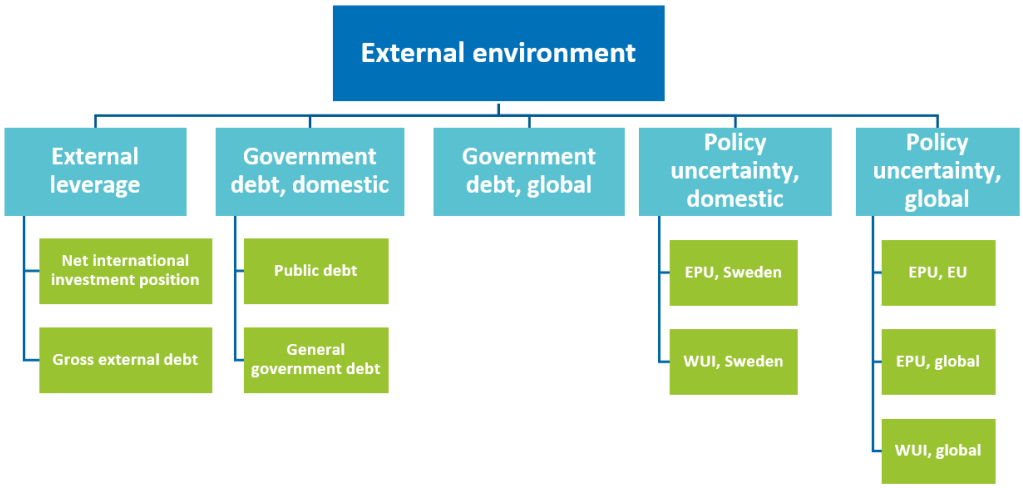


Figure 6 The figure illustrates the sectoral indicator for the external environment. The sectoral indicator is an equally weighted average of five underlying sub-indicators as represented by the turquoise boxes. Some of the sub-indicators consist of underlying sub-indicators; these are presented by the green boxes.

External leverage. Countries can be either net lenders or borrowers in the global financial system. Firms and governments can raise funds on international capital markets to finance investment or consumption, and banks can both provide loans to foreign debtors as well as issue securities in other jurisdictions. Similarly, households can invest in equity or fixed-income markets abroad. On aggregate, this implies that Sweden could be either borrowing or lending, in net terms (i.e. consolidating flows from abroad and flows to other countries). The balance of payments is the book-keeping system tracking flows across countries, based on definitions from the International Monetary Fund.

We include two measures of external leverage. The first is the net international investment position (NIIP), which is simply the difference between foreign assets held by Swedish agents less Swedish assets funded by foreign agents. The NIIP is positive when Sweden is a net creditor, i.e. lending to other countries. A positive current account balance increases the NIIP, whereas a current account deficit reduces the NIIP. Negative NIIP implies Sweden needs to pay foreign creditors and refinance its loans to other countries to keep its domestic assets in operation. A negative NIIP therefore implies exchange rate and refinancing risks. Previous research has indeed shown that large current account deficits have often preceded crises (Georgiadjs and Mijakovic, 2019).

Over the course of the past two decades, Sweden has turned from a net borrower to a net lender, due to structural changes in government policies and the introduction of a flexible exchange rate regime. We capture this structural change by including (the inverse of) the NIIP in our external leverage component.

The second measure is Sweden's gross external debt. Even though Sweden is nowadays a net lender, this masks that external debt has been increasing at the same time. Naturally, this reflects increasingly integrated international capital markets, and Sweden's good international reputation and sound government policies. Still, this external debt needs to be repaid and refinanced. Therefore, we also include the gross external debt position in our external leverage component. Both the NIIP and the gross

external debt position are scaled by (Swedish) GDP, and (since both measure stocks over flows) are de-trended using the local level filter. The series are available on a quarterly frequency since 1982.

Government debt. The government is another player in the financial system, though being of a different type than households, firms and financial institutions. In principle, the government can always generate additional revenues (such as taxes) to finance its debt service expenditures. However, unsound fiscal policies have obvious repercussions for external positions and the welfare of its residents. A high and unsustainable debt burden is a signal of fiscal instability. A strong position will help counterbalance the impact of any shock – by increasing government spending, the government can stimulate aggregate demand when the private sector faces distress. The government can also support and resolve failing banks, provided it has resources to do so. In addition, high government debt will typically result in smaller private sector debt burdens, as (per Ricardian equivalence) the government needs to raise taxes to repay its creditors, resulting in lower disposable income and smaller debt capacity for private sector agents.

We include government debt ratios for both Sweden and for a selection of foreign countries in the government debt component of the external environment indicator. We discuss these series in turn.

Swedish government debt. We include two measures of debt. Public debt is the debt position managed by the National Debt Office (Riksgälden), and equals the sum of loans and issued debt security volumes (government bonds). This measure, available since the 1950s, only includes the debt position of the state. For that reason, we also include the general government's debt, which covers the state, other (central and local) authorities and the public pension system. This measure is more robust to variations in centralization of decision-making (i.e. whether the central or local governments raise taxes and have discretionary spending powers), but has a shorter history. The combination of the two (by means of a chained index) is our preferred metric of Swedish government debt. We scale both variables by GDP and de-trend using a local level filter.

Sweden's public debt reached over 70 per cent of GDP in the 1990s crisis, and general government debt was very high at the time. Since then, as a result of major reforms in the public sector and in the tax scheme, Sweden has shifted from a high-debt country to a low-debt country. As expected, this decline in government debt has created room for private sector debt, and the composition of the national debt has shifted away from the public sector to the private sector. Our Swedish debt components of the external environment indicator capture these structural changes.

Global government debt. We also include the general government debt ratios for a selection of countries. The rationale is that the space for fiscal stimulus on a global level can also affect financial stability in Sweden. A shock from abroad can be strongly amplified when foreign fiscal authorities are unable to counterbalance the effects, and, given Sweden's strong links to the rest of the world, can transmit to Sweden. Certainly, global government debt is not the only metric available to capture the potential for international transmission of shocks, but it is one relevant factor. We include general government debt-to-GDP ratios for 21 countries[41]. The data comes from the IMF, and is available on an annual basis since 1968. We compute a GDP-weighted chained index as our preferred measure of global government debt ratios, de-trended using the local level filter.

On a global scale, government debt has developed rather differently compared to Sweden, especially since the global financial crisis in 2008-09. Many countries have increased their public debt burdens dramatically, amongst others as a result of increased welfare spending for the unemployed and through bank rescue packages. This implies elevated risks even for financial stability in Sweden, as binding constraints on global fiscal policies could be a detriment to counterbalance the next crisis.

[41] Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Switzerland, the United Kingdom and the United States.

Uncertainty indices. The last components of the external environment indicator are uncertainty indices. Uncertainty may be defined as a situation where economic agents are aware of their limited knowledge of current information and possible future outcomes (Kostka and van Roye, 2017). From this perspective, uncertainty can affect how agents behave, and whether agents can make sound investment and consumption decisions. A high degree of uncertainty has been shown to impact GDP and other important economic variables negatively.

As a practical example, take a (hypothetical) situation where a government considers deep reforms of housing policies. Between launching the idea and the final implementation when all details and consequences are known, this creates uncertainty for current owners, prospective buyers and building developers. This situation could be detrimental for the housing market, already manifested today as a deterioration of housing market performance (for instance, price falls, building pauses etc.). Other examples, such as income tax reforms, could impact both fiscal affairs and employment.

We include two different uncertainty indices to describe uncertainty. First, we use the Economic Policy Uncertainty Index (EPU) by Baker, Bloom and Davis (2016). The EPU is derived by counting the frequency of words connected to the economy (E), to policy (P), and to uncertainty (U) from major newspaper archives. The index tends to peak around episodes with large uncertainty, for instance Brexit, the European sovereign debt crisis and the Greece bailout, and exchange rate devaluations.

Second, we use the World Uncertainty Index (WUI) by Ahir, Bloom and Furceri (2018). This index is similar in nature to the EPU, but counts the word "uncertain" (or variants thereof) in the country reports of the Economist Intelligence Unit, and scales this by the total word count. This yields an uncertainty index – the WUI – for 143 countries, which has been available on a quarterly basis since the 1950s.

We construct a *Swedish uncertainty index* by combining the EPU for Sweden (Armelius et al., 2017) with the WUI for Sweden (using a chained index). We also construct a *Global uncertainty index* by combining the EPU for Europe, the (GDP-weighted) global EPU index and the global WUI (again using a chained index). Both these indices are components of the external environment indicator. We use a 4-quarter exponential moving average to filter episodes with long-lasting uncertainty from short-term variations in uncertainty word counts.

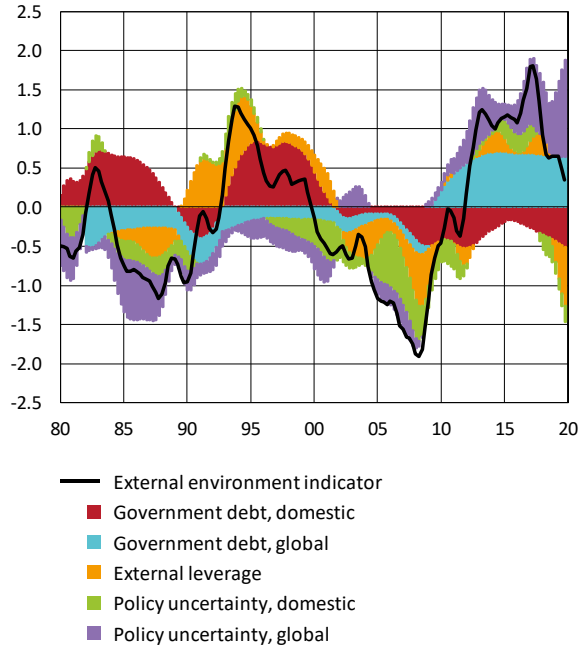
All of the uncertainty indices that we include are rather volatile, and all of them have been on the rise following the, highly uncertain, outbreak and development of the coronavirus this spring. Apart from the most recent and sudden spikes in uncertainty, the measures have been showing a slowly increasing level of economic policy uncertainty, especially in Europe and globally. Historically, we have observed spikes in uncertainty indices following the 9/11 attacks in 2001, the SARS virus outbreak and Iraq war in 2003, the 2008 financial crisis and European sovereign debt crisis, events connected to the trade war between China and the US, and events connected to Brexit.

An analysis of cross-country comparisons show that uncertainty levels vary across countries, and are, on average, smaller in advanced economies and more synchronized between economies that have tighter trade relationships and/or financial linkages (Ahir et al., 2018). Both Baker et al. (2016) and Ahir et al. (2018) further show that changes in uncertainty levels explain variations in GDP growth by affecting investment, employment and output.

The external environment indicator and its decomposition

The indicator for the external environment is illustrated in chart 6. The black line corresponds to the aggregated external environment indicator, and the five coloured areas correspond to the five sub-indicators described in the previous section.

Chart 6 The external environment indicator and its decomposition
Standard deviation



Note. A higher value indicates a higher level of risks and vulnerabilities. Coloured areas represent each of the five sub-indicators that together describe the external environment. An area above (below) zero means that the corresponding sub-indicator contributes positively (negatively) to, i.e. increases (decreases), risks and vulnerabilities, reflected in the external environment at a given point in time. 31 Jan 1980 – 31 Dec 2019.

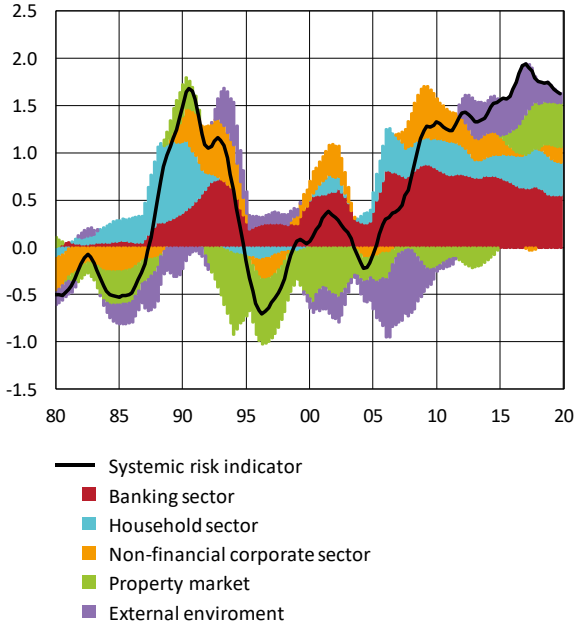
Source: The Riksbank

Historically, Sweden's public debt has decreased, lowering the external environment indicator. The indicator however shows somewhat elevated levels of vulnerability. In other countries, however, public debt is high, which more than offsets this effect. Uncertainty, as measured by the uncertainty indices, has been on the rise, and its contribution to external risks and vulnerabilities has been increasing over the last few years. On the other hand, a good net international investment position helps decrease vulnerabilities. Overall, the external environment indicator points to relatively low vulnerability levels.

3.6 The systemic risk indicator and its decomposition

We now turn to the aggregated indicator for financial risks and vulnerabilities in the Swedish financial system, illustrated in chart 7. The indicator aggregates the previously described five sectoral indicators that cover the most important sectors and markets from a financial stability perspective: banks, households, companies, the property market and the external environment. The black line represents the aggregated systemic risk indicator and the coloured areas each represent a different part of the system that contributes to overall risks and vulnerabilities at a given point in time.

Chart 7 The systemic risk indicator and its decomposition
Standard deviation



Note. A higher value indicates a higher level of risks and vulnerabilities. Coloured areas represent the five sectoral indicators that together form the systemic risk indicator. An area above (below) zero means that the corresponding sectoral indicator contributes positively (negatively) to, i.e. increases (decreases), risks and vulnerabilities in the Swedish financial system at a given point in time. 31 Jan 1980 – 31 Dec 2019.

Source: The Riksbank

The systemic risk indicator in chart 7 currently signals high risks to financial stability in Sweden. By the end of 2019, the indicator reaches a level similar to 2007, the onset of the global financial crisis. The indicator thus signals somewhat lower risks today compared to 2016, mainly due to a slowdown in credit growth and housing prices. Over time, the indicator typically rises ahead of major historical events, such as the 1990s crisis and the more recent global financial crisis in 2008-09. Naturally, events like the recent coronavirus outbreak cannot be predicted. However, by means of our indicator we may have an estimate of how bad it can get if something were to happen, given the developments in important parts of the financial sector.

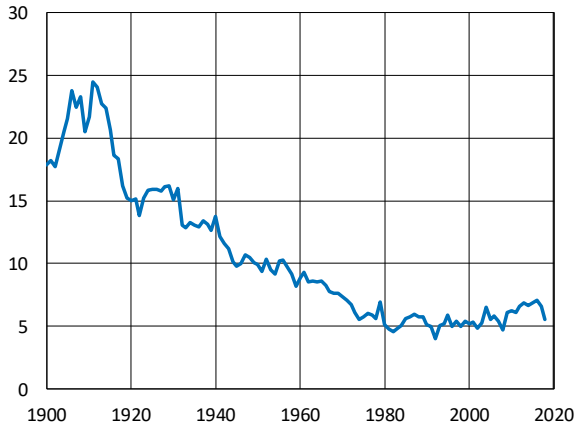
It is important to emphasize that the indicator has not been specifically designed to predict crises nor is it a perfect indicator of risks and vulnerabilities. It is also not an indicator of stress, even if some input variables (such as uncertainty indices and asset-value-based variables) respond quickly to imbalances or other events. We believe that our indicator is helpful in monitoring factors that *are important* when assessing the probability and size of future systemic financial crises, and how this develops over time. Vulnerability levels can remain elevated for long periods of time, but crises tend to be deeper and more costly when they do occur after a long period of rising vulnerabilities.

4 Sensitivity analysis

In this section we present a version of our indicator where we change some of the assumptions that were made originally. Specifically, we re-do the aggregation, both for sectoral indicators and for the main indicator, by removing all of the data points prior to 1980. We carry out this exercise in order to see if, and how, the indicator changes when we shorten the time period for which information is available to us.

To illustrate why this type of sensitivity analysis is important from a statistical point of view, and therefore important for what the indicator looks like in the end, we study the time series for banks' average equity-to-assets ratio over time as an example (see chart 8).

Chart 8 Average equity-to-assets ratio among Swedish banks 1870-2019
Per cent



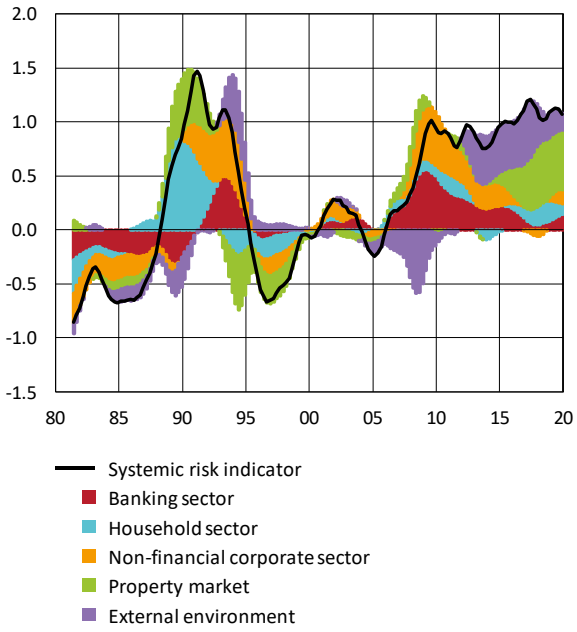
Note. The equity-to-assets ratio is defined as net worth divided by the book value of total assets.
Sources: Hortlund (2005), Statistics Sweden and Macrobond

The series begins in 1870 and takes a value of nearly 30 per cent at the time. Over time, bank capital decreases slowly and reaches a level of just above 5 per cent as of today. If we computed the average equity-to-assets ratio over this whole time period, it would be around 10 per cent. This average is considered quite high given that the corresponding level today and for the last forty years has been fluctuating around 5 per cent. When standardizing using the average since 1870, today's capital levels are deemed very low. In contrast, if we use data as of 1980, today's capital level would be rather normal or even high. The average since 1980 is around 5 per cent, and therefore 6 per cent would be considered a high capital level in a historical perspective. This example provides a good illustration of how different choices of sample periods can affect how we judge vulnerability levels today. As our benchmark, we always include the longest (reliable) data series available.

Chart 9 shows the main indicator and its breakdown when using data from 1980 onwards for all input series. It shows that the level of risks and vulnerabilities today is lower; however, the dynamics of the indicator remain approximately the same. Some sectors, for example the bank and household sectors (see chart 7), contribute less to risks and vulnerabilities in comparison to the systemic risk indicator based on all data available. Correspondingly, we observe that the property market instead is the largest contributor to overall risks and vulnerabilities in the financial system when using data from 1980.

During the development of this indicator, other variants, variables and set-ups have also been tested. We make no attempt to describe the impact of making changes to the detailed input series or other assumptions. We leave some adjustments that might matter most for future research: the weighting scheme for the variables entering the indicator, and the transformations applied to the variables. For instance, rather than equal weights, we could weigh each variable according to its ability to forecast recessions or financial crises. Another example would be to use growth rates rather than levels for capturing credit, house prices and other variables.

Chart 9 The systemic risk indicator and its decomposition
Standard deviation



Note. The indicator is based on data starting in 1980. A higher value indicates a higher level of risks and vulnerabilities. Coloured areas represent the five sectoral indicators that together form the systemic risk indicator. An area above (below) zero means that the corresponding sectoral indicator contributes positively (negatively) to, i.e. contributes to increase (decrease), risks and vulnerabilities in the Swedish financial system at a given point in time. 31 Jan 1980 – 31 Dec 2019.

Source: The Riksbank

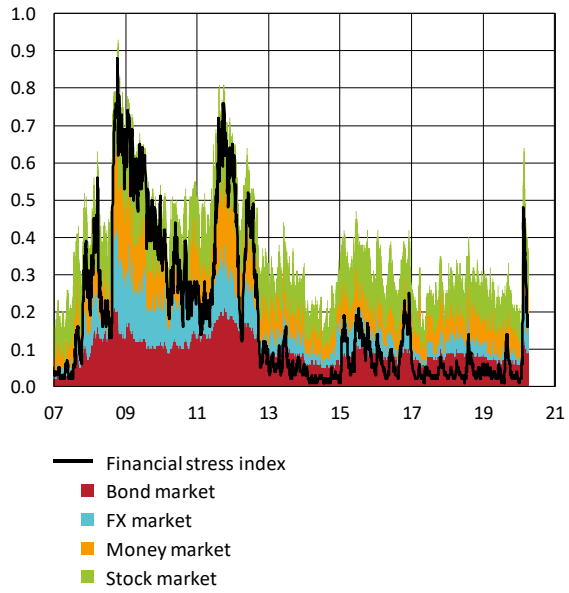
5 The systemic risk indicator in comparison to other existing indicators

The indicator of risks and vulnerabilities in the Swedish financial system developed in this staff memo is not the only available indicator with relevance to financial stability in Sweden. In this chapter, we briefly discuss similarities and differences to some alternative indicators.

***Financial stress index for Sweden*.** This indicator (illustrated in chart 10), developed by Riksbank staff (see Johansson and Bonthron, 2013), measures turbulence and distress in the Swedish bond, stock, money and foreign currency swap markets. A high value signals a materialization of risks and a high level of stress today. The purpose of this indicator is to provide an aggregate measure of financial stress in the bond, stock, money and foreign exchange markets.[42]

Our systemic risk indicator differs from the financial stress index by quantifying risks and vulnerabilities that threaten financial stability in the upcoming years. Financial stress indicators instead try to say something about interruptions to the normal functioning of financial markets (Keeton and Hakkio, 2009) and can be described as "systemic risk that has already materialized" (Louzis and Vouldis, 2012). Hakkio and Keeton (2009) further summarize the symptoms of financial stress as being characterized by one or more of the following: increased asymmetry of information, uncertainty about asset values and investors' behaviour, and a decreased willingness to hold risky and/or illiquid assets. As our systemic risk indicator measures the build-up of risks and vulnerabilities whereas a stress index measures realization of risks, the two indicators' purposes are complimentary to each other.

Chart 10 Financial stress index for Sweden
Ranking (0 = low stress 1 = high stress)



Note. The Swedish stress index has been produced by the Riksbank using a method similar to that used by the ECB for the European stress index. See Johansson and Bonthron (2013), Further development of the index for financial stress in Sweden, Sveriges Riksbank Economic Review 2013:1. Sveriges Riksbank.The last observation in the chart is 30 April 2020.

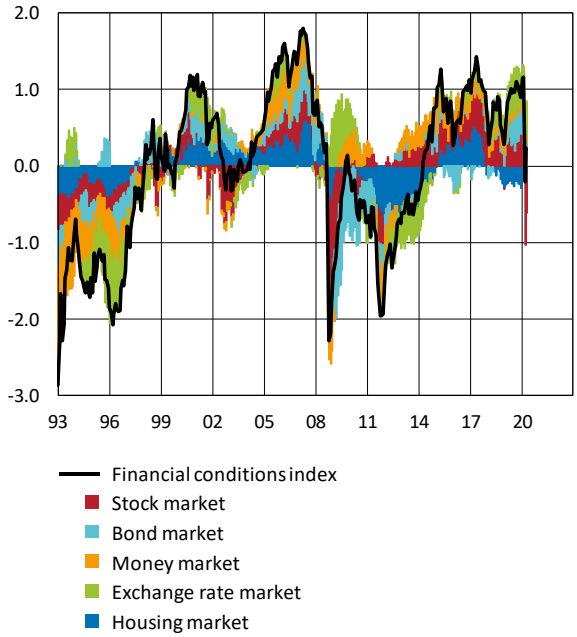
Sources: Bloomberg and the Riksbank

[42] See a.o. Hakkio and Keeton (2009), Holló et al (2012), Monin (2017) and Duprey et al (2017) for other stress indices.

***Financial conditions index for Sweden*.** This indicator (illustrated in chart 11), developed by Riksbank staff (see Alsterlind et al., 2020), summarizes the state of affairs in financial markets. The financial conditions index is an aggregate of developments in the Swedish housing, bond, money, stock and foreign exchange markets. The purpose of this indicator is to support monetary policy decision making, as the central bank can influence financial conditions directly (by altering the policy rate, for instance), but more importantly as (exogenous) financial conditions matter for the transmission of monetary policy to the real economy and subsequently demand and inflation. A financial conditions index aims to reflect financial conditions by summarizing the status of a number of indicators that describe the state of the financial markets and the interest rates and conditions encountered by households and companies when they need to borrow or invest capital (Kliesen et al., 2012). Such indices typically tell us something about the ease of obtaining financing: "*they gauge the costs, conditions and availability of domestic funds to the local economy"* (IMF, GFSR April 2017).[43]

The indicator developed in this staff memo differs from the financial conditions index by focusing on financial stability rather than monetary policy transmission. This objective difference matters, amongst other things, for the transformations applied to certain variables. For instance, increasing housing or stock prices are normally signs of looser financial conditions, laying the ground for good economic performance in the coming periods. Yet increasing asset prices can also be a signal of elevated valuations, and contribute to risks for sharper price corrections from a stability perspective. More generally, periods with loose financial conditions and low volatility are likely positive for expected growth, but the same periods can lead to higher risk-taking. Down the road, this might have consequences for financial stability (see the work by e.g. Borio, 2014; Minsky, 1977; Kindleberger and Aliber, 2015) for a broader discussion of boom-bust patterns in credit and asset prices and macro financial linkages).

Chart 11 Financial conditions index and contributions from the sub-markets
Standard deviation



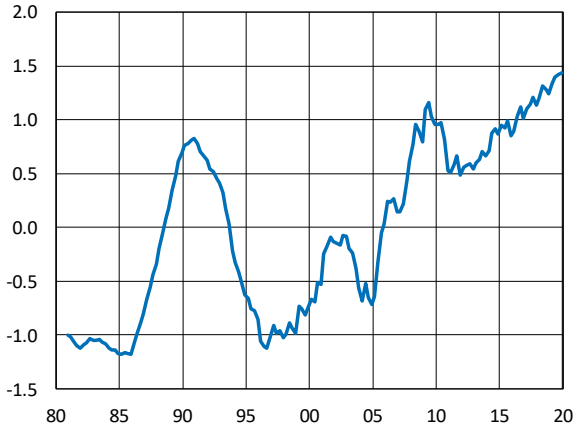
Note. A higher value indicates more expansionary financial conditions. The last observation in the chart is 30 April 2020.

Source: The Riksbank

[43] See a.o. Hatzius et al (2010), Brave and Butters (2011), Koop and Korobilis (2014) and Bank of England (2019) for other financial conditions indices.

***Financial fragility indicator for Sweden*.** This indicator (illustrated in chart 12), developed by Riksbank staff (see Giordani et al., 2017), has the same purpose as the systemic risk indicator developed in this staff memo. The goal is to monitor financial system risks and vulnerabilities. The main difference is in the scope of variables included in the index. The financial fragility indicator includes three variables, namely private sector credit as a percentage of GDP, housing prices in relation to per-capita disposable income, and the ratio between stable and unstable sources of funding. We include many more variables to have a broader analysis and understanding of financial system risks and vulnerabilities. Otherwise, the financial fragility indicator lays the ground for the indicator developed in this staff memo, both in terms of purpose and in the treatment of trending variables.

Chart 12 Indicator of financial fragility
Deviation from trend



Note. The indicator is based on deviations from trend in three underlying variables: lending to households and companies in relation to GDP, real house prices and the relationship between non-stable and stable financing sources for the Swedish banking sector. For more information, see Giordani, P., Spector, E. and Zhang, X. (2017), A new early warning indicator of financial fragility in Sweden, *Economic Commentaries* no. 1. Sveriges Riksbank.

Sources: Statistics Sweden and the Riksbank

Other systemic risk indicators. Internationally, other central banks and supranational authorities employ indicators in financial stability oversight as well. We mention two that might be of particular interest. First, the ECB uses its *Systemic risk indicator* (SRI) for Europe (see Lang et al., 2019), which captures risks from credit, real estate markets, asset prices and external imbalances, and is designed to give early warnings for financial crises. Second, the ECB uses a *Financial cycle indicator* (see Schüler, Hiebert and Peltonen, 2015) to provide country-specific financial cycles. This indicator exploits common movements and fluctuations in credit and asset prices, emphasizing movements that are in a similar direction.

6 Concluding remarks

In this staff memo, we have presented a new indicator of risks and vulnerabilities in the Swedish financial system – the systemic risk indicator. The indicator aims at giving a first glance of the level and change in the risks relevant for financial stability in Sweden. Changes in the risk outlook can focus attention on the monitoring and in-depth analysis of the drivers of this change, especially when the indicator signals elevated risks. We construct the indicator so that higher levels indicate greater risks and vulnerabilities.

The systemic risk indicator is an aggregation of five underlying sectoral indicators. The sectoral indicators are meant to gauge risks and vulnerabilities stemming from different parts of the financial system that are relevant from a financial stability perspective. These parts are the banking sector, the household sector, the non-financial corporate sector, the property market and the external environment. Underlying each of these sectoral indicators are variables that aim to describe developments related to risks, vulnerabilities and resilience in each sector. The final systemic risk indicator is an equally weighted average of the five sectoral indicators.

The indicator currently signals elevated risks to financial stability in Sweden. By the end of 2019, the indicator reaches a level similar to 2007, immediately prior to the onset of the global financial crisis in 2008-09. The indicator also signals somewhat lower risks today compared to 2016, mainly due to a slowdown in credit growth and housing prices. Over time, the indicators (sectoral and the overarching systemic risk indicator) typically rise ahead of major historical events, such as the 1990s crisis and the more recent global financial crisis of 2008-09. This is a desirable feature, and suggestive of the capability of the indicator to give "early-warning" signals.

It is important to emphasize that the systemic risk indicator has not been specifically designed to predict crises nor is it a perfect indicator of risks and vulnerabilities. It is also not an indicator of stress. We believe that our indicator is helpful in monitoring factors that *are important* when assessing the probability and size of future systemic financial crises, and how these develop over time. Vulnerability levels can remain elevated for long periods of time, but crises tend to be deeper and more costly when they occur after a long period of rising vulnerabilities.

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